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Some Fixed Point and Common Fixed Point Theorems for Rational Inequality in Hilbert Space

Rajesh Shrivastava[1], Neha Jain[2], K. Qureshi[3]
[1]Deptt. of Mathematics, Govt. Science and comm. College Benazir Bhopal (M.P) India
[2]Research Scholar, Govt. Science and comm. College Benazir Bhopal (M.P) India
[3]Additional Director, Higher Education Dept. Govt. of M.P., Bhopal (M.P) India

Abstract :- *There are several theorems are prove in Hilbert space, using various type of mappings . In this paper, we prove some fixed point theorem and common fixed point . Theorems, in Hilbert space using different, symmetric rational mappings . The object of this paper is to obtain a common unique fixed point theorem for four continuous mappings defined on a non-empty closed subset of a Hilbert space .*
Keywords :- *Fixed point , Common Fixed point , Hilbert space , rational inequality , continuous mapping .*

I. Introduction

The study of properties and applications of fixed points of various types of contractive mapping in Hilbert and Banach spaces were obtained among others by Browder [1] ,Browder and Petryshyn [2,3] , Hicks and Huffman [5] ,Huffman [6] , Koparde and Waghmode [7] . In this paper we present some fixed point and common fixed point theorems for rational inequality involving self mappings . For the purpose of obtaining the fixed point of the four continuous mappings . we have constructed a sequence and have shown its convergence to the fixed point .

II. MAIN RESULTS

Theorem 1 :-

Let E, F and T be for continuous self mappings of a closed subset C of a Hilbert space H satisfying conditions :

$1c_1$: $E(H) \subset T(H)$ and $F(H) \subset T(H)$

$ET = TE$, $FT = TF$

$1c_2$:
$$\|Ex - Fy\| \le \alpha \left[\frac{\|Tx - Ty\|\{\|Tx - Ex\| + \|Ty - Fy\|\}}{\|Tx - Fy\| + \|Ty - Ex\|} \right] + \beta \left[\|Tx - Ex\| + \|Ty - Fy\| \right] + \gamma \left[\|Tx - Fy\| + \|Ty - Ex\| \right] + \delta \|Tx - Ty\|$$

For all $x, y \in C$ with $Tx \neq Ty$, where non negative $\alpha, \beta, \gamma, \delta$ such that $0 \le \alpha + \beta + \gamma + \delta < 1$. Then E, F, T have unique common fixed point .

Proof :- Let $x_0 \in C$, Since $E(H) \subset T(H)$ we can choose a point $x_1 \in C$, such that $Tx_1 = Ex_0$, also $F(H) \subset T(H)$, we can choose $x_2 \in C$ such that In general we can choose the point :

$$Tx_{2n+1} = Ex_{2n} \quad \text{.....(1.1)}$$

$$Tx_{2n+2} = Fx_{2n+2} \quad \text{.....(1.2)}$$

Now consider

$$\left\|Tx_{2n+1} - Tx_{2n+2}\right\| = \left\|Ex_{2n} - Fx_{2n+1}\right\|$$

From $1c_2$

$$\left\|Tx_{2n} - Fx_{2n+1}\right\| \le \alpha \left\lceil \frac{\left\|Tx_{2n} - Tx_{2n+1}\right\|\left\{\left\|Tx_{2n} - Ex_{2n}\right\| + \left\|Tx_{2n+1} - Fx_{2n+1}\right\|\right\}}{\left\|Tx_{2n} - Fx_{2n+1}\right\| + \left\|Tx_{2n+1} - Ex_{2n}\right\|} \right\rceil$$

$$+\beta\left[\left\|Tx_{2n} - Ex_{2n}\right\| + \left\|Tx_{2n+1} - Fx_{2n+1}\right\|\right]$$

$$+\gamma\left[\left\|Tx_{2n} - Fx_{2n+1}\right\| + \left\|Tx_{2n+1} - Ex_{2n}\right\|\right] + \delta\left\|Tx_{2n} - Tx_{2n+1}\right\|$$

$$\left\|Tx_{2n+1} - Fx_{2n+2}\right\| \le \alpha \left\lceil \frac{\left\|Tx_{2n} - Tx_{2n+1}\right\|\left\{\left\|Tx_{2n} - Tx_{2n+1}\right\| + \left\|Tx_{2n+1} - Tx_{2n+2}\right\|\right\}}{\left\|Tx_{2n} - Tx_{2n+2}\right\| + \left\|Tx_{2n+1} - Tx_{2n}\right\|} \right\rceil$$

$$+\beta\left[\left\|Tx_{2n} - Tx_{2n+1}\right\| + \left\|Tx_{2n+1} - Tx_{2n+2}\right\|\right]$$

$$+\gamma\left[\left\|Tx_{2n} - Tx_{2n+2}\right\| + \left\|Tx_{2n+1} - Tx_{2n+1}\right\|\right] + \delta\left\|Tx_{2n} - Tx_{2n+1}\right\|$$

$$\left\|Tx_{2n+1} - Tx_{2n+1}\right\| \le \left\lceil \frac{\alpha + \beta + \gamma + \delta}{1 - \beta - \gamma} \right\rceil \left\|Tx_{2n} - Tx_{2n+1}\right\|$$

$$\left\|Tx_{2n+1} - Tx_{2n+1}\right\| \le q\left\|Tx_{2n} - Tx_{2n+1}\right\|$$

where

$$q = \left\lceil \frac{\alpha + \beta + \gamma + \delta}{1 - \beta - \gamma} \right\rceil < 1;$$

For n= 1,2,3, …….

Whether , $\left\|Tx_{2n+1} - Tx_{2n+2}\right\| = 0$ or not

Similarly , we have

$$\left\|Tx_{2n+1} - Tx_{2n+2}\right\| \le q^n.\left\|Tx_0 - Tx_1\right\|$$

For every positive integer n , this means that ,

$$\sum_{i=0}^{\infty}\left\|Tx_{2i+1} - Tx_{2i+2}\right\| \le \infty$$

The sequence $\left(T^n x_0\right)_{n\in N}$ converges to same u in C , so by (1.1) & (1.2) :

$\left\{E^n x_0\right\}_{n\in N}$ and $\left\{F^n x_0\right\}_{n\in N}$ also converges to the some point u ,respectively.

Since E, F, T are continuous , there is a subsequence t of $\left\{F^n x_0\right\}_{n\in N}$ such that :

$$E\left[T(t)\right] \to E(u), T\left[E(t)\right] \to T(u), F\left[T(t)\right] \to F(u), T\left[F(t)\right] \to T(u)$$

By $(1c_1)$ we have , $E(u) = F(u) = T(u)$ ……(1.3)

Thus , we can write

$$T(Tu) = T(Eu) = E(Tu) = E(Eu) = E(Fu) = T(Fu) = F(Tu) = F(Eu) = F(Fu) \quad \text{……(1.4)}$$

By $(1c_2)$, (1.3) and (1.4) we have , if $E(u) \neq F(Eu)$

$$\|Eu - F(Eu)\| \le \alpha \left[\frac{\|Tu - T(Eu)\|\left[\|Tu - Eu\| + \|T(Eu) - F(Eu)\|\right]}{\|Tu - F(Eu)\| + \|T(Eu) - Eu\|} \right]$$
$$+ \beta \left[\|Tu - Eu\| + \|T(Eu) - F(Eu)\| \right]$$
$$+ \gamma \left[\|Tu - F(Eu)\| + \|T(Eu) - Eu\| \right] + \delta \|Tu - T(Eu)\|$$

$$\|Eu - F(Eu)\| \le (\beta + \gamma + \delta)\|Eu - F(Eu)\|$$

Thus we get a contraction ,

Hence $Eu = F(Eu)$ .....(1.5)

From (1.4) and (1.5) we have

$$Eu = F(Eu) = T(Eu) = E(Eu)$$

Hence Eu is a common fixed point of E, F and T .

Uniqueness :-

Let v is another fixed point of E, F and T different u ,

Then by $(1c_2)$ we have

$$\|u - v\| = \|Eu - Fv\|$$

$$\|Eu - Fv\| \le \alpha \left[\frac{\|Tu - Tv\|\left[\|Tu - Eu\| + \|Tv - Fv\|\right]}{\|Tu - Fv\| + \|Tv - Eu\|} \right]$$

$$+ \beta \left[\|Tu - Eu\| + \|Tv - Fv\| \right] + \gamma \left[\|Tu - Fv\| + \|Tv - Eu\| \right] + \delta \|Tu - Tv\|$$

$$\|u - v\| \le (2\gamma + \delta)\|u - v\|$$

Which is a contradiction .

Therefore u is a unique fixed point of E, F & T in C .

Hence Proved

Theorem 2 :-

Let E, F and T be for continuous self mappings of a closed subset C of a Hilbert space H satisfying the following condition :

$2c_1$: $E(H) \subset T(H)$ & $F(H) \subset T(H)$

$$ET = TE \quad , \quad FT = TF$$

$2c_2$:
$$\|E^r x - F^s y\| \le \alpha \left[\frac{\|Tx - Ty\|\left[\|Tx - E^r x\| + \|Ty - Fy\|\right]}{\|Tx - F^s y\| + \|Ty - E^r x\|} \right]$$
$$+ \beta \left[\|Tx - E^r x\| + \|Ty - F^s y\| \right] + \gamma \left[\|Tx - F^s y\| + \|Ty - E^r x\| \right]$$
$$+ \delta \|Tx - Ty\|$$

For all x, y in C , where non negative $\alpha, \beta, \gamma, \delta$ such that

$0 \le \alpha + \beta + \gamma + \delta < 1$ with $Tx \ne Ty$, If some positive integers r, s exixts

Such that E^r, F^s & T are continuous .

Then E, F, T have unique common fixed point.

Proof :- we have

$E(H) \subset T(H)$ & $F(H) \subset T(H)$

$ET = TE$, $FT = TF$

It follows that :

$E^r(H) \subset T(H)$ & $F^s(H) \subset T(H)$

$E^r T = TE^r$, $F^s T = TF^s$

By theorem (1) , there is a unique fixed point in C such that ,

$u = Tu = E^r u = F^s u$ .....(2.1)

i.e u is the unique fixed point of T , E^r & F^s .

Now $T(Eu) = E(Tu) = Eu = E(E^r u) = E^r(Eu)$ .....(2.2)

and $T(Fu) = F(Tu) = Fu = F(F^s u) = F^s(Fu)$ .....(2.3)

Hence it follows that Eu is a common fixed point of E^r & T , similarly Fu is a common fixed point of T & F^s in X . The uniqueness of u from
(2.1) , (2.2) &(2.3),
Implies that : $u = Eu = Fu = Tu$
This complete the proof of the theorem .
Remark :-

(i) If $r = s = 1$ the we get theorem 1 .

.....x.....

Theorem 3 :-

Let A, B, S & T be continuous self mappings of a closed subset C of a Hilbert Space H satisfying the following condition :

$3c_1$: $A(H) \subseteq T(H)$ & $B(H) \subseteq T(H)$

$AS = SA$, $BT = TB$

$3c_2$: $\|Ax - By\| \le \alpha \|Sx - Ty\| + \beta_{\max}\left[\|Sx - Ax\|, \|Ty - By\|, \|Sx - By\|, \|Ty - Ax\|\right]$

For all x, y in C with $Tx \neq Ty$, where non negative such that $0 \le \alpha + \beta < 1$;

Then A, B, S, T have unique common fixed point in C .

Proof :- Let x_0 be an arbitrary point of C , since $A(H) \subseteq T(H)$ we can choose the point x_1 & y_0 in C such that ,

$Ax_0 = Tx_1 = y_0$

Also $B(H) \subseteq S(H)$,we can choose the point x_2 & y_1 in C such that

$Bx_1 = Sx_2 = y_1$

In general we can choose the points

$Tx_{2n+1} = Ax_{2n} = y_{2n}$ .....(3.1)

and $Sx_{2n+2} = Bx_{2n+1} = y_{2n+1}$ .....(3.2)

For all $n = 0, 1, 2, 3, \ldots\ldots$

Now consider ,

$\|y_{2n} - y_{2n+1}\| = \|Ax_{2n} - Bx_{2n+1}\|$

From $3c_2$:

$\|Ax_{2n} - Bx_{2n+1}\| \le \alpha \|Sx_{2n} - Tx_{2n+1}\| + \beta_{\max}\left[\|Sx_{2n} - Ax_{2n}\|, \|Tx_{2n+1} - Bx_{2n+1}\|, \|Sx_{2n} - Bx_{2n+1}\|, \|Tx_{2n+1} - Ax_{2n}\|\right]$

$\|y_n - y_{2n+1}\| \le \alpha \|y_{2n-1} - y_{2n}\| + \beta_{\max}\left[\|y_{2n} - y_{2n-1}\|, \|y_{2n+1} - y_{2n-1}\|, \|y_{2n} - y_{2n+1}\|\right]$ .....(3.3)

There arise three cases ,

Case 1:- If we take max is $\|y_{2n-1} - y_{2n}\|$, then (3.3) gives ,

$$\|y_{2n+1} - y_{2n}\| \le (\alpha + \beta)\|y_{2n-1} - y_{2n}\|$$

Case 2 :- If we take max is $\|y_{2n+1} - y_{2n}\|$, then (3.3) gives ,

$$\|y_{2n+1} - y_{2n}\| \le \frac{\alpha}{1-\beta}\|y_{2n-1} - y_{2n}\|$$

Case 3 :- If we take max is $\|y_{2n+1} - y_{2n-1}\|$, then (3.3) gives ,

$$\|y_{2n+1} - y_{2n}\| \le \frac{\alpha + \beta}{1-\beta}\|y_{2n-1} - y_{2n}\|$$

From the above cases 1,2 ,3 we observe that ,

$$\|y_{2n+1} - y_{2n}\| \le q\|y_{2n-1} - y_{2n}\|$$

$$where \qquad q = \max\left[(\alpha + \beta), \frac{\alpha}{1-\beta}, \frac{\alpha + \beta}{1-\beta}\right] < 1$$

$$for \quad n = 1, 2, 3, \ldots\ldots\ldots$$

Similarly we have ,

$$\|y_{2n+1} - y_{2n}\| \le q^n \|y_0 - y_1\|$$

For every positive integer n , this means that ,

$$\sum_{i=0}^{\infty} \|y_{2i+1} - y_{2i}\| < \infty$$

Thus the completeness of the space implies that the sequence $\{y_n\}_{n \in N}$ converges to the some point u in C , so by (3.1) & (3.2) the sequence

$\{A^n x_0\}, \{B^n x_0\}, \{S^n x_0\}, \{T^n x_0\}$ also converges to the some points u respectively ;

Since A, B, S, T are continuous , this implies

$$Tx_{2n+1} = Ax_{2n} = y_{2n} \to u \qquad as \quad n \to \infty$$

$$Sx_{2n+2} = Bx_{2n+1} = y_{2n+1} \to u \qquad as \quad n \to \infty$$

The pair (A, S) and (B, T) are weakly compatible which gives that , u is a common fixed point of A , B , S & T.

Uniqueness :-

Let as assume that w is another fixed point of A , B , S & T different from u , i.e. $u \neq w$ then

$Tu = Au = u$ & $Sw = Bw = w$

From $3c_2$ we have ,

$$\|u - w\| < (\alpha + \beta)\|u - w\|$$

which contradiction .

Hence u is a unique common fixed point of A , B , S ,T in C .

This complete the proof of the theorem.

……x……

Theorem 4 :-

Let E , F & T be for continuous self mappings of a closed subset C of a Hilbert Space H satisfying the following condition

$4c_1$: $E(H) \subset T(H)$ & $F(H) \subset T(H)$

$ET = TE$, $FT = TF$

$4c_2$:

$$\{\|Ex - Fy\|\}^2 \le \alpha \|Tx - Ex\|\|Ty - Fy\| + \beta \|Tx - Fy\|\|Ty - Ex\| + \gamma \|Tx - Ex\|\|Ex - Ty\| + \delta \|Tx - Ty\|\|Ty - Fy\|$$

For all $x, y \ in \ C$, where non negative $\alpha, \beta, \gamma, \delta$ such that $0 \le \alpha + \beta + \gamma + \delta < 1$, with $Tx \ne Ty$ then E , F , T have unique common fixed point .

PROOF :-

Let $x_0 \in C$, Since $E(H) \subset T(H)$ we can choose a point $x_1 \in C$,

Such that $Tx_1 = Ex_0$, also $F(H) \subset T(H)$, we can choose $x_2 \in C$ such that

$Tx_2 = Fx_1$.

In general we can choose the point :

$$Tx_{2n+1} = Ex_{2n} \qquad .....(4.1)$$

$$Tx_{2n+2} = Fx_{2n+1} \qquad .....(4.2)$$

$for \ every$ n $\in$ N

We have

$$\left\|Tx_{2n+1} - Tx_{2n+2}\right\|^2 = \left\|Ex_{2n} - Fx_{2n+1}\right\|^2$$

$$\begin{aligned}\left\|Ex_{2n} - Fx_{2n+1}\right\|^2 \le \alpha &\left\|Tx_{2n} - Ex_{2n}\right\|\left\|Tx_{2n+1} - Fx_{2n+1}\right\| \\ &+ \beta \left\|Tx_{2n} - Fx_{2n}\right\|\left\|Tx_{2n+1} - Ex_{2n+1}\right\| \\ &+ \gamma \left\|Tx_{2n} - Ex_{2n}\right\|\left\|Ex_{2n} - Tx_{2n+1}\right\| \\ &+ \delta \left\|Tx_{2n} - Tx_{2n+1}\right\|\left\|Tx_{2n+1} - Fx_{2n+1}\right\|\end{aligned}$$

$$\begin{aligned}\left\|Tx_{2n+1} - Tx_{2n+2}\right\|^2 \le \alpha &\left\|Tx_{2n} - Tx_{2n+1}\right\|\left\|Tx_{2n+1} - Tx_{2n+2}\right\| \\ &+ \beta \left\|Tx_{2n} - Tx_{2n+2}\right\|\left\|Tx_{2n+1} - Tx_{2n+1}\right\| \\ &+ \gamma \left\|Tx_{2n} - Tx_{2n+1}\right\|\left\|Tx_{2n+1} - Tx_{2n+1}\right\| \\ &+ \delta \left\|Tx_{2n} - Tx_{2n+1}\right\|\left\|Tx_{2n+1} - Tx_{2n+2}\right\|\end{aligned}$$

$$\left\|Tx_{2n+1} - Tx_{2n+2}\right\| \le (\alpha + \delta)\left\|Tx_{2n} - Tx_{2n+1}\right\|$$

For n = 1,2,3,……..

Whether $\left\|Tx_{2n+1} - Tx_{2n+2}\right\| = 0$ or not

Similarly we have

$$\left\|Tx_{2n+1} - Tx_{2n+2}\right\| \le (\alpha + \delta)^n \left\|Tx_0 - Tx_1\right\|$$

For every positive integer n , this means that ,

$$\sum_{i=0}^{\infty} \left\|Tx_{2i+1} - Tx_{2i+2}\right\| < \infty$$

The sequence $\left\{T^n x_0\right\}_{n \in N}$ converges to some u by (4.1) & (4.2).

$\left\{E^n x_0\right\}_{n \in N}$ and $\left\{F^n x_0\right\}_{n \in N}$ also converges to the some point respectively.

Since E , F , T are continuous ,this is a subsequence t of $\left\{T^n x_0\right\}_{n \in N}$ such that ,

$$E\left[T(t)\right] \to E(u) \quad , \quad T\left[E(t)\right] \to T(u)$$

$$F\left[T(t)\right] \to F(u) \quad , \quad T\left[F(t)\right] \to T(u)$$

By ($4c_1$) we have ,

$E(u) = F(u) = T(u)$ .....(4.3)

$thus, \quad T(Tu) = T(Eu) = E(Tu) = E(Eu) = E(Fu) = T(Fu) = F(Tu) = F(Eu) = F(Fu)$ .....(4.4)

by $4c_2$, (4.3) & (4.4) we have

$$E(u) \neq F(Eu)$$

$$\|Eu - F(Eu)\|^2 \leq \alpha \|Tu - Eu\| \|T(Eu) - F(Eu)\| + \beta \|Tu - F(Eu)\| \|T(Eu) - Eu\| + \gamma \|Tu - Eu\| \|Eu - T(Eu)\| + \delta \|Tu - T(Eu)\| \|Tu - F(Eu)\|$$

$$\|Eu - F(Eu)\| \leq 0$$

thus we get a contradiction .

Hence $Eu = F(Eu)$ .....(4.5)

From (4.4) & (4.5) we have

$$Eu = F(Eu) = T(Eu) = E(Eu)$$

Hence Eu is a common fixed point of E , F & T .

Uniqueness :-

Let v is another fixed point of E , F & T different from then by $1c_2$ we have ,

$$\|u - v\|^2 = \|Eu - Fv\|^2$$

$$\|Eu - Fv\|^2 \leq \alpha \|Tu - Eu\| \|Tv - Fv\| + \beta \|Tu - Fv\| \|Tv - Eu\| + \gamma \|Tu - Eu\| \|Eu - Tv\| + \delta \|Tu - Tv\| \|Tv - Fv\|$$

$$\|u - v\| \leq \beta \|u - v\|,$$

Which is a contradiction.

Therefore u is unique fixed point of E , F & T .

Hence Proved

REFERENCES

[1] Browder , F.E. – Fixed point theorem for non-linear semi- contractive mappings in Banach spaces .Arch. Rat. Nech. Anal.,21:259-269(1965/66).

[2] Browder , F.E. and Petryshyn , W.V. the solution by Iteration of non linear functional equations in Banach spaces , Bull. Amer. Math. Soc., 72: 571-576(1966) .

[3] Browder , F.E. and Petryshyn , W.V. Contraction of Fixed points of non-linear mapping in Hilbert spaces . J. Math. Nal. Appl., 20 :197-228 (1967).

[4] Fisher, B. Common fixed point and constant mappings satisfying a rational inequality , Math. Sem. Kobe Univ. ,6: 29-35(1978).

[5] Hicks T.L. and Huffman Ed. W. Fixed point theorem of generalized Hilbert space . J. Math. Nal. Appl., 64 : 381-385 (1978).

[6] Huffman Ed. W. Striet convexity in locally convex spaces and fixed point theorems in generalized Hilbert spaces. Ph.D. Thesis, Univ. of Missouri – Rolla, Missouri (1977).

[7] Koparde, P.V. & Waghmode, D.B.,Kanan type mappings in Hilbert spaces , Scientist of Physical sciences, 3(1) : 45-50 (1991).

[8] **Pagey , S.S.**, shrivastava Shalu and Nair Smita , common fixed point theorem for rational Inequality in a quasi 2-mertric space. Jour. Pure. Math. ,22 : 99-104 (2005).

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Recent trend: Use of metakaolin as admixture: A review

Prof. R.M. Sawant[1], Dr. Y.M. Ghugal[2]
[1]*Head of Civil Engineering Department, P.E.S. College of Engineering, Nagsenvan, Aurangabad, 431002, Maharashtra, India.*
[2]*Head of Civil Engineering Department, Government College of Engineering, Karad, Maharashtra, India.*

Abstract: *Due to worldwide infrastructural development, since 20th century use of concrete has tremendously increased which resulted in heavy manufacturing of cement. Production of cement results in heavy environmental pollution due to emission of CO_2 gas. Also the raw materials used for the manufacturing of cement are quarried from the natural geological formations. Researchers have started working on partial supplementation of ordinary portland cement mineral or raw materials by naturally occuring, manufactured, or manmade waste. Various types of pozzolonic materials viz.fly ash, silica fume, metakaolin, blast furnace slag etc. are available which has cementeous properties. Blending these materials with ordinary portland cement can improve the cementing and mechanical properties of cement. These days use of metakaolin is tremendously gaining popularity in partial replacement of cement due to its fineness in improving various strengths and parameters of mortars and concrete.*

Key words: *Pozzolanic materials, Ordinary Portland Cement, Kaolinite, Metakaolin, Mechanical properties*

I. INTRODUCTION

Metakaolin is a dehydroxylated form of the clay mineral kaolinite . Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume .The quality and reactivity of metakaolin is strongly dependent of the characteristics of the raw material used. Metakaolin can be produced from a variety of primary and secondary sources containing kaolinite. Metakaolin is refined calcined kaolin clay under carefully controlled conditions to create an amorphous aluminosilicate which is reactive in concrete. Natural pozzolans like fly ash and silica, metakaolin also reacts with the calcium hydroxide (lime) byproducts produced during cement hydration. Between 100-200°C, clay minerals lose most of their adsorbed water. Between 500-800°C kaolinite becomes calcined by losing water through dehydroxilization. The dehydroxilization of kaolin to metakaolin is an endothermic process due to the large amount of energy required to remove the chemically bonded hydroxyl ions. Above this temperature range, kaolinite becomes metakaolin, with a two-dimensional order in crystal structure. This material is ground to a required finess of 700-900m^2/kg. In order to produce a pozzolan (supplementary cementing material) nearly complete dehydroxilization must be reached without overheating, i.e., thoroughly roasted but not burnt. This produces an amorphous, highly pozzolanic state, whereas overheating can cause sintering, to form the dead burnt, nonreactive refractory, called mullite.

The mineral composition of cement and metakaolin higly resembles with each other along with their functions. Table 1. Shows the major minerals in ordinary portland cement and metakaolin along with their functions as a binding material.

Table 1. Mineral Composition of Ordinary Portland Cement and Metakaolin.

Major Minerals	Abbrevation	Percentage		Function of Minerals
		Cement	Metakaolin	
Lime	Cao	60.2-66.3	2.00	Controls strength and soundness
Silica	SiO_2	18.6-23.4	51.52	Gives strength, excessive qty causes slow setting
Alumina	Al_2O_3	2.4-6.3	40.18	Quick setting, exess lowers strength
Iron oxide	Fe_2O_3	1.3-6.1	1.23	Imparts color
Magnesium Oxide	MgO	.6-4.8	0.12	Color and excess cause cracking
Sodium Oxide	Na_2O	.05-1.2	0.08	Controls residues, excess causes cracking
Sulhpor	SO_3	1.7-4.6	0	Makes cement unsound

Percentages of minerals in Table.1for cement and metakaolin are self explanatory and justify the replacement of ordinary portland cement by metakaolin for enhancing better performance of cement.

II. LIT`ERATURE SURVEY

Several researchers have studied on various parameters by replacing the cement by metakaolin, which includes fineness, mineral composition, workability, various strengths of cement mortars and concrete, permeability, chloride permeability, resistance to chemical attack, sorphtivity, durability, alkali aggregate reactivity etc.

The mechanical properties were studied in mortars and the microstructural development in pastes by X-ray diffraction, thermogravimetry analysis, mercury intrusion porosimetry and isothermal calorimetry. They showed that 45% of substitution by 30% of metakaolin and 15% of limestone gives better mechanical properties at 7 and 28 days than the 100% PC reference. Also proved that calcium carbonate reacts with alumina from the metakaolin, forming supplementary AFm phases and stabilizing ettringite. Using simple mass balance calculations derived from thermogravimetry results, we also present the thermodynamic simulation for the system, which agrees fairly well with the experimental observations. It is concluded that gypsum addition should be carefully balanced when using calcined clays because it considerably influences the early age strength by controlling the very rapid reaction of aluminates [1].

Studies on two parts, firstly the effectiveness of four minerals admixtures *Viz.* fly ash, silica fumes, high Reactive metakaolin, and black carbon with varying particle3 size gradations and shapes was investigated from a rebound reduction point of view. Secondly high reactive metakaolin and silica fume were compared on the basis of hardened mechanical properties with special emphasis on flexural toughness in presence of fiber reinforcement. They found that in rebound reduction paricle size is more governing factor than its shape and silica fume is more superior than high reactive metakaolin due to its fine particle size but the blend of silica fume and high reactive metakaolin achieves overall better properties [2].

The effect on mechanical and durability properties of high strength concrete by incorporating metakaolin at a constant water/binder ratio of 0.3 was studied. Metakaolin mixtures with cement replacement of 5%, 10% and 15% were designed for target strength and slump of 90 MPa and 100 ± 25 mm. They observed that 10 % replacement level was the optimum level in terms of compressive strength, beyond 10% replacement levels, the strength was decreased but remained higher than the control mixture. Compressive strength of 106 MPa was achieved at 10% replacement. Splitting tensile strength and elastic modulus values have also followed the same trend. In durability tests MK concretes have exhibited high resistance compared to control and the resistance increases as the MK percentage increases. This investigation has shown that the local metakaolin has the potential to produce high strength and high performance concretes [3].

Laboratory evaluations were carried out to assess the long term performance of concrete containing high reactive metakaolin produced in North America for resistance to chloride penetrations and reduction in expansion due to alkali silica reactivity. However, the reduction was not large enough to depassivate steel reinforcement [4].

Experiments on two metakaolins with similar mineralogical compositions but with different surface areas were carried out. Workability, setting time, strengths, elastic modulus, and heat evaluations were measured. It was observed that the effect of metakaolin surface area on compressive strength was particularly evident at lower water to cementeous materials ratios and generally at later ages. The greater surface area metakaolin caused a greater and more rapid heat evolution, indicating a higher reactivity and greater rate of hydration product formation [5].

The influence of low temperature on the performance of concrete containing metakaolin was studied by partial replacement of ordinary portaland cement with 10 to 30% of metakaolin by weight of cement. The concrete was subjected to water and air curing at 5^{o}C. Compressive strength was conducted on water cured specimen. They concluded that inclusion of 15% metakaolin increases linear shrinkage and beyond 20% metakaolin shrinkage is reduced [6].

Experimental study was carried out on the magnesium sulphate resistance of mortar and paste incorporating different percentages of metakaolin. Their results confirmed that mortars having high metakaolin showed lower resistance to sulphate concentrations of magnesium solution. However in lower metakaolin there were no visibly differences in the deterioration of mortars specimens. They concluded that it is necessary to pay special attention when metakaolin concrete is exposed to highly concentrated magnesium sulfate solution [7].

Researcher studied and described the strength enhancement observed in mortars containing metakaolin additions between 10 and 30%. It was found that compressive strengths increase with increased curing times and depended strongly on the activation temperature used. Strength enhancements did not depend significantly on the concentration of metakaolin addition. Significant improvements in compressive strengths of cement mortars, up to 80% or more, was found in selected cases [8].

Study on fresh concrete properties of high strength fibre reinforced concrete with metakoalin was done which included wet density, temperature and workability by addition of crimped steel fibres at 0%,2.5%,5%,7.5% and 10% of weight of cement and metakaolin at 0%,5%,10%,15% and 20% to the weight of cement. The fiber considered in this study was crimped steel fibre having aspect ratio85. Experimental investigation was done using M60 mix with w/c ratio 0.3 [9].

Changes on some mechanical properties of concrete specimens produced by metakaolin, fly ash and steel fibers with the objective to obtain more ductile high strength concrete were observed. Three types of steel fibers were used in the experiments and volume fractions of steel fiber were 0.5% to 4.0%. The mechanical strength as well as ductility was increased due to partial replacement of Metakaolin and steel fibres. The use of metakaolin increased mechanical strength of concrete. On the other hand, the addition of steel fiber into concrete improves ductility of high strength concrete significantly [10].

Replacement of cement with metakaolin was done to find out the durability of concrete against sulphate attack. Three replacements of cement with metakaolin (5, 10 and 15% by weight) were done with water cement ratio of 0.5 and 0.6. After the specified days, the samples were immersed in 5% sodium sulphate solution for 18 months. Metakaolin addition proved to be beneficial in improving the resistance of concrete to sulphate attack. Metakaolin with the water cement ratio of 0.5 exhibited better results in sulphate resistance than 0.6. Autoclaved cured specimens had better resistance against sulphate than moist cured specimens [11].

The effect of Metakaolin and silica fume on the properties of concrete was studied. Experimentation with seven concrete mixtures of 0,5,10, and 15% by mass replacement of cement with high reactivity metakaolin or silica fume, at a water cement ratio of 0.35 and sand-to-aggregate ratio of 40% was carried out. The effect of metakaolin or silica fume on the workability, strength, shrinkage and resistance to chloride penetration of concrete were also investigated. The incorporation of both metakaolin and Silica fume in concrete was found to reduce the free drying shrinkage and restrained shrinkage cracking width. It was also reported that the incorporation of metakaolin or silica fume in concrete can reduce the chloride diffusion rate significantly. The performanance of silica fume was found to be better than metakaolin [12].

Eight mix proportions were used to produce high-performance concrete, where they replaced either cement or sand by 10% or 20% metakaolin by weight of the cement content. The strength development of metakaolin concrete was evaluated using the efficiency factor (k value). With regard to strength development the poor Greek metakaolin and commercially obtained metakaolin yielded the same results. The replacement with cement gave better results than that of sand. When Metakaolin replaced cement, its positive effect on concrete strength generally started after 2 days where as in case of sand it started only after 90 days. Both Metakaolin exhibited very high k-values (close to 3.0 at 28 days) and are characterized as highly reactive pozzolanic materials that can lead to concrete production with excellent performance [13].

Statistical models for predicting the consistency of concrete incorporating portland cement, fly ash and metakaolin were studied. From the experimental results of standard consistency tests, the effect of variations of pozzolanic replacement materials was obtained. Cement was replaced by 40% and 50%. Consistency parameters were found out from the best fit models. Values of consistency were calculated by the proposed models and gave a good agreement with observed experimental data. It indicated that the models were reliable, accurate and can be used in practice to predict the consistency of portland cement-fly ash-metakaolin blends [14].

Study of a set of parameters of high performance concrete (HPC) with metakaolin including physical characteristics, mechanical properties, fracture-mechanical properties, durability characteristics, hydraulic, thermal properties and chloride binding characteristics was carried out. Experimental results showed that the replacement of portland cement by 10% metakaolin as an optimal amount leads in most cases either to improvements or at least does not significantly impair substantial properties of the analyzed HPC. Basic physical properties and heat transport, and storage properties are very similar to common HPC, mechanical and fracture mechanical properties were improved, water- and water vapor transport parameters were substantially reduced, frost resistance was better, resistance against de-icing salts was found to be slightly worse but still meets very well the required criteria. They reported that the chemical resistance of concrete with 10% of metakaolin instead of portland cement in distilled water and HCl is better than for Portland cement concrete [15].

By partial replacement substance for cement in concrete, the use of metakaolin in concrete effectively enhanced the strength properties. The optimum level of replacement was reported as 7.5%. The result showed that 7.5% of metakaolin increased the compressive strength of concrete by 14.2%, the split tensile strength by 7.9% and flexural strength by 9.3% [16].

The effect of metakaolin on strength and workability of concrete was investigated. Results showed that the use of metakaolin decreased the workability and to get the required slump, high range water reducing admixtures (HRWRA) were essential. HRWRA resulted in deflocculation of metakaolin particles and thus a

well dispersion of metakaolin particles were achieved. The work concluded that use of HRWRA was very essential in concrete containing fine particles like metakaolin to achieve well dispersion and better results [17].

Study on the effect of steel fiber content on the mechanical properties of Steel Fibre Concrete with metakaolin by using destructive test (DT) under compression testing machine as well as nondestructive test (NDT) by rebound hammer was performed. M20 grade concrete with volume fraction of the round crimped steel fiber with 1%, 2%, 3% & 4% increment and 5%, 10%, 15% & 20% of metakaolin as a replacement of cement with water/cement ratio was taken as 0.5. Total 18 cubes for above mentioned percentage of steel fiber with metakaolin were tested under compression and by rebound hammer, results were compared with conventional concrete [18].

HPC's containing different mineral as well as chemical admixtures exhibits different properties in fresh as well as hardened states. Several factors determine these properties like: type of mineral as well as chemical admixture, type of aggregates, water-cement ratio, curing method etc. They reviewed test results on HPC with metakaolin, silica fume, with and without fibers (steel, glass, polypropylene) etc [19].

It was observed and concluded that construction material, consumes natural resources like lime, aggregates and water. In this content, an interest was made by civil engineers to replace the composite concrete material with industrial wastes, agricultural wastes, and waste glass. In this content, metakaolin was a pozzolanic material used in wide range in partial replacement of cement in concrete which was treated as economical and also due to its pozzolanic action increases strength and durability properties of concrete. In view a review was done in utilization of metakaolin in concrete as a partial replacement material to cement which has given excellent results [20].

Experiments on self compacting concrete were carried out. Studied on its mix proportioning and testing methods for flow characteristics which they found different from those of the ordinary concrete was done. Super plasticizer was used for enabling flow while keeping coarse aggregate in a viscous suspension. They attempted to study fresh and hardened properties of self compacting concrete using metakaolin as partial replacement of cement in different percentages in addition to filler. Modified Nan-su method has been used for design mix as the study was carried out for medium strength of concrete [21].

The effect of partial replacement of cement by metakalion by various percentages viz 0%, 10%, 20%, and 30% on the properties of high performance concrete, when it is subjected to magnesium sulphate attack was studied. An aggregate binder ratio of 2 and different water binder ratios *viz.* 0.3, 0.35, 0.40 and 0.45 was used in this investigation. Concrete specimens of size 150 x 150 x 150mm were casted to find residual compressive strength and specimens of size 100 x 100 x 100mm were casted to find percentage weight loss; both the sizes of specimens were casted and cured as per IS specification. After 28 days water curing, the concrete specimens were kept immersed in 5% concentrated magnesium sulphate solution for 30, 60 and 90 days for observation. Before immersion, they were weighed accurately and after required days of immersion and observation, the specimens were removed from magnesium sulphate media, weighed accurately and tested for their compressive strength; weight loss and hardness of concrete were studied. The various results which indicate the effect of replacement of cement by metakalion on HPC are presented in this paper to draw useful conclusions. The results were compared with reference mix. Test results indicate that use of replacement of cement by metakalion in HPC has improved performance of concrete up to 10% [22].

Inclusion of metakaoilin increases the compressive, tensile, flexural and bend strength and modulus of elasticity of concrete considerably; however, the workability is slightly compromised. This paper presents the review of investigations carried out to find the suitability of metakaolin in production of concrete[23].

Kinetics of air moisture absorption on three samples of metakaolin under industrial and laboratory condition from enriched kaoline at 23^{o}C was studied. Time intervals for enriching equilibrium were established *i.e.* equilibrium moisture contents at relative humidity of the air vasrying between 64% and 97%. A kinetic equation is put forward to describe the experimental data at constant relative humidity of the air Ψ, as well as a generalized equation for the rate of process, which takes into account the influence of relative humidity. It was found that unlike water soluble substances in case of metakaolin the entire process occurs basically as adsorption [24].

Investigation was made on the reaction between metakaolin $Ca(OH)_2$- water and flyash- $Ca(OH)_2$-water. They observed that in the initial period of curing metakaoiln combined lime with a very high rate that indicated that the overall rate of the reaction taking place in early age of portland cement- metakaolin concretes and cement mortars was limited by the hydration of cement phases. At initial stage the reaction between fly ash – $Ca(OH)_2$ and water was at a moderate rate as compared to metakaolin – $Ca(OH)_2$- water. Their results justified the combined use of metakaolin – fly ash ash- Portland cement in concrete industry [25].

Experimental performance was studied on the magnesium sulfate resistance of mortar and paste specimens incorporating 0%, 5%, 10% and 15% metakaolin (MK). The resistance of mortar specimens was evaluated using visual examination, reduction in compressive strength and expansion measurements. Results confirmed that mortar specimens with a high replacement level of metakaolin showed lower resistance to a higher sulfate

concentration of magnesium solution. However, in a lower concentration, there were no visibly remarkable differences in the deterioration of mortar specimens, even up to 360 days of exposure, regardless of replacement levels of metakaolin. The negative effect of metakaolin on the magnesium sulfate resistance is partially attributed to the formation of gypsum but not ettringite and thaumasite. In addition, the reduction of calcium hydroxide and the increase of secondary C–S–H in the cement matrix due to pozzolanic reaction of metakaolin provided an opportunity to lead to the conversion of primary and secondary C–S–H gel into the M–S–H gel. It is concluded that it is necessary to pay special attention when using metakaolin in concrete exposed to highly concentrated magnesium sulfate solution [26].

The resistance of mortar specimens incorporating 0%, 5%, 10%, 15%, 20%, 25% and 30% metakaolin to the magnesium chloride solution was determined. Results confirmed that specimens with high replacement level of metakaolin showed higher resistance to magnesium solution. He observed that with the reduction of calcium hydroxide and the increase of secondary C–S–H in the cement matrix, metakaolin provide a good resistive agent to aggressive chloride solution by consuming liberated lime and so prevent the formation of Friedel's salt. The maximum development of compressive strength was achieved for the specimens made from ordinary portland cement-metakaolin blended cement mortars containing a metakaolin content of 25% by weight. Bulk densities of all metakaolin mortar specimens were found between 1.4-2 gm /cm^3 [27].

Mechanical properties of plain and metakaolin concretes with and without steel fiber were experimented. To develop the metakaolin included steel fiber reinforced concrete mixtures, portland cement was partially replaced with MK as 10% by weight of the total binder content. Two types of hook ended steel fibers with length/aspect ratios of 60/80 and 30/40 were utilized to produce fiber reinforced concretes. Two series of concrete groups were designed with water to binder ratios (w/b) of 0.35 and 0.50. The effectiveness of metakaoilin and different types of steel reinforcement on the compressive, flexural, splitting, and bonding strength of the concretes were investigated. All tests were conducted at the end of 28 days of curing period. Analyses of variance on the experimental results were carried out and the levels of the significance of the variables on the mechanical characteristics of the concretes were determined. Moreover, correlation between the measured parameters was carried out to better understand the interaction between mechanical properties of the concretes. Their results revealed that incorporation of MK and utilization of different types of steel fibers significantly affected the mechanical properties of the concretes, irrespective of w/b ratio [28].

Tests on square large-scale steel-fiber-reinforced high-strength concrete HSC columns under concentric compression loading were performed. The experimental program was mainly designed to examine the effect of the volumetric steel-fiber ratio on the behavior of reinforced HSC large-scale elements subjected to axial compression loading. The test program was also designed to examine the combined confinement effect of steel fibers and transverse steel reinforcement. Thus, the test variables studied herein are the steel-fiber volumetric ratio and the volumetric ratio, yield strength, and spacing of the transverse steel ties. The results show that adding discrete fibers to HSC mixtures in reinforced concrete columns not only prevents the premature spalling of the concrete cover but also increases the strength and ductility of the axially loaded reinforced member. This behavior was predicted by the proposed fiber-reinforced concrete stress-strain model, which takes into account most of the parameters that influence confinement effectiveness: the concrete strength; the spacing, yield strength, volumetric ratio and configuration of the transverse reinforcement; the distribution of the longitudinal reinforcement; and the diameter, length, shape, volumetric ratio, and frictional bond strength of the fibers. Predictions were found to be in good agreement with experimental results [29].

Durability properties of steel fiber reinforced ,metakaolin blended concrete, when it is exposed to certain types of chemicals were investigated. Metakaolin is a thermally structured, ultra fine pozzolona, which replaces industrial byproducts such as silica fume, fly ash, etc., An experimental investigation has been carried out to evaluate the durability in terms of chemical resistance and weight loss of steel fibre reinforced concrete with and without metakaolin for concrete of M20 grade. In this investigation an attempt is made with chemicals like H_2SO_4 and HCl. Crimped steel fibres with 60 as aspect ratio at 0, 0.5%, 1.0% and 1.5% of volume of concrete are used.The results show that the percentage of weight loss is reduced and compressive strength is increased in the case of steel fibre reinforced concrete and concrete containing 10% metakaolin replaced concrete when compared to the normal concrete. Also the less percentage weight loss is noticed in the case of HCl and severe in the case of H_2SO_4 [30].

III. CONCLUSION

It can be concluded that the partial replacement of cement by metakaolin has a good influence on the strengths of the cement mortars and concrete. The mineral morphology of both cement and metakaolin being identical contributes as a better binding material. Following advantages can be derived by use of 10 to 15% metakaolin by weight of cement with optimum fiber content varying from 1 to 3% by weight of cement.

i) It increases strengths of all basic properties *viz.* compressive strengths, flexure strengths, split strengths, tensile strengths etc.
ii) It reduces efflorescence which occurs when calcium is transported by water to the surface where it combines with carbon dioxide from the atmosphere to make calcium carbonate, which precipitates on the surface as a white residue.
iii) It increases resistance to chemical attack, and reduces alkali silica reactivity.
iv) It enhances workability and finishing of concrete.
v) It reduces shrinkage due to particle packing.
vi) It can be used in formation of high performance, high strength, and lightweight concrete, precast and poured-mold concrete, fibercement and ferrocement products, glass fiber reinforced concrete, Countertops, art sculptures, mortar and stucco *etc.*

REFERENCES

[1] Antoni M. , Rossen J, Martirena F., Scrivener, "Cement Substitution by a Combination of Metakaolin and Limestaone", Cement and Concrtete Resesrch , vol. 42, 2012, pp. 1579-1589.
[2] V. Bindiganavile, N. Banthia, "Fiber Reinforced dry mix with metakaolin", Cement and Concrete Composities,23, 2001, 503-514.
[3] P. Dinkar, Pradosh K. Sahoo, and G. Sriram, "Effect of Metakaolin Content on the Properties of High Strength Concrete", International Journal of Concrete Structures and Materials Vol.7, No.3, , 2013, pp.215–223.
[4] K.A. Gruber, Terry Ramlochan, Andrea Boddy, R.D. Hooton, M.D.A. Thomas, " Increasing Concrete Durability with High – Reactivity Metakaolin" Cement and Concrete Structures, vol. 23, 2001, 479- 484.
[5] J.M. Justice And k.e. Kurtis, "Influence of Metakaolin Surface area on Properties of Cement Based Materials", Journal of material in Civil Engineering , ASCE, vol. 19, 2007, 762-771.
[6] J.M . Khatib, "Low Temperature Curing fof Metakaolin Concrete", Journal of Mareials and Civil Enginerring , 21, 2009, 362-367.
[7] S.T. Lee, H.Y. Moon, R.D. Hooton, J.P. Kim," Effect of Solution Concentrations and Replacement Levels of Metakaolin on the Resistance of Mortars exposed to Magnesium Sulfate Solutions" Cement and Concrete Research, 35, 2005, 1314-1323.
[8] Potgieter – Vermaak S.S. and Potgieter, " Metakaoiln as an Extender in South African Cement" Cement and Concrete Research, ASCE, 18:4, 0899-1561,2006, pp.619-623.
[9] Sabale V.D., Ghugal Y.M., "Experimental Study of Fresh Concrete Properties of Fiber Reinforced Concrete with Metakoalin", International Journal of Emerging Engineering Research and Technology Volume 2, Issue 4, , 2014, pp. 85-95.
[10] Shikhare V.B., Kalurkar L.G., " Combine Effecct of metakaolin, Fly Ash and Steel fiberes on Mechanical Properties of High Strength Concrete" Journal Of Mechanical and Civil Engineering, vol.7, 2013, pp.01-04
[11] Nabil M. Al-Akhras "Durability of Metakaolin Concrete to Sulfate attack" Cement and Concrete Research, vol.36, 2006, pp.1727–1734.
[12] Jian-Tong Ding and Zongjin Li, " Effects of Metakaoiln and Silica Fumes on Properties of Concrete", ACI Materials Journals, 2002, 393-398.
[13] Badogiannis E, Papadakis V.G. , Chaniotakis E, Tsivilis s, "Exploitation of Poor Greek Kaolins: Strength Develpoment of Metalkoalin Concrete of k- value", Cement and Concrete Research, vol. 34, 2004, 1035-1041.
[14] Jiping Bai and Albinas Gailius,"Consistency of fly Ash and Metakaolin Concrete" Journal of Civil Engineering and Management, vol. 15. No. 2, ,2009, pp.1341-1349.
[15] Eva Vejmelkova, Milena Pavlikova, Martin Keppert, Zbynek Kersner, Pavla Rovnanikova, Michal ondracek, Martin sedlmajer, Robert Cerny, "High Perfornamce concrete with Czech Metakaoiln: Experimental Analysis of Strength, Toughness and Durability Charecteristics" Construction and Building and Materials, vol.24, , 2010, pp.1404-1411.
[16] Murali.G and Sruthee P, "Experimental Study of Concrete with Metakaolin as Partial Replacement of Cement" International Journal Emerging Trends in Engineering and Development, vol.4, issue 2, , 2012, pp.344-348.
[17] Paiva.H, velosa A. Cachim P. Ferreira V.M. "Effect of Metakaolin Dispersion on the Fresh and Hardened State Properties of Concrete", Cement and Concrete Research, vol.42, 2012, pp.607-612.
[18] D. T. Rahane, Pallavi Pasnur, "Non-Destructive Test: Steel Fiber Reinforced Concrete With Metakaolin", International Journal of Mechanical And Production Engineering, vol. 2, Issue- 7, 2014, pp. 83-85.
[19] Nidhi Murali, Nivin Philip, "A Study on Mechanical and Durability Properties of High Performance Concrete Containing Metakaolin and Steel Fibre- Review", Transactions on Engineering and Sciences Vol. 2, no. 6, 2014, pp. 45-51.
[20] Dr.K.Srinivasu, M.L.N.Krishna Sai, Venkata Sairam Kumar.N, "A Review on Use of Metakaolin in Cement Mortar and Concrete", International Journal of Innovative Research in Science, Engineering and Technology Vol. 3, Issue 7, 2014, pp. 14697-14701.
[21] Prof. Shriram H. Mahure, Dr. V. M. Mohitkar, Dr. K. Ravi, "Effect Of Metakaolin On Fresh And Hardened Properties Of Self Compacting Concrete", International Journal Of Civil Engineering and Technology, vol.5, no. 2, 2014, pp.137-145.

[22] Beulah M, Prahallada M. C., "Effect of Replacement of Cement by Metakalion on the Properties of High Performance Concrete Subjected to Magnesium Sulphate Attack", International Journal of IT, Engineering and Applied Sciences Research, vol. 2, no. 2, 2013, pp. 16-22.
[23] Vikas Srivastava, Rakesh Kumar and V.C. Agarwal , "Metakaolin Inclusion: Effect on mechanical properties of concrete", Journal of Scientific and Industrial Research, vol. 2, no. 5, , 2012, pp. 251-253.
[24] J. Ninov, "Hygroscopic Sorption properties of Metakaolin", Journal of the University of Chemical Technology and Metallurgy, Vol. 45,no. 1, , 2010, pp. 47-52.
[25] Dojkov I., Styaanov S., Ninov J., Petrov B., "On the consumption of Lime by Metakaolin, Flyash and aoline in Model Systems", Journal of Chemical Technology and Metallurgy, vol.48, 2013, pp. 54-60.
[26] S.T Lee,H.Y Moon, R.D Hooten, J.P Kim, "Effect of solution Concentrations and Replacement Levels of Metakaolin on the Resistance of Mortars Exposed to Magnesium Sulfate Solutions", Cement and Concrete esearch , vol. 35, no. 7, 2005, pp. 1314–1323.
[27] Hisham M. Khater " Influence of Metakaolin on Resistivity of Cement Mortar to Magnesium Chloride Solution" Ceramics- Silikaty, Vol. 54, issue 4, , 2010, pp. 325-333.
[28] Erhan Güneyisi, Mehmet Gesog˘ lu , Arass Omer Mawlod Akoi , Kasım Mermerda s, "Combined Effect of Steel Fber and Metakaolin Incorporation on Mechanical Properties of Concrete", Composites: part B 56, 2014, pp. 83-91.
[29] P. Paultre, M.ASCE, R. Eid Y. Langlois and Y. Lévesque, "Behavior of Steel Fiber-Reinforced High-Strength Concrete Columns under Uniaxial Compression", Journal Of Structural Engineering, vol. 136, 2010, pp. 1225-1235
[30] P. Srinivasa Rao, Sravana, Z. Abdul Rahim and T. Seshadri Sekhar, "Durability Studies on Steel Fibre Reinforced Metakaolin Blended Concrete", AKGEC International Journal of Technology, Vol. 3, No. 1,pp 38-43,

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Assessment of concrete by using incremental dynamic analysis method

Hamidreza Ashrafi[1],Peyman Beiranvand[2],Amir Mohammad Amiri[3],Hossein Foruzesh[4]
[1](Department of Civil Engineering/ Razi University Of Kermanshah, Iran)
[2](Ph.D student, Department of Civil Engineering / Razi University Of Kermanshah, Iran)
[3](Department of Civil Engineering/ Lorestan University, Iran)
[4](M.A student, technical & engineering faculty / Islamic Azad University, Bushehr , Iran)
Corresponding author:Hamidreza Ashrafi
Email:h.r.ashrafi@razi.ac.ir

ABSTRACT: *In this paper, the seismic performance of reinforced concrete constructions with moment frame system that by using the common rules has been designed, by probabilistic method is evaluated. In this study, six concrete moment frames with medium formability and with high degree of importance in Tehran city on the basis of regulations and standards of Iran design and in Open Sees software modeling and assigned of nonlinear behavior of structural components was performed. To perform incremental nonlinear dynamic analysis from the suggested number of 22 pairs of accelerograph related to remote domain available in FEMAP-695 regulations about hard soil was used. Selective accelerographs into two methods by using spectral acceleration of IDA curve mean once and once again with spectral acceleration of 2800 standard plan were scaled and in time history analysis of frameworks under the study were used and mean values of maximum relative displacement between the floor and maximum displacement of roof was obtained. for better judgment about frameworks under studied in SAP software under incremental nonlinear static analysis taking into account the target displacement to maximum displacement mean of roof obtained from nonlinear time history analysis was placed and components yield and the entire structure was investigated. Also the results resulting from probability of exceeding the performance of concrete moment frame structures with very high importance and high performance range shows the continuous use.*

Keywords -*incremental nonlinear dynamic analysis (IDA), seismic performance, concrete moment frame, breakdown, uninterrupted usability*

I. INTRODUCTION

In recent years with advances in technology and experiences from past earthquakes researchers found that for safety design against earthquake control methods with power are not responding to the needs of structural seismic and the displacement controller factor is more effective method. On this basis design based on performance for different levels of earthquake was created, in which inelastic displacements more than design based on the elastic forces isnecessary. These researchers nonlinear static method to check non-elastic displacements and predict the behavior after materials flow at the disposal, and it by applying different loading patterns have expanded so that now this method because of the ease and well accuracy in all regulations of the world including 440,360,274,273FEMA and ATC-40 and Vision 2000 etc. has been proposed. Researchers like passage of static analysis only to incremental static analysis (push over) and from time history analysis only to incremental time history analysis so that the earthquake loading be scaled on that, have conducted. With the advancement of computer science and its calculations capability, Cornell and Vamvatsikos [1] devised the IDA method, that is a parametric analysis method that needs and seismic capacity by influence the structural models to the different accelerographs of the earthquake that have also scaled are achieved. So that this method has recently been accepted by FEMA as IDA incremental dynamic analysis as a modern method to determine the overall capacity of structures has been authenticated. In fact, all the researchers with comparing the existing methods to improve these methods and Invented a new way were discussed so evaluation of earthquake lateral load distribution methods has a long history.

According to the 2800 standard of Iran National Building Regulations sixth issue of Iran, moment frames is frame in which the behavior of members and connections are mainly moment. As a result of severe earthquakes, moment frames should be able to meanwhile the experience of relative deformations of levels without destroying in their beams and columns, tolerate lateral forces and be transmit. So in this system columns under axial force and moment and cut are placed and beams are under the cut and moment. [2]According to the ninth issue of Iran National Building Regulations formability is the ability of energy dissipation by the nonlinear behavior the whole structure or its members, under the influence of deformations of going and backing with large range without an appreciable reduction in their resistance. Also this regulation defines the following three regions formability according to the power of energy dissipation of structures and for each one also offers criteria whether in design or whether in construction site discussion. [3]

FEMA and ATC regulation's writers by regarding the importance and accuracy of incremental dynamic analysis issue in a joint project with the name of FEMAP-695 were studied this method and conditions and recommendations for conducting this analysis were presented in this study, addition using them but also for more accuracy from the selective accelerographs of this regulation has also been used. In the majority of scientific researches to dynamic analysis of two-dimensional frame are confined and from the effect of the interaction frames are ignored. So in this research according to the latest changes of FEMAP-695 instruction to evaluate the two-dimensional concrete moment frame a structure with medium ductility by internal regulations rules has designed to two-dimensional incremental the dynamic analysis method is discussed. Up to fact of these frames performance based on being two-dimensional of model and analysis, taking advantage of incremental dynamic analysis and applying the measures of latest instructions (FEMAP-695) fully is checked.

in this paper, three concrete structural frames, that from each one 2 frame, with a span length and different height with medium ductility base on the 2800 standard and the sixth and ninth issue of national building regulations by using SAP2000 software is analyzed and designed, and to evaluate the performance of them as well as the ability to attract and energy dissipation caused by various earthquakes, by using criteria of FEMAP695 and remote area records proposed inn these regulations and recorded on the site of PEER, and two-dimensional simulation in Open Sees software, under the incremental nonlinear dynamic analysis were placed until in relevant curves, seismic performance area of threshold of breakdown to be explored. The level of breakdown performance is said to the level of performance that structure to lose the ability of vertical and lateral bearing. this limit for IDA curve according to FEMA (2000a, b) equal to equal to 10% or gradient of the curve of IDA, to reach of 20% of the elastic gradient can be selected that point as the performance point of structural breakdown.

II. Materials and methods

1.1. Incremental nonlinear dynamic analysis method

Since the to achieve capacity of structure beyond the elastic limit need to use of nonlinear analysis and considering that in the meantime incremental dynamic analysis method (IDA) due to the lack of lateral load pattern and distribution of shear in height in terms of theoretical and practical have much lower problems, to this reason for monitoring and evaluation of unusual and irregular structures or structures with a high degree of importance from this method is used. As a result of IDA method is to obtain one or more curves that in them damage parameter can be expressed in terms of intensity or vice versa. The unique information these curves express about the nature of the response of a few degrees of freedom constructs that can be justification on the development of this method by existing of time difficult process on it. In addition, with high accuracy of this method can be received performance of other methods presented also well. It is worth noting that previous methods did not have this ability completely. The purpose of the four-lane curve: Area of elastic, hardening positive (non-negative), negative hardening and smoothly resistance of final residual is that by falling towards decays the zero resistance. By having this curve the actual system behavior and design parameters will be much clearer and can be realized to verify the previous methods such as types of lateral loads pattern of Push Over method or spectral and linear method for estimated in behavior after the structure failure Because the concrete and its behavior in range of nonlinear behavior is a bit complicated, so by having such an instrument can be studied with more detail to the performance of a concrete structure against earthquake [4].The first step in performing an IDA analysis having a good understanding of inputs and outputs of this type of analysis recently Seismic Research Institute in Berkeley, California is a logical process for solving this problem has been presented. This process is defined as way which initially by performing a seismic risk analysis in desired area a parameter called seismic intensity measure or IM as an input to the structure to be applied. In the next stage by incremental nonlinear dynamic analysis for every IM, structural response to existing seismic stimulation, obtained and by name of engineering parameter of representative structure needed (EDP) will be achieved. In the next step with the introduction of a structural damage indicator can be achieved damages occurrence

probability or exceed the maximum allowed probability of vibration input of a specific amount and also in next steps can be determined the repair costs amount caused by compensation. The IDA curves are a series of IM curves against EDP that the probability of lateral studies on it will be done. [5]

✓ **Scale factor (SF)**

Scale factor is a non-negative scaled integer accelerograph that with it's multiplied in initial accelerograph, accelerograph scaled is obtained. Although the scale factor is the easiest way to create an accelerograph scaled. [6]

✓ **Intensity Measure of earthquake (IM)**

Earthquake intensity measure a accelerograph scaled, a non-negative number that by a function dependent on the initial accelerograph and increases linearly with increasing the SF. Large quantities for determining the intensity of an earthquake have been suggested but may be how to scaling them not always clear. Such as: seismic moment, earthquake duration and the modified Mercalli intensity and typical examples of IM, including peak ground acceleration (PGA), peak ground velocity (PGV), acceleration response spectra for 5% damping and mode in the first cycle time for structure ((T1, 5%) Sa) and more. [6]

✓ **Damage Measure (DM)**

Damages Measure is a non-negative number that represents the response of a structure modeled in effect of seismic loading determined in the previous section. In other words, DM is a visible quantity that is part of output relevant nonlinear dynamic analysis or is derivable from it. [6] Types of malfunction indicator are: Maximum shear of foundation, nodal periods, maximum formability floors, different damage indices (such as the cumulative hysteretic energy, the index of maximum relative displacement for roof or ROOF $^{\theta}$, or the maximum relative displacement or MAX$^{\theta}$ floors etc. Selecting a suitable DM depends on the type of structure and type of application. May be of two or more DM For different response characteristics, Limit states or failure modes be used. To assess the damage to non-structural members in a multi-floor frame of the maximum accelerations the floors is a good choice, On the other hand to assess the structural damage to a building, MAX$^{\theta}$ well is in relation to the period of connections and general or local breakdown for the structure And a DM is appropriate.In this study MAX$^{\theta}$ as DM used has been selected. Response of structures often marked numerically is usually the absolute value of them is used. Or positive and negative sections are discussed separately. [1]

2.1. Modeling the frameworks of under the studied

Concrete structures 4, 8 and 12 floors from each 2 frame with length And various floors based on the height of 2800 standard (Third Edition) sixth issue of National Building Regulations loaded And by using the software of SAP2000 And reinforcement (tensile and compressive) beam and columns sections by using ACI318- 99 regulation of this program have been determined.

It is noteworthy that for the design of these armatures moment, once by combining the ACI318- 99 load and conditions the same regulation, determined And once again by combining load of the ninth issue and regulation of concrete Canada, 2004 were determined and choose the diameter of the armature based on the obtained areas by so performed that be covered both regulation.

In addition, to ensure once For the most critical loading position Ninth loading compounds issue of Forces Created in a determined element And Based on the regulations issue of Ninth National Building Regulations rebar design was done. Results mainly between the results of ACI318- 99 and concrete Canada regulation of 2004 were placed and the number of elected rebar was responsive requirement of this regulation as well.So can be claimed that moment armatures of these models criteria issue of Iran's ninth national building regulations are satisfied... Shear armatures (stirrups) also based on the regulations formability of Ninth National Building Regulations issue and the most critical loading position has been determined.

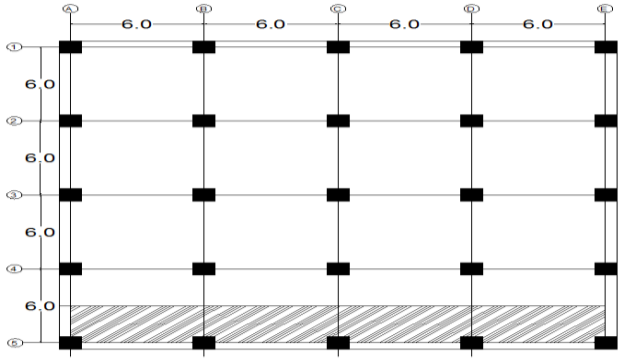


Fig. 1. Structures Plan of S14, S18, S112

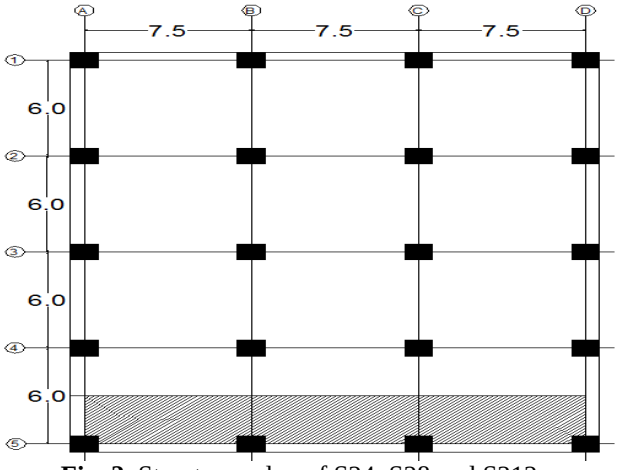


Fig. 2. Structures plan of S24, S28 and S212

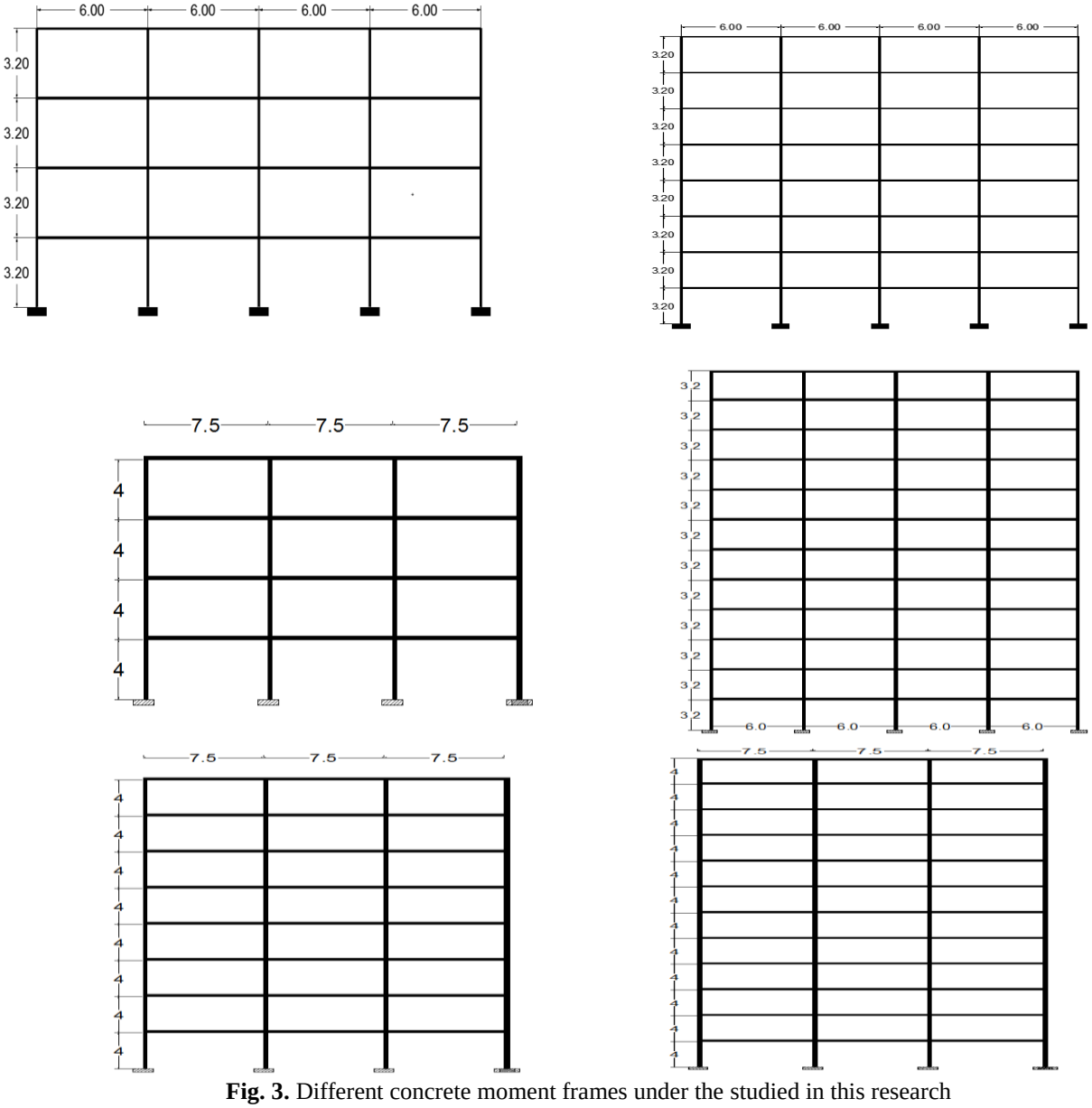


Fig. 3. Different concrete moment frames under the studied in this research

Once again based on the modifications made on nonlinear static analysis that this is not just to compare analysis results of nonlinear static and incremental nonlinear dynamic has been done. Total of 22 accelerographs from collection of accelerographs related to remote area available in regulation of FEMAP-695 belongs to the soil type 2 (according to the standard definition in 2800) we choose. So incremental nonlinear dynamic analysis of these accelerographs have been used.

The studied models in the Open Sees software made modeling and then based on the accelerographs of the selective in the previous step, incremental nonlinear dynamic analysis was conducted and the curve of this analysis (Figure IDA) for every 6 structure will be achieved. The outputs obtained from analysis (structural response to a gradual increase in the intensity of earthquakes) graphically depicted by using Excel software and the capacity of uninterrupted usage mode has been determined at 50% for every six frames.in this study from the two method scaling the pairs of accelerographs for evaluation Frames under study has been used: in the first method, at first should be drawn range of all selective pairs accelerographs and then spectral acceleration corresponding to like period, denoted item of structure (% 5, T1 (Sa)) to be extracted and the spectral acceleration corresponding like period of denoted item of structure (% 5, T1 (Sa)).Range of Iran's 2800 standard plan be achieved and obtained by dividing the spectral acceleration pairs of spectra accelerographs on the resulting spectral acceleration from range of 2800 standard plan, scale factor for all accelerographs pairs with this method is obtained.The second method is similar to pervious method With the difference that instead of spectral acceleration mode period of the first structure obtained from range of 2800 standard plan, Spectral acceleration of curve 50% (average curve) obtained from IDA analysis corresponding by maximum relative displacement between floors of 1% for performance level of usability without interruption have been used.After the scaling pair of accelerographs to two methods titled by using Open Sees software frames under study with selective accelerographs pair again put under the nonlinear time history analysis and results of maximum relative displacement between the floors and displacement of corresponding roof we extract and from them is taken the average. In addition to the better judgment of nonlinear static analysis (pushover) and viewing the range of plastic hinges in SAP software is used.

II. Results and discussion

From the frames, under the incremental nonlinear dynamic analysis (IDA), has placed and for all frames, viscous damping, equivalent (ξ =% 5) be considered that the amount conventional is for frames. Each frame, under the different intensities of selective accelerographs collection, was placed and their various responses, including relative displacement (Drift), Lateral displacement of floors and shear of foundation was measured.Each accelerograph with incremental indexes of 0.1g started and by step of 0.2 g, as far as software results reflects the lack of convergence, which probably indicate the general instability of the frame, has been continued. Also effects of soil-structure interaction have been ignored, but the effects of P - Δ in the analysis has been considered.

2.1. Curve of incremental nonlinear dynamic analysis

in analysis of IDA that by using the accelerographs numerous is done, like this article that from the 22 accelerograph pair have been used, instead of only a curve of IDA, we have a set of these curves that they say to it a curve set of (IDA Curve Set),. Each frame, will be had a curve set of IDA. In this article, by having 6 concrete moment frame models with the different average formability, Totally 6 curve set of IDA, will be produced. Selecting a proper damage measure (DM) or demand parameter (EDP) depends on application or the desired structure target.If the purpose of assessing the damage entered to non-structural elements available in a multi-floors frame, maximum acceleration parameter of floors is the best choice on the other hand, if the assessment of damage and damage entered to shear building be considered, the parameters of maximum relative displacement between floor (maxIDR) can be described as well the rotation of structural connections and plastic joints composed and thus general and partial breakdown of building, so is a good option nominated for parameter of EDP. Relative displacement parameter between floors (IDR) of a floor is the difference of displacement the roof of desired floor parameter of relative displacement between floors (IDR) of a floor, Displacement is the difference between floors and ceiling from the movement of the floor, divided by the floor height. Relative displacement between the floors of all floors Calculated for each time step in dynamic analysis and the maximum amount of it between floors is recorded And parameter of maximum relative displacement between floors (maxIDR), is obtained. So in this study, parameter of maximum relative displacement between floors (maxIDR) as the engineering demand parameter (EDP) has been selected. [1]

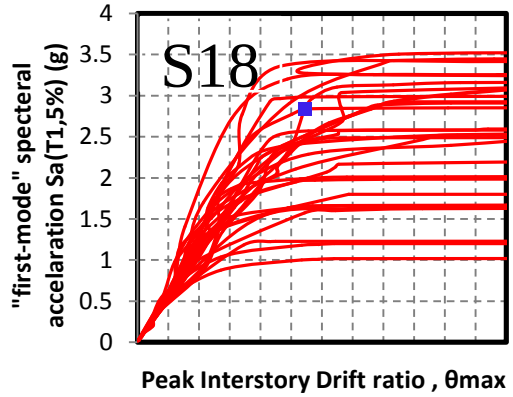
2.2. Review the outputs obtained from incremental nonlinear dynamic analysis

Something that has of importance equal to analysis, the next step of processing the data obtained and perhaps most important measure selection earthquake intensity (IM) and damage measure (DM) is appropriate. Several effective communication with the measure selection earthquake intensity (IM) there is [1], so here

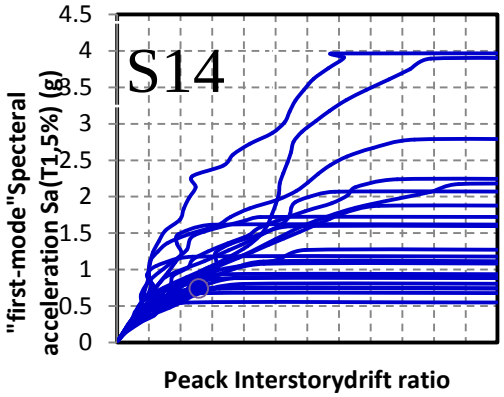
spectral acceleration) (SA (T1, 5%), Measure of earthquake intensity (IM) and maximum relative displacement between the floors (DM) have been our selective parameters. So only a small number of ground motion accelerographs to provide favorable demand and capacity estimates are necessary because it provides a complete description of response. After selecting Measure of earthquake intensity (LM) and damage measure (DM) we still have a lot of information obtained from incremental dynamic analysis (IDA) we face which should significantly ordered and be classified, that by using proper software This task very easily is performed. IDA curves set related to under study frames in Figure 4 have been shown.

2.3. Summary the curves of incremental nonlinear dynamic analysis

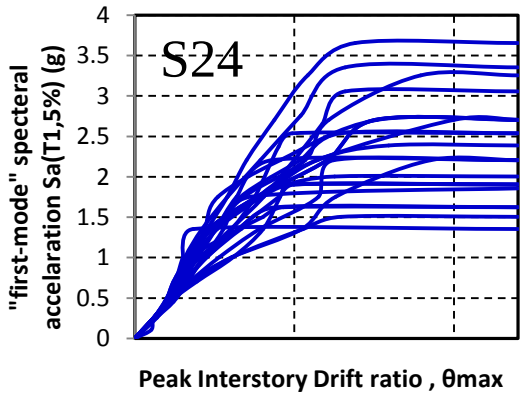
By creating curves of IDA for each record and then the definition of limit state, a lot of information can be collected. Only part of this information in the form of (4) has been shown. IDA curves shows a wide range of structural behavior and considerable changes of one record to another record that must by using the appropriate methods, are summarized. This information to distribution of mentioned damage measure in intensity measure of the earthquake and exceed of the threshold probability, a certain breakdown that in the level of mentioned intensity measure of the earthquake will be reduced. Capacities of limit state can be summarized easily in a number of central values such as (mean or median) and a measure of dispersion, for example (mean deviation). As a result we mean curve (50 percentages) of damage measure and intensity measure of the earthquake, have calculated, that in the Figure 5 as the graph has been plotted.



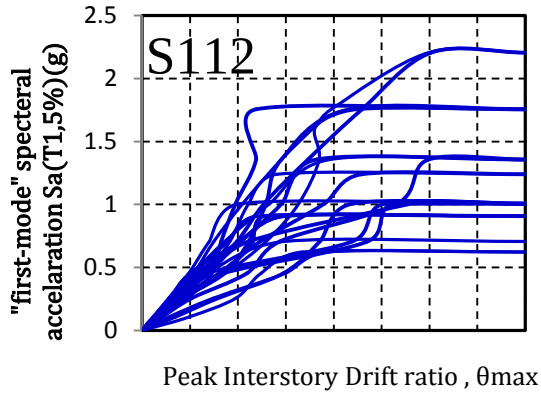
8floors 4 spans



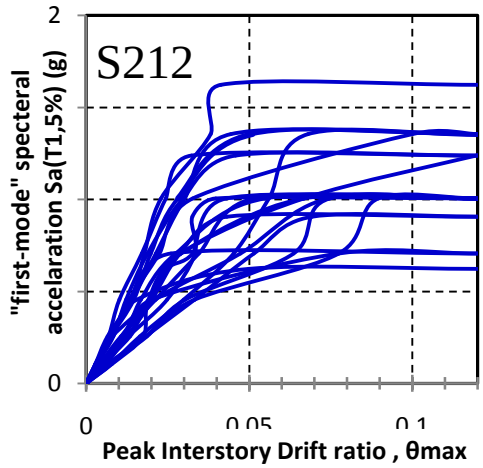
4floors 4 spans

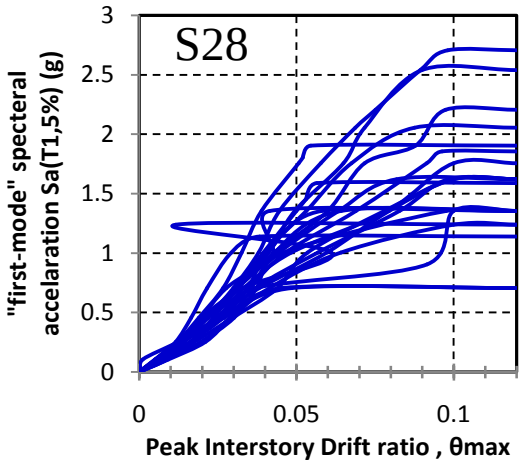


3floors 4 spans



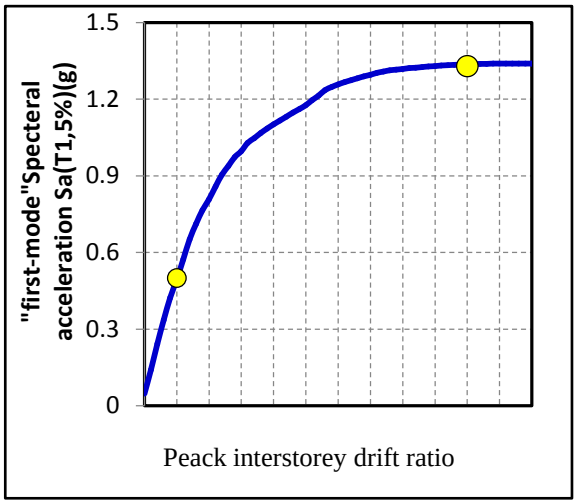
4floors 12 spans



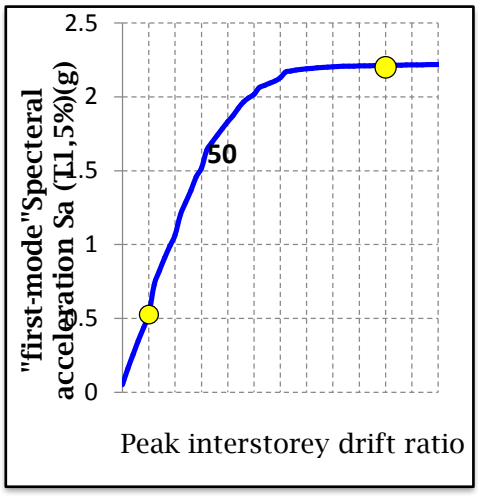


3floors 12 spans 3floors 8 spans

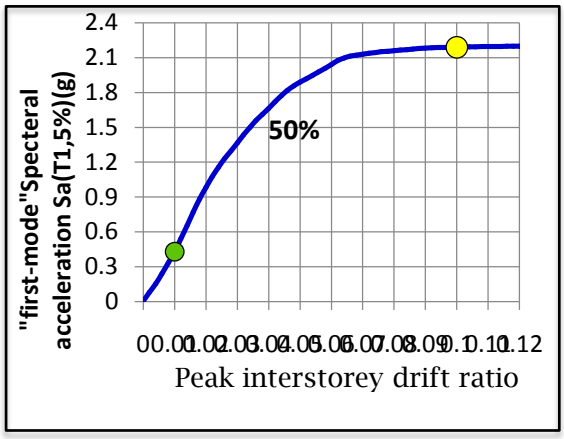
Fig. 4. IDA curves set related to different frame



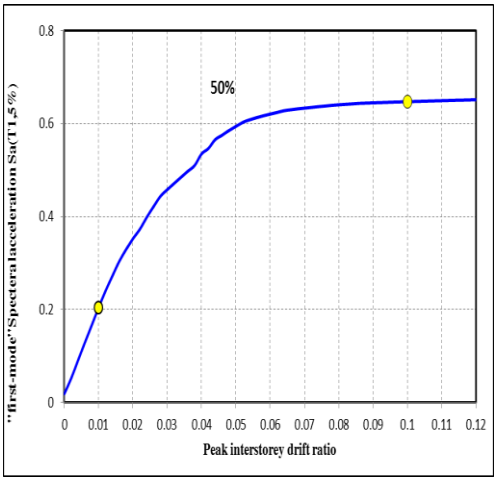
4floors 8 spans



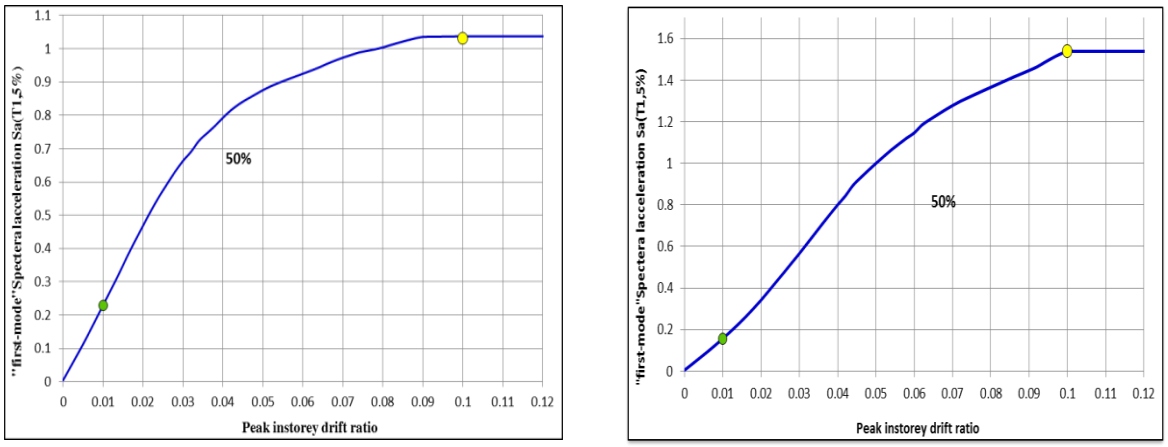
4floors 4 spans



3floors 4 spans



4floors 12 spans



3floors 12 spans 3floors 8 spans

Fig. 5. Summarize the average curve of IDA different frames

2.4. Evaluation of seismic frames performance of under study

In this study to evaluate the seismic performance of frames under study, from the average curve of IDA and range of 2800 standard plan of Iran (soil type 2) in order to scaling the selective accelerographs to perform time history analysis and extract the maximum relative displacement between floors and maximum displacement of roof has been used. Thus, the following two methods to scaling the accelerographs have been used:

The first method: first should be drawn range of all the selective accelerographs pair and then corresponding spectral acceleration with period like first mode of structure (Sa (T1, 5%)) based on the range of Iran's 2800 standard plan be achieved and obtained by dividing the spectral acceleration pair spectra accelerographs On the obtained spectral acceleration from the range of plan 2800 standard, Scale factor for all accelerographs pair with this method is obtained.

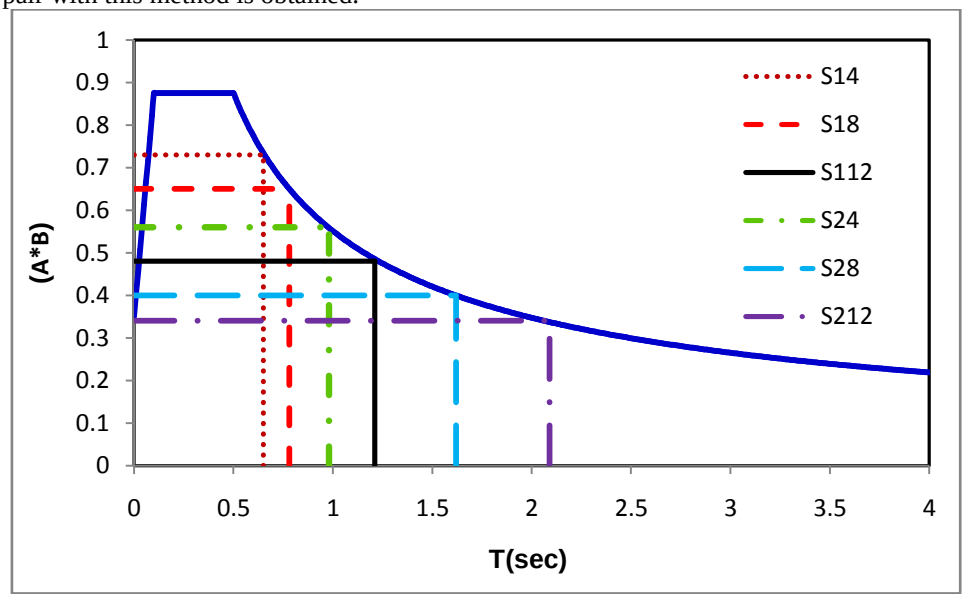


Fig. 6. spectral acceleration corresponding with period like under study first mode frames

The second method: this method is similar to pervious method with the difference that instead of spectral acceleration first mode period structure obtained from range of 2800 standard plan, Spectral acceleration curve 50% (average curve) obtained from IDA analysis Corresponding with maximum relative displacement between floors of 1% For level of performance of usability without interruption have been used. After the scaling accelerographs pair to two methods titled by using Open Sees software under study frames with selective accelerographs pair again put under the nonlinear time history analysis and maximum results of relative displacement between floors and displacement corresponding of roof extracted and is taken average

from them that aim of this controls the under study frames in range of performance level uninterrupted usability (IO). Thus to judge engineering in two ways has been performed as follows:

1. The average control of maximum relative displacement between the floor obtained from nonlinear time history analysis with uninterrupted usability performance (IO) equal = maxθ % 1. [7]

2. The average maximum displacement corresponding roof obtained from nonlinear time history analysis as displacement of aim to perform the nonlinear static analysis (Pushover) in SAP software and view the range of plastic hinges in the beams and columns and a range of performance of members and entire structural are used. Summary information on the average maximum relative displacement between floor and roof displacement as Table (1) and Table (2), and the statistics charts in Figures (7) to (9) has been provided.

Table 1. The average of maximum relative displacement between floor and roof displacement obtained from nonlinear time history analysis scaled with spectral acceleration of 2800 standard

	Span 6 m-Iran Spectrum				Span 7.5 m-Iran Spectrum			
Story	IDR 1	IDR 2	DIS-1	DIS-2	IDR 1	IDR 2	DIS-1	DIS-2
12	0.0509	0.0516	427.3	425.2	0.0625	0.062	422.96	430.3
8	0.0121	0.012	132.7	135.5	0.0223	0.023	518.81	493.9
4	0.009	0.0098	93.67	97.83	0.0126	0.0123	154.788	155.1

Table 2. Average of maximum relative displacement between floor and roof displacement obtained from nonlinear time history analysis scaled with curve spectral acceleration of 50% obtained from IDA analysis Corresponding maximum relative displacement between floors of 1%

	Span 6 m-IDA				Span 7.5 m-IDA			
Story	IDR 1	IDR 2	DIS-1	DIS-2	IDR 1	IDR 2	DIS-1	DIS-2
12	0.015	0.0157	125.2	138.03	0.015	0.0158	288.61	278.1
8	0.009	0.0096	106.35	110.52	0.01	0.010	146.056	147.0
4	0.006	0.0065	62.07	64.48	0.0098	0.00987	116.72	119.2

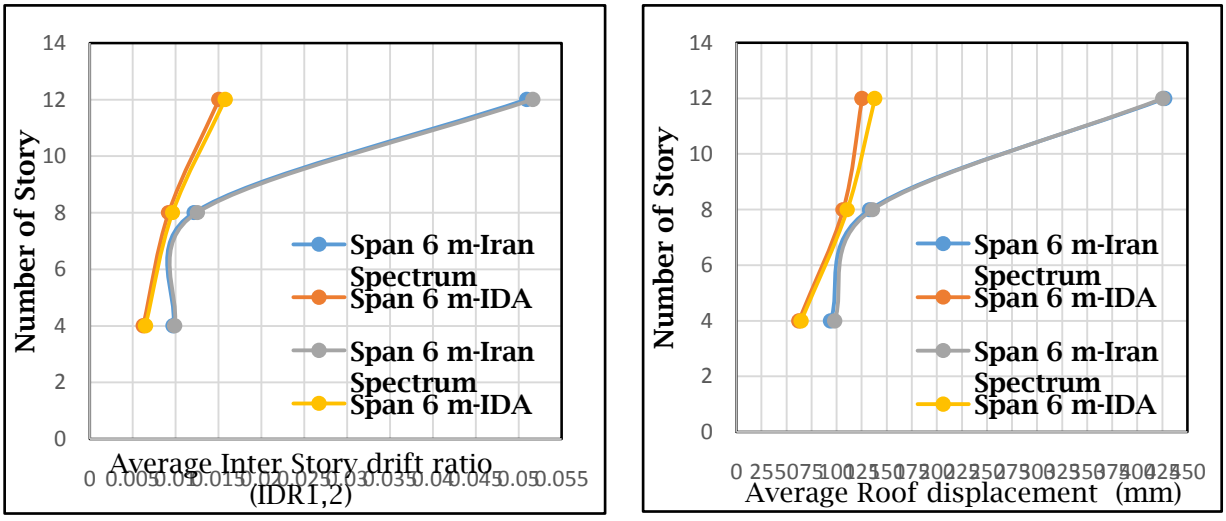
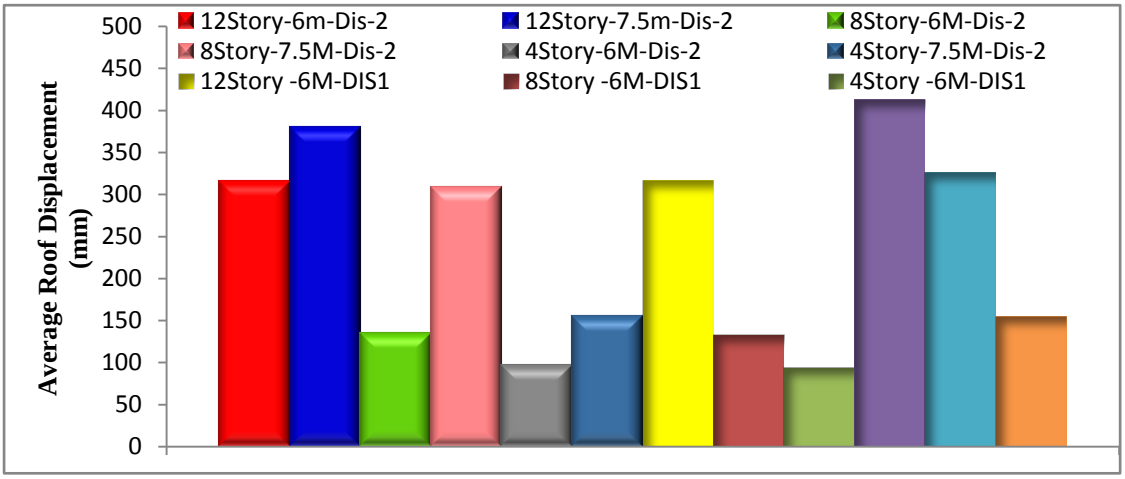


Fig. 7. Figure maximum relative displacement between floor and maximum displacement roof for frames of S14, S18, and S112 For both sides of accelerographs



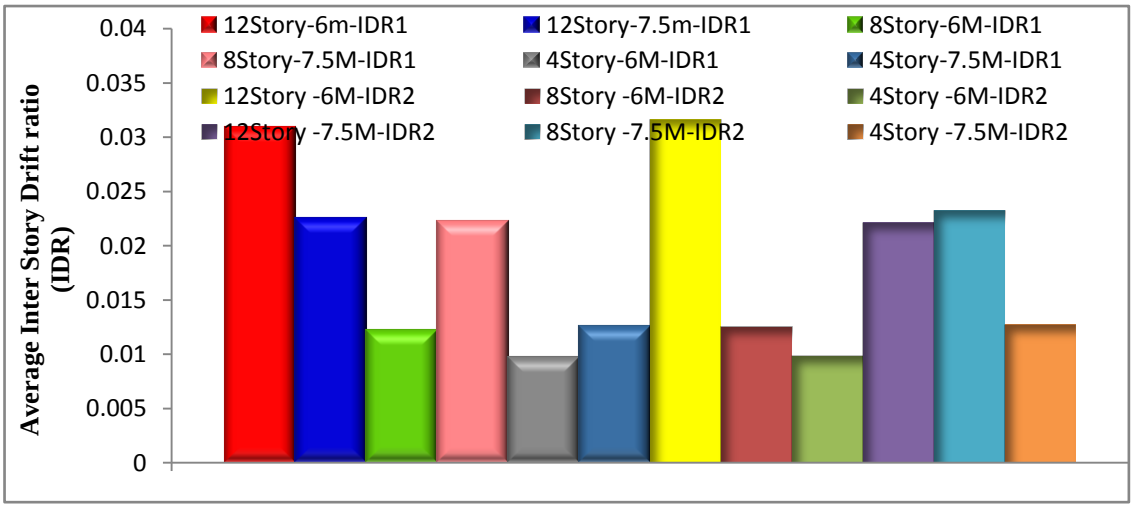
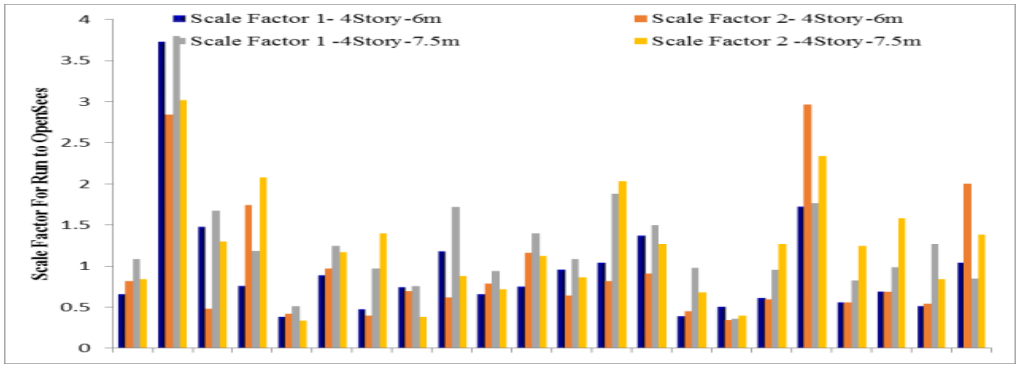


Fig. 8. by maximum relative displacement between floor diagram and maximum displacement of roof for frames of S24, S212, S28 and S14, S18, S112 For both sides of accelerographs



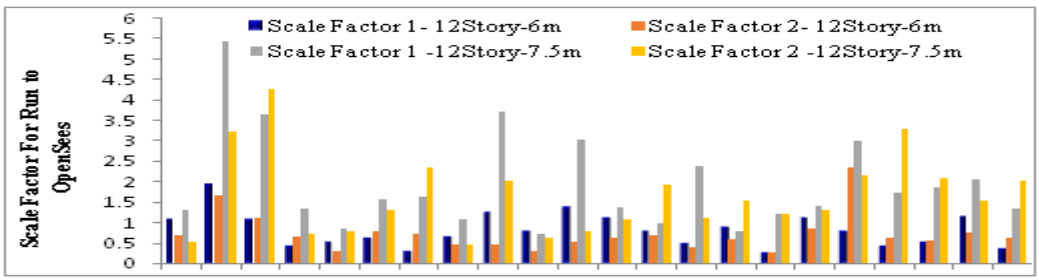


Fig. 9. statistical diagram of scale factor used in the nonlinear time history analysis for structures with spans of 6 and 7.5 meter with 4 floors, 8 floors and 12 floors

Table 3. The evaluation results of the present study frames with nonlinear time history analysis

		Span 6 m			Span 7.5 m		
Method	Story	IDR≤ 1%	IDR > 1%		IDR≤ 1%	IDR > 1%	
IDA	12	0.01	------	Ok	------	0.0158	Not Ok
	8	0.0096	------	Ok	0.0102	------	Ok
	4	0.0064	------	Ok	0.0098	------	Ok
2800	12	------	0.0516	Not Ok	------	0.0625	Not Ok
	8	------	0.0125	Not Ok	------	0.0232	Not Ok
	4	0.0098	------	Ok	------	0.01277	Not Ok

According to figures of 7 to 9 and Table 3, it can be concluded that the structures under study were examined by IDA, uninterrupted performance levels and the threshold of breakdown except S212 structure other structures as well as the performance levels has not violated. But the structures that by 2800 code have been scaled all except S14 structure have violated their performance level. With this interpretations it can be concluded that the structure which are evaluated by IDA have more accurate than structures which are evaluated by 2800.

2.5. Pushover analysis of produced models

In this study, with the help of SAP software and frames pushover analysis with displacement equivalent to maximum displacement for roof in nonlinear time history analysis, frames status are examined and deformed form of structure and joints created in structure in the last analysis, in Figures of (10) to (12) has been shown.

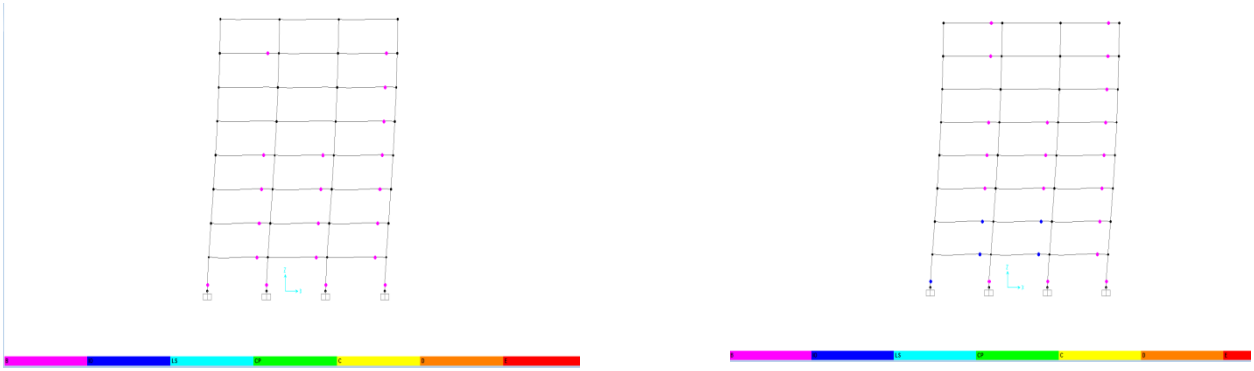


Fig. 10. display plastic joints of frame S28 Modeling in SAP software and under the pushover analysis with displacement of goal obtained from scaled method with range 2800 standard plan and with spectral acceleration of curve 50% obtained from IDA analysis corresponding to the maximum relative displacement between floors 1%

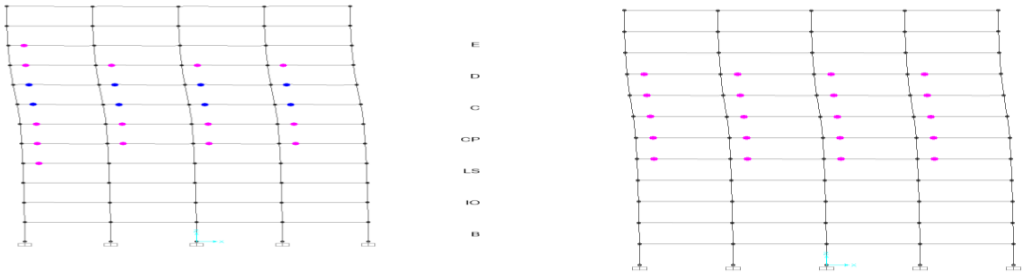


Fig. 11. display plastic joints of frame S112 Modeling in SAP software And under the pushover analysis with of goal displacement Obtained from the scaled with range of 2800 standard plan and with spectral acceleration of curve 50% obtained from IDA analysis corresponding to the maximum relative displacement between floors 1%

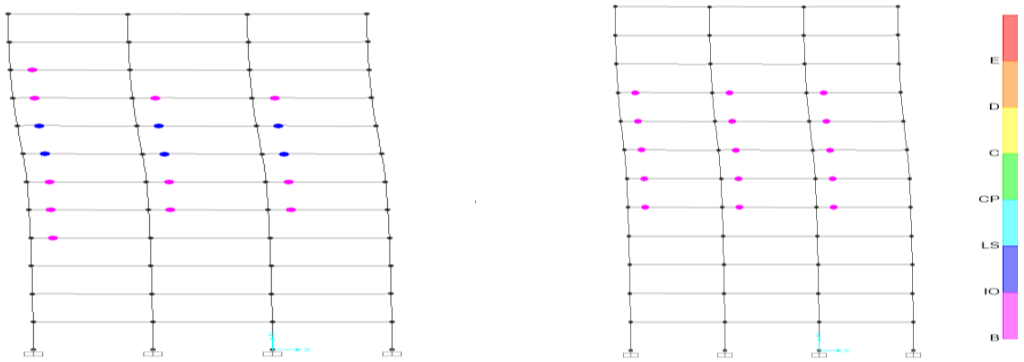


Fig. 12. display plastic joints of frame S212 Modeling in SAP software and under the pushover analysis with displacement of goal Obtained from scaled method with range of 2800 standard plan and with spectral acceleration of curve 50% obtained from IDA analysis corresponding to the maximum relative displacement between floors 1%

Table 4. The results of under study frames by using incremental nonlinear static analysis in SAP software

		Span 6 m		Span 7.5 m	
Method	Story	Displacement		Displacement	
IDA	12	255	Ok	368.03	Ok
	8	110	Ok	147.04	Ok
	4	64	Ok	119.26	Ok
2800	12	425	Not Ok	530.88	Not Ok
	8	135	Not Ok	493.89	Not Ok
	4	97	Ok	155.15	Not Ok

According to the table above, under study structures of S24, S28 and S212 with spans of 7.5 meters, and first method of scaling, It is necessary Initially should be drawn entire range of selective accelerographs pair and then spectral acceleration corresponding to period like denoted item of structures (T1 (Sa,5%)) to be extracted (T1 (sa,5%)) 2800 standard plan range of Iran obtained and by dividing the spectral acceleration achieved from the range of accelerographs pair on the spectral acceleration resulting from range of 2800 standard plan, scaled factor for all accelerographs pairs by this method is achieved none of the structures did not provided the level of uninterrupted performance. Considering that 2800 regulation life safety performance level is having none of under study structures that by 2800 method have been scaled performance level of breakdown threshold have not provided; but all structures under study that by using IDA method have been scaled uninterrupted performance level and the breakdown threshold have covered.

III. Conclusion

In this study, six concrete moment frame with average formability and with high importance degrees in Tehran Based on Regulation and standards in Iran design and in Open Sees software modeling and assigned nonlinear behavior of structures components was performed. For incremental nonlinear dynamic analysis the number of 22 accelerograph pair suggested related to remote area available in regulation of FEMAP-695 related to hard ground was used. After performing incremental nonlinear dynamic analysis By using program outputs of the IDA curves set And the average curve of IDA is drawn Then on the average curve of IDA Corresponding spectral acceleration maxθ=1% was determined. Accelerographs selective in two ways: Once by using spectral acceleration of curve average of IDA and once again, spectral acceleration 2800 standard plan scaled and in time history analysis under study frames was used and averages values of maximum relative displacement between floors and the maximum displacement for roof was obtained.

According to the material presented in the previous chapters, the results obtained are:

1. nonlinear time history analysis with accelerographs scaled by spectral acceleration of curve by 50% obtained from IDA analysis corresponding to maximum relative displacement between floors 1%, Because of lower

values of averages maximum relative displacement between floors and maximum roof displacement more capacity and a higher performance level of the structure than nonlinear time history analysis with accelerographs scaled spectral acceleration 2800 standard shows.

2. Due to being constant the number of floors and increasing the height and spans of beams and increasing period of the structure damages measure of DM or maximum relative displacement between floors increased and shows the lower performance level of under study frames.

3. the obtained results of pushover analysis it can be seen structures of S18, S112 and S14 in nonlinear time history analysis have more maximum relative displacement between floors of than maxθ=1% In this analysis, have joints with uninterrupted usability performance level.

4. The results obtained indicate that 12 floors structures three spans (S212) and eight floors three spans (S28) as well as 4 floors structures three spans (S24) that in nonlinear time history analysis have more maximum relative displacement between floors than max θ=1% uninterrupted usability performance levels have rejected.

5. According to the results related to this research all structures under study that by IDA have been scaled both levels of uninterrupted performance usability performance levels and threshold of breakdown have provided.

References

[1] **Vamvatsikos, D. Cornell, C.A.** Incremental Dynamic Analysis.2002 Engineering and Structural Dynamics 2002; 31 (3): 491-514.

[2] Earthquake Plan Regulations, 2800 Third Edition, Building and Housing Research Center, July 2005

[3] **Sana'i, Abraham,** vulnerability assessment steel building with MRF system and see ways to improve the seismic performance of existing structures, master's thesis, University of Science and Technology, Iran University of Civil Engineering, to help doctor Ahmed Niknam, 2003.

[4] **Niknam, A., Skandari, M.**, Application of incremental dynamic analysis of reinforced concrete moment frame structures, the third national conference on retrofitting and Urban Management, 2010

[5] **Baker, J. and Cornell, C.A.** A Vector-Valiued Ground Motion Intensity Measure for Probabilistic Seismic Demand Analysis, Report No. RMS-89, RMS Program, Stanford University, Stsnford.2005.

[6] **Asghari Varzaneh, MA,** evaluate the seismic performance of steel moment frame uninterrupted probabilistic method, master's thesis, University of Science and Technology, University of Civil Engineering, to help doctor Ahmed NIKNAM, 2012.

[7] FEMA Seismic design criteria for new moment-resisting steel frame construction. Federal Emergency Management Agency Report no. 356, 2001.

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The Development Of Career Competence Instrument Based On Computer Assisted Testing For Students Of Junior High Schools In Jakarta, Indonesia

Dr. Gantina Komalasari, M.Psi.[1)] danHerdi, M.Pd.[2)]
[1]*Fakultas Ilmu Pendidikan, Universitas Negeri Jakarta*
[2]*Fakultas Ilmu Pendidikan, Universitas Negeri Jakarta*

ABSTRACT : *This research is motivated by results of theoretical studies and empirical facts about the importance of student's career competence achievement, as well as the study of government policies on the mandate for the assessment in the specialization program/career counseling of Junior High School students. The research was aimed at developing student's career competence standardized instrument based on Computer Assisted Testing (CAT) which is effective as a support system of specialization program/career counseling in junior high schools. The study employed the standardized instrument development procedure (Anwar, 2010). The study population was all Grade IX students of Junior High School of Jakarta in the academic year of 2015/2016. The research sample was gained by using multistage cluster random sampling technique. Members of the research sample were 466 junior high school students representing the five regions of Jakarta. The data collection was performed by using Junior High School Student's Career Competence Scale. The data were then analyzed by using validity and reliability tests. Operational data analysis was performed by using IBM SPSS version 20.0 for Windows. The results show that: first, all statements of Junior High School Student's Career Competence Scale are valid because the Sig. (2-tailed) < α (0.05); second, the reliability of Junior High School Student's Career Competence Scale is in the high category because the reliability index reached r = 0.880. The final version of Junior High School Student's Career Competence Scale consists of 43 items.*

Keywords: *Standardized instruments career competency, computer assisted testing, supporting system, specialization program/career counseling, junior high school students*

I. PENDAHULUAN

Pelaksanaan implementasi kurikulum 2013 mengamanatkan adanya program peminatan peserta didik pada taraf Sekolah Menengah Pertama (SMP) yang dikelola dalam rangka mendapatkan data dan informasi terkait dengan kecenderungan peserta didik pada arah peminatannya. (Badan Pengembangan SDM dan PMP Kemendikbud, 2013a). Salah satu komponen penting dalam layanan peminatan peserta didik SMP adalah asesmen terhadap aspek peminatan – salah satunya kompetensi karir - peserta didik. Dengan dimilikinya kompetensi karir (arah peminatan yang jelas), peserta didik tamatan SMP menurut Badan Pengembangan SDM dan PMP Kemendikbud (2013b) "diharapkan telah memiliki konsep yang tegas dan jelas *mau ke mana dan menjadi apa* mereka itu selanjutnya setelah menamatkan SMP tersebut?"

Kebijakan tersebut mendesak untuk segera dilaksanakan secara masif dengan penuh perencanaan dan persiapan yang matang. Argumentasinya adalah fakta empirik seperti yang dikemukakan oleh Kementerian Pemuda dan Olahraga Republik Indonesia (Republika, 2012) bahwa pengangguran terdidik di usia produktif berjumlah 41, 81%, dan pengangguran terdidik dari jenjang SMP berjumlah 7,45%. Menurut Badan Pengembangan SDM dan PMP Kemendikbud (2013b) kondisi ini salah satunya disebabkan oleh fakta empirik banyaknya kecenderungan peserta didik tamatan SMP yang melanjutkan studi ke jenjang yang lebih tinggi belum (tidak) didasarkan atas arah peminatannya yang didukung oleh potensi dan kondisi diri secara memadai.

Jika dianalisis dari teori perkembangan karir, fakta tentang tingginya angka pengangguran terdidik di usia produktif disebabkan oleh belum tercapainya kompetensi karir (North Carolina Public Shool, 2001; ASCA, 2004; Cobia & Henderson, 2003) atau kematangan karir (Super, 1986; Super dalam Sharf, 1992; Crites, 1986; Zunker, 1990; Osipow; 1990; Herr & Cramer, 1999; Paton & Lokan, 2001; Hassan, 2006; dan Versnel *et al.*, 2011) sehingga mengalami kesulitan dalam pemilihan dan pembuatan keputusan karir secara tepat. Oleh karena

itu, diperlukan upaya agar peserta didik mampu memahami secara akurat dan mengembangkan kompetensi karir dirinya sendiri secara optimal.

Salah satu upaya yang dapat dilakukan agar peserta didik SMP mampu memahami secara akurat dan mengembangkan kompetensi karir dirinya sendiri secara optimal adalah mengikuti asesmen. Asesmen kompetensi karir adalah prosedur sistematik dan fondasi layanan program peminatan/konseling karir untuk membantu peserta didik SMP dalam mengeksplorasi, merencanakan, dan mengembangkan kompetensi karir agar mampu memilih dan membuat keputusan karir secara tepat. Menurut Reardon, Sampson, & Lenz (2000) asesmen karir dapat meningkatkan fokus kesiapan diri dalam mengatasi masalah dan membuat keputusan karir.

Berdasarkan uraian tersebut, guru BK/K dituntut memiliki kompetensi dan kinerja profesional dalam pemilihan teknik dan prosedur, pengadministrasian, pelaporan, dan penggunaan hasil asesmen peminatan (kompetensi karir) peserta didik. Argumentasinya adalah asesmen kompetensi karir merupaan hal yang esensial untuk membantu peserta didik SMP mengarahkan dan mengembangkan peminatannya serta memilih, membuat keputusan, dan mencapai kesuksesan karir. Namun, fakta empirik masih menunjukkan terdapat hambatan dan kelemahan dalam pelaksanaan program peminatan di SMP yang dilaksanakan oleh guru BK/K. Salah satu hambatannya adalah belum tersedianya fasilitas pendukung utama asesmen kompetensi karir berupa instrumen baku kompetensi karir untuk peserta didik SMP. Hasil studi pendahuluan Komalasari & Herdi (2015) menemukan bahwa hanya 6.7% guru BK/K yang melakukan asesmen karir sebagai dasar pengembangan program peminatan/konseling karir. Guru BK/K 100% guru BK/K membutuhkan instrumen baku asesmen kompetensi karir berbasis CAT. Oleh karena itu, perlu dikembangkan instrumen baku asesmen kompetensi karir peserta didik SMP.

Para pakar teknologi dalam bimbingan dan konseling karir menyarankan kepada para konselor karir (guru BK/K) untuk menggunakan dan memanfaatkan *Computer Assisted Testing* (CAT) dalam kegiatan asesmen karir (arah peminatan, kompetensi karir) peserta didik di sekolah. *CAT* dapat berpengaruh signifikan pada asesmen karir, mempermudah diseminasi informasi karir, mempermudah akses terhadap informasi karir berdasarkan hasil asesmen, dan interaktif (Whiston, 2000), hasil asesmen lebih akurat (Sampson, 1990), membuat proses pengolahan, penginterpretasian dan presentasi informasi menjadi lebih cepat, efisien, dan akurat karena dirancang secara otomatis, biaya murah, lebih aman, interaktif, bersahabat, dan bersifat pribadi sehingga proses asesmen kompetensi karir menjadi lebih efektif. Intinya, asesmen karir berbasis CAT lebih meningkatkan upaya asesmen dan eksplorasi diri dan karir (Fowkes & Whirter, 2007).

Berdasarkan kajian teoretik dan fakta empirik tersebut, penelitian ini difokuskan pada pengembangan instrumen baku kompetensi karir berbasis *computer assisted testing*sebagai sistem pendukung program peminatan di SMP.

II. KAJIAN LITERATUR

2.1. Kompetensi Karir Peserta Didik SMP

Super (Sharf, 1992; Osipow, 1983; Herr & Cramer, 1984; Brown& Lent, 2005) menjelaskan bahwa perkembangan karir peserta didik di SMP berada pada subtahap kapasitas dan mulai masuk ke tahap eksplorasi karir. Pada tahap ini, peserta didik memiliki rasa ingin tahu yang tinggi dan berusaha menggali dan mempertimbangkan berbagai informasi karir (potensi diri, sekolah lanjutan, dan informasi dunia kerja).

Pada tahap eksplorasi karir ini, peserta didik jenjang SMP diharapkan mampu mengembangkan kompetensi karir secara optimal. Jika ia berhasil mencapai kompetensi karir, maka diprediksi akan mencapai kesuksesan karir pada tahapan karir selanjutnya. Sebaliknya, jika gagal, maka diprediksi akan mengalami kegagalan karir dan kekecewaan pada tahapan selanjutnya. Menurut Cobia & Henderson (2007), Gysbers & Henderson (2006), dan *ASCA National Standards for Students*(2005)standar kompetensi karir yang harus dikuasai peserta didik jenjang SMP, yaitu: (a) standar kompetensi A: peserta didik menguasai kecakapan menginvestigasi dunia kerja dalam hubungannya dengan diri sendiri dan pembuatan informasi karir; (b) standar kompetensi B: peserta didik menguasai strategi untuk mencapai kesuksesan dan kepuasan karir di masa depan; dan (c) standar kompetensi C: peserta didik memahami hubungan antara kualitas pribadi, pendidikan, pelatihan, dan dunia kerja.

2.2 Pengembangan Instrumen Baku Berbasis *Computer Assisted Testing*

Asesmen arah peminatan dan kompetensi karir peserta didik membutuhkan instrumenasesmen yang baku dan berkualitas. Asesmen dengan instrumen yang baku dan berkualitas diharapkan dapat menghasilkan data dan informasi yang akurat, lengkap, dan komprehensif, memperjelas arah peminatan dan tingkat kompetensi karir, serta mempermudah dalam mengembangkan program dan layanan peminatan yang tepat sesuai kebutuhan peserta didik.

Instrumen asesmen kompetensi karir yang baku dan berkualitas tentunya perlu diperoleh dari hasil pengembangan dengan mengikuti prosedur yang jelas. Azwar (2010) berpendapat bahwa prosedur dasar dalam pengembangan instrumen (skala psikologis) minimal menempuh langkah-langkah berikut: identifikasi tujuan ukur, penetapan konsep ukur, operasionalisasi konsep ukur, menjabarkan definisi operasional variabel menjadi sejumlah indikator, penulisan item berdasarkan indikator, review item, melakukan uji coba, pengujian validitas dan reliabilitas, menyempurnakan instrumen, dan mengadministrasikan instrumen.

Para pakar teknologi dalam bimbingan dan konseling karir menyarankan kepada para konselor karir (guru BK/K) untuk menggunakan dan memanfaatkan *Computer Assisted Testing* (CAT) atau disebut juga *Computer Assisted Assessment* (CAA) dalam kegiatan asesmen karir (arah peminatan, kompetensi karir) peserta didik di sekolah. Menurut Whiston (2000) CAT atau CAA adalah penggunaan komputer dalam mengumpulkan, menskoring, mengadministrasikan data asesmen. CAT atau CAA merupakan proses asesmen yang interaktif antara individu dan komputer.

Menurut para pakar konseling karir, *CAT* atau CAA dapat berpengaruh signifikan pada asesmen karir, mempermudah diseminasi informasi karir, mempermudah akses terhadap informasi karir berdasarkan hasil asesmen, efisien, dan interaktif (Whiston, 2000), hasil asesmen lebih akurat (Sampson, 1990), membuat proses pengolahan, penginterpretasian dan presentasi informasi menjadi lebih cepat, efisien, dan akurat karena dirancang secara otomatis, biaya murah, lebih aman, interaktif, bersahabat, dan bersifat pribadi sehingga proses asesmen kompetensi karir menjadi lebih efektif. Intinya, asesmen karir berbasis CAT lebih meningkatkan upaya asesmen dan eksplorasi diri dan karir (Fowkes & Whirter, 2007).

2.3 Asesmen Kompetensi Karir Berbasis*CAT*sebagai Sistem Pendukung Program Peminatan

Menurut Drummond & Jones, 2010) asesmen merupakan kegiatan mengumpulkan dan mengintegrasikan infomasi tentang individu dari berbagai metode (seperti wawancara, observasi, tes) dan berbagai sumber (seperti anggota keluarga, guru, orang yang sukses). Asesmen merupakan komponen fundamental dari keseluruhan upaya bantuan profesional dan proses konseling. Asesmen yang dilakukan dengan menggunakan beragam metode dan sumber akan membantu memahami individu, mengembangkan program layanan secara akurat dan komprehensif. Asesmen peminatan peserta didik merupakan proses mengumpulkan, menganalisis, dan menginterpretasikan data dan/atau informasi tentang peserta didik dan lingkungannya. Kegiatan ini dilakukan untuk mendapatkan gambaran tentang berbagai kondisi peserta didik dan lingkungannya sebagai bahan dasar untuk memahami arah peminatan peserta didik dan untuk mengembangkan program layanan peminatan yang sesuai dengan kebutuhan (Badan Pengembangan SDM dan PMP Kemendikbud, 2013a).

Asesmen peminatan/karir dilakukan dengan tujuan untuk *screening*, identifikasi dan diagnosis, perencanaan intervensi, dan kemajuan dan evaluasi hasil (Drummond & Jones, 2010; dan Badan Pengembangan SDM dan PMP Kemendikbud, 2013a). Menurut Reardon, Sampson, & Lenz (2000) asesmen karir dapat meningkatkan fokus kesiapan diri dalam mengatasi masalah dan membuat keputusan karir.

Di dalam keseluruhan layanan bimbingan dan konseling (Cobia & Henderson, 2003; Gysbers & Henderson, 2006) dan program peminatan secara khusus asesmen (Badan Pengembangan SDM dan PMP Kemendikbud, 2013a) menduduki tempat yang sentral dan fundamental sebagai dasar pengembangan program layanan peminatan yang sesuai dengan kebutuhan peserta didik. Sementara itu, instrumen asesmen peminatan (kompetensi karir) merupakan salah satu sistem pendukung keterlaksanaan proses asesmen secara khusus dan program layanan bimbingan dan konseling dan peminatan secara umum. Tanpa instrumen asesmen peminatan yang memadai dan berkualitas, mustahil data dan informasi hasil asesmen yang akurat akan diperoleh. Penggunaan data dan informasi hasil asesmen yang tidak akurat jika digunakan untuk keperluan pengembangan program peminatan akan sia-sia karena tidak sesuai dengan karakteristik dan kebutuhan peserta didik.

III. METODE PENELITIAN

Penelitian menggunakan prosedur pengembangan dan standardisasi instrumen baku berbasis *paper & pencil test* (Azwar, 2010). Prosedur yang dimaksud, yaitu:identifikasi tujuan ukur, penetapan konsep ukur, operasionalisasi konsep ukur, menjabarkan definisi operasional variabel menjadi sejumlah indikator, penulisan item berdasarkan indikator, review item, melakukan uji coba, pengujian validitas dan reliabilitas, menyempurnakan instrumen, dan mengadministrasikan instrumen.

Sampel penelitian studi pendahuluan berjumlah 30 orang guru BK/K dan 466 peserta didik kelas IX SMP Negeri di Provinsi DKI Jakarta yang dijaring menggunakan teknik *multistage cluster random sampling.*

Pengumpulan data menggunakan instrumen asesmen kebutuhan dan Skala Kompetensi Karir Peserta Didik (SKKPD-SMP).Teknik analisis validitas instrumen menggunakan *interrater realiability*.Teknik analisis validitas butir menggunakan *item-total product moment*.Teknik analisis reliabilitas menggunakan teknik *Cronbach Alpha*.Secara operasional, teknik analisis data menggunakan bantuan perangkat lunak*IBM SPSS 20.0 for Windows.*

IV. HASIL DAN PEMBAHASAN

Pengembangan instrumen baku kompetensi karir peserta didik SMP berbasis *paper and pencil test*menggunakan prosedur dari Azwar (2010) yaitu: (a) identifikasi tujuan ukur; (b) penetapan konsep ukur; (c) operasionalisasi konsep ukur; (d) menjabarkan definisi operasional variabel menjadi sejumlah indikator; (e) penulisan item berdasarkan indikator; (f)*review* item; (g) melakukan uji coba; (h) pengujian validitas dan reliabilitas; (i) menyempurnakan instrumen; dan(j) mengadministrasikan instrumen.

Tahap 1.Identifikasi tujuan ukur. Tujuan pengembangan instrumen baku ini adalah untuk mengukur kompetensi karir peserta didik SMP.

Tahap 2.Penetapan konsep ukur.Konstruk yang digunakan untuk mengembangkan kompetensi karir peserta didik SMP adalah kompetensi karir peserta didik SMP dari *ASCA National Standards for Students* (ASCA, 2005).Konstruk ini dipilih karena penjabaran standar kompetensi, kompetensi dasar, dan indikatornya sangat rinci dan lengkap dibandingkan dengan konstruk kompetensi karir lainnya.Selain itu, konstruk ini telah divalidasi dan dinilai penting dikuasai oleh peserta didik SMP menurut 30 orang guru BK/K SMP di Provinsi DKI Jakarta.

Tabel 4.1
Rincian Konstruk Kompetensi Karir Peserta Didik SMP Hasil Validasi Guru BK/K

ID	SK/KD/Indikator	Rerata	Kesimpulan
A	**Peserta didik menguasai kecakapan menginvestigasi dunia kerja dalam hubungannya dengan diri sendiri dan pembuatan informasi karir**	**4.4**	**Penting**
A1	***Mengembangkan kesadaran karir***	4.2	Penting
A1.1	Mengembangkan kecakapan untuk menempatkan, mengevaluasi, dan menginterpretasi informasi karir	4.2	Penting
A1.2	Mengevaluasi pekerjaan tradisional dan modern	3.9	Penting
A1.3	Mengemb angkan kesadaran terhadap kemampuan, kecakapan, minat, dan motivasi pribadi	4.3	Penting
A1.4	Mempelajari cara berinteraksi dan bekerja sama dalam tim	4.4	Penting
A1.5	Mempelajari pembuatan keputusan	4.3	Penting
A1.6	Mempelajari cara menetapkan tujuan	4.4	Penting
A1.7	Memahami pentingnya perencanaan	4.5	Sangat penting
A1.8	Mengembangkan kompetensi dalam area minat tertentu secara berkelanjutan	3.9	Penting
A1.9	Mengembangkan hobi dan minat vokasional	4.2	Penting
A1.10	Menyeimbangkan antara bekerja dan penggunaan waktu luang	4.1	Penting
A.2	***Mengembangkan kesiapan menjadi karyawan***	4.0	Penting
A.2.1	Memperoleh kecakapan kemampuan kerja seperti bekerja dalam tim, pengentasan masalah, dan organisasi	4.3	Penting
A.2.2	Menerapkan kecakapan kesiapan kerja untuk melihat peluang ketenagakerjaan (karir)	4.1	Penting
A.2.3	Mendemonstrasikan pengetahuan tentang perubahan di tempat kerja	3.8	Penting
A.2.4	Mempelajari hak dan tanggung jawab sebagai atasan dan karyawan	4.0	Penting
A.2.5	Belajar menghargai keunikan individu di tempat kerja	4.1	Penting
A.2.6	Mempelajari cara menulis resume	3.9	Penting
A.2.7	Mengembangkan sikap positif terhadap kerja dan belajar	4.5	Sangat penting
A.2.8	Memahami pentingnya tanggung jawab, kesalingtergantungan,	4.4	Penting

ID	SK/KD/Indikator	Rerata	Kesimpulan
	ketetapan waktu, integritas, dan usaha di tempat kerja.		
A.2.9	Menggunakan kecakapan mengelola waktu dan tugas	4.4	Penting
B	**Peserta didik menguasai strategi untuk mencapai kesuksesan dan kepuasan karir di masa depan**	4.2	Penting
B.1	***Memperoleh informasi karir***	4.2	Penting
B.1.1	Menerapkan kecakapan pembuatan keputusan dalam perencanaan karir, pemilihan kursus, dan transisi karir	4.3	Penting
B.1.2	Mengidentifikasi kecakapan, minat, dan kemampuan pribadi serta kaitannya dengan pilihan karir terkini	4.2	Penting
B.1.3	Mendemonstrasikan pengetahuan tentang proses perencanaan karir	3.9	Penting
B.1.4	Mengetahui kelompok okupasi (pekerjaan)	4.0	Penting
B.1.5	Menggunakan penelitian dan sumber informasi untuk memperoleh informasi karir	3.9	Penting
B.1.6	Belajar menggunakan internet untuk mengakses informasi perencanaan karir	4.4	Penting
B.1.7	Mendeskripsikan pilihan karir tradisional dan modern dan kaitannya dengan pilihan karir	3.8	Penting
B.1.8	Memahami perubahan kebutuhan ekonomi dan kemasyarakatan yang mempengaruhi tren dan pelatihan ketenagakerjaan	4.0	Penting
B.2	***Mengidentifikasi tujuan karir***	***4.1***	***Penting***
B.2.1	Mendemonstrasikan kesadaran terhadap pendidikan dan pelatihan yang dibutuhkan untuk mencapai tujuan karir	4.0	Penting
B.2.2	Mengases dan memodifikasi perencanaan pendidikan untuk mendukung karirnya	4.1	Penting
B.2.3	Menggunakan kemampuan kerja dan kecakapan kesiapan kerja dalam magang, mentoring, asistensi dan/atau pengalaman kerja orang lain	3.7	Penting
B.2.4	Memilih kursus kerja yang sesuai dengan minat karir	4.1	Penting
B.2.5	Memelihara portofolio perencanaan karir	3.7	Penting
C	**Peserta didik memahami hubungan antara kualitas pribadi, pendidikan, pelatihan, dan dunia kerja**	**4.2**	**Penting**
C.1	***Memperoleh pengetahuan untuk mencapai tujuan karir***	***4.0***	***Penting***
C.1.1	Memahami hubungan antara prestasi pendidikan dan kesuksesan karir	4.3	Penting
C.1.2	Menjelaskan bagaimana pekerjaan dapat membantu mencapai kesuksesan dan kepuasan pribadi	4.2	Penting
C.1.3	Mengidentifikasi preferensi dan minat pribadi yang mempengaruhi pilihan dan kesuksesan karir	4.0	Penting
C.1.4	Memahami bahwa perubahan di tempat kerja mempersyaratkan belajar sepanjang hayat dan kecakapan baru	4.1	Penting
C.1.5	Mendeskripsikan dampak pekerjaan terhadap gaya hidup	3.9	Penting
C.1.6	memahami pentingnya keadilan dan akses dalam pilihan karir	4.0	Penting
C.1.7	Memahami pentingnya pekerjaan dan ekspresi kepuasan pribadi	4.1	Penting

ID	SK/KD/Indikator	Rerata	Kesimpulan
C.2	***Menerapkan kecakapan untuk mencapai tujuan karir***	***4.1***	***Penting***
C.2.1	Mendemonstrasikan bagaimana minat, kemampuan, dan prestasi berhubungan dengan tujuan pribadi, sosial, pendidikan, dan karir	4.1	Penting
C.2.2	Mempelajari cara menggunakan kecakapan mengelola konflik dengan teman sebaya dan orang dewasa	4.3	Penting
C.2.3	Belajar bekerja sama dengan orang lain sebagai anggota tim	4.5	Sangat penting
C.2.4	Menerapkan kecakapan akademik dan kesiapan kerja berlandaskan situasi belajar seperti magang, *asistensi* dan/atau pengalaman mentoring	4.1	Penting

*Tahap 3.Operasionalisasi konsep ukur.*Dalam penelitian ini kompetensi karir peserta didik SMP didefinisikan sebagai skor total dari kecakapan sikap dan kesadaran, pengetahuan, dan keterampilan dasar peserta didik SMP yang diperlukan agar berhasil menghadapi transisi dari sekolah ke dunia kerja sesuai dengan tahap dan tugas perkembangan karirnya yang diukur melalui instrumen skala psikologis. Kompetensi karir peserta didik SMP yang dimaksud meliputi: (a) menguasai kecakapan menginvestigasi dunia kerja dalam hubungannya dengan diri sendiri dan pembuatan informasi karir; (b) menguasai strategi untuk mencapai kesuksesan dan kepuasan karir di masa depan; (c) memahami hubungan antara kualitas pribadi, pendidikan, pelatihan, dan dunia kerja.rincian indikatornya disajikan pada tabel 4.1.

*Tahap 4.Menjabarkan definisi operasional variabel menjadi sejumlah indikator.*Konstruk standar kompetensi, kompetensi dasar, dan indicator kompetensi karir peserta didik SMP yang digunakan bersumber dari *ASCA National Standards for Students* (ASCA, 2005).Konstruk kompetensi karir peserta didik tersebut telah divalidasi sesuai dengan konteks Indonesia oleh guru BK/K SMP di Provinsi DKI Jakarta.Konstruk kompetensi karir peserta didik SMP yang dimaksud disajikan pada tabel 4.1.

*Tahap 5.Penulisan item berdasarkan indikator.*Hasil dari penulisan item berdasarkan indikator kompetensi karir peserta didik SMP. Contoh pernyataan untuk indicator mengikuti kursus kerja yang sesuai dengan minat karir, yaitu "Semua kursus keterampilan dan kegiatan ekstrakurikuler yang saya ikuti sesuai dengan cita-cita, minat, dan bakat yang dimilik." Pilihan jawaban yang disediakan menggunakan skala psikologis empat poin, yaitu: 1 = Sangat Tidak Sesuai; 2 = Tidak Sesuai; 3 = Sesuai; dan 4 = Sangat Sesuai.

Tahap 6. Review item. *Review* item dilakukan oleh pakar bimbingan dan konseling (karir), pakar penelitian dan evaluasi pendidikan atau psikometrik dari Jurusan Psikologi Pendidikan dan Bimbingan (PPB) Fakultas Ilmu Pendidikan (FIP) Universitas Pendidikan Indonesia (UPI). Hasil pengujian *interrater reliability* menggunakan rumus dari Ebel (Guilford, 1959 : 395-397). Koefisien validitas antarpenimbang instrumen SKKPD-SMP diperoleh dengan menggunakan rumus *interrater reliability* dengan hasil seperti tertuang pada Tabel 4.2berikut.

Tabel 4.2
Koefisien Validitas Antarpenimbanguntuk Instrumen SKKPD-SMP

Koefisien Validitas	Nilai Koefisien	*T*	Signifikan pada *p*<
r_{11}	0,475	3,012	0,05
r_{33}	0.519	3,894	0,05

Tabel 4.2 menunjukkan bahwa para pakar menilai instrumen SKKPD-SMP dapat digunakan untuk mengukur kompetensi karir peserta didik SMP karena isi setiap pernyataan memiliki kecocokkan dengan indikator pernyataan tersebut. Selain itu, para pakar memberikan masukan berikut: (a) pernyataan-pernyataan yang memiliki dua indikator atau lebih sebaiknya dipecah; (b) menghindari pernyataan yang memiliki banyak fokus/aspek; dan (c) pernyataan sebaiknya menggunakan kalimat tunggal.

*Tahap 7.Melakukan uji coba instrumen kepada peserta didik SMP.*Uji coba instrumen dilakukan kepada 473 orang peserta didik kelas IX SMP Negeri di Provinsi DKI Jakarta.Hal ini didasarkan pada pendapat Azwar (2010) bahwa setiap item instrumen sebaiknya diujicobakan kepada 6-12 orang sampel.Namun, setelah data yang telah diisi sampel diidentifikasi kelengkapannya, hanya 466 orang peserta didik yang datanya dapat diolah dan dianalisis lebih lanjut.

*Tahap 8.Pengujian validitas dan reliabilitas.*Hasil pengujian validitas item SKala Kompetensi Karir Peserta Didik SMP *(N = 466)* menggunakan teknik *item-total product moment* dengan bantuan perangkat lunak *IBM SPSS version 20.0 for Windows*. Hasil pengujian validitas menunjukkan bahwa 43 item yang diuji dinyatakan valid karena nilai *Sig. (2-tailed) < α (0.01&0.05)*. Ringkasan hasil pengujian validitas item disajikan pada Tabel 4.3.

Tabel 4.3
Ringkasan Hasil Pengujian Validitas Item SKKPD-SMP

Item	*R*	*Sig. (2-tailed)*		Item	*R*	*Sig. (2-tailed)*	
X1.	0.360**	0.000	Valid	X23.	0.450**	0.000	Valid
X2.	0.272**	0.000	Valid	X24.	0.426**	0.000	Valid
X3.	0.412**	0.000	Valid	X25.	0.449**	0.000	Valid
X4.	0.386**	0.000	Valid	X26.	0.325**	0.000	Valid
X5.	0.373**	0.000	Valid	X27.	0.325**	0.000	Valid
X6.	0.373**	0.000	Valid	X28.	0.527**	0.000	Valid
X7.	0.431**	0.000	Valid	X29.	0.524**	0.000	Valid
X8.	0.406**	0.000	Valid	X30.	0.482**	0.000	Valid
X9.	0.368**	0.000	Valid	X31.	0.475**	0.000	Valid
X10.	0.140**	0.003	Valid	X32.	0.488**	0.000	Valid
X11.	0.438**	0.000	Valid	X33.	0.491**	0.000	Valid
X12.	0.449**	0.000	Valid	X34.	0.445**	0.000	Valid
X13.	0.316**	0.000	Valid	X35.	0.447**	0.000	Valid
X14.	0.469**	0.000	Valid	X36.	0.423**	0.000	Valid
X15.	0.371**	0.000	Valid	X37.	0.329**	0.000	Valid
X16.	0.341**	0.000	Valid	X38.	0.341**	0.000	Valid
X17.	0.423**	0.000	Valid	X39.	0.377**	0.000	Valid
X18.	0.540**	0.000	Valid	X40.	0.405**	0.000	Valid
X19.	0.378**	0.000	Valid	X41.	0.457**	0.000	Valid
X20.	0.500**	0.000	Valid	X42.	0.441**	0.000	Valid
X21.	0.416**	0.000	Valid	X43.	0.464**	0.000	Valid
X22.	0.396**	0.000	Valid				

** Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*

Pengujian reliabilitas instrumen Skala Kompetensi Karir Peserta Didik SMP menggunakan *Cronbach's Alpha* (α) (Cronbach dalam Drummond & Jones, 2010) dengan bantuan *IBM SPSS Version 20.0 for Windows*.Hasil pengujian menghasilkan indeks reliabilitas sebesar 0.880.Artinya, reliabilitas Skala Kompetensi Karir Peserta Didik SMP berada pada kategori tinggi (Drummond & Jones, 2010, p. 94).

*Tahap 9.Menyempurnakan instrumen.*Pernyempurnaan instrumen yang dilakukan pada tahap ini adalah memperbaiki redaksi pernyataan agar mudah dipahami oleh responden yaitu peserta didik SMP. Instrumen SKKPD-SMP berbasis *pencil and paper test* versi final terlampir pada lampiran.

*Tahap 10.Mengadministrasikan instrumen.*Pengadministrasian instrumen SKKPD-SMP berbasis *pencil and paper test* versi final dirancang secara sederhana agar mudah dalam melaksanakannya. Seluruh pernyataan SKKPD-SMP positif berbentuk skala psikologis empat poin, yaitu: 4 = Sangat Sesuai; 3 = Sesuai; 2 = Tidak Sesuai; atau 1 = Sangat Tidak Sesuai. Skor setiap pernyataan kemudian dianalisis menggunakan rata-rata dan standar deviasi untuk mendapatkan gambaran profil kompetensi karir peserta didik SMP, baik secara umum, setiap standar kompetensi, kompetensi, maupun indikatornya.Analisis dapat dilakukan secara berkelompok maupun individual.Contoh penyajian hasil analisis profil kompetensi karir peserta didik SMP terlampir pada lampiran.

V. KESIMPULAN

Asesmen kompetensi karir memiliki fungsi yang vital dalam keseluruhan penyelenggaraan program peminatan/-konseling karir di SMP. Asesmen kompetensi karir yang tepat akan mempermudah dalam membantu peserta didik melakukan asesmen dan eksplorasi diri dan karir sehingga akan memfokuskan pada kesiapan mengatasi masalah dan membuat keputusan karir.

Instrumen baku kompetensi karir yang berhasil dikembangkan diberi nama Skala Kompetensi Karir Peserta Didik (SKKPD-SMP) yang valid dan reliabel. Hasil validasi pakar menggunakan teknik *interrater*

reliability menunjukkan instrumen SKKPD-SMP memiliki kecocokan antara isi rumusan pernyataan dengan indikator yang diukur dengan nilai koefisien $r_{33} = 0.519$. Hasil pengujian validitas butir menggunakan *item-total product moment* menunjukkan bahwa seluruh (43) butir pernyataan yang dikemmbangkan dinyatakan valid karena nilai *Sig. (2-tailed)* seluruh pernyataan< *0.01 & 0.05.*Hasil pengujian reliabilitas menggunakan *Cronbach Alpha* menunjukkan SKKPD-SMP memiliki reliabilitas yang tinggi (*r* = 0.880). Instrumen SKKPD-SMP versi final terdiri atas 43 pernyataan, meliputi: (1) 19 pernyataan untuk standar kompetensi A: peserta didik menguasai kecakapan menginvestigasi dunia kerja dalam hubungannya dengan diri sendiri dan pembuatan informasi karir; (2) 13 pernyataan untuk standar kompetensi B: peserta didik menguasai strategi untuk mencapai kesuksesan dan kepuasan karir di masa depan; dan (3) 11 pernyataan untuk standar kompetensi C: peserta didik memahami hubungan antara kualitas pribadi, pendidikan, pelatihan, dan dunia kerja.

Penelitian selanjutnya diperlukan untuk mengembangkan instrumen baku SKKPD-SMP berbasis CAT yang teruji secara empirik dengan sampel yang lebih luas meliputi seluruh Indonesia.

VI. REFERENSI

[1] American School Counselor Association (2005).*ASCA national standards for students.*Alexandria, VA: Author.

[2] Azwar, S. (2010). *Penyusunan skala psikologi*. Yogyakarta: Pustaka Pelajar.

[3] Badan Pengembangan SDM dan PMP Kemendikbud RI (2013a). *Modul asesmen peminatan peserta didik*. Jakarta: Kemendikbud.

[4] _____. (2013b). *Panduan khusus bimbingan dan konseling: Pelayanan arah peminatan peserta didik.* Jakarta: Kemendikbud.

[5] Brown, S.D., &Lent, R.W. (Eds.) (2005). *Career development and counseling: Putting theory and research to work.* USA: John Wiley & Sons, Inc.

[6] Cobia, D.C., &Henderson, D.A. (2003). *Developing an effective and accountable school counseling program* (2ndEdition). New Jersey: Pearson.

[7] Fowkes, K.M., & McWhirter, E.H. (2007). Evaluation of computer assisted career guidance in middle and secondary education settings: Status, obstacles, and suggestions. *Journal of Career Assessment, 15* (3), 388-400, doi: 10.1177/1069072707301234

[8] Gysbers, N.C., &Henderson, P. (2006). *Developing &managing: Your school guidance and counseling program (4th Edition).* USA: American Counseling Association.

[9] Hassan, B. (2006). Career maturity of Indian adolescents as a function of self-concept, vocational aspiration and gender. *Journal of the Indian Academy of Applied Psychology*, *32* (2) 127-134.

[10] Herr, E.L., &Crammer, S.H. (1984). *Career guidance and counseling through the life span*. Toronto: Little, Brown & Company.

[11] Osipow, S.H. (1996). *Theories of career development*. New Jersey: Prentice-Hall Inc.

[12] Patton, W., &Lokan, J. (2001). Perspectives on Donald Super's construct of career maturity. *International Journal for Educational and Vocational Guidance,1*, 31–48.

[13] Reardon, R.C., Sampson, J.P., & Lenz, J.G. (2000).Career assessment in a time of changing roles, relationships, and context.*Journal of Career Assessment, 8* (4), 351-359.

[14] Republika (2012). *Kemenpora: Pengangguran terdidik capai 47,81 Persen*. [Online]. Tersedia di: http:/www.republika.co.id/: diunduh 14 April 2014.

[15] Sampson, J.P. (1990). Computer assisted testing and the goals of counseling psychology. *The Counseling Psychologist, 18*, 227-239.

[16] Sharf, R. S. (1992). *Applying career development theory to counseling*. California: Brooks/Cole Publishing Company.

[17] Sweet, R. (2001). Career information, guidance and counselling services: Policy perspectives. *Australian Journal of Career Development, 10* (2), 11-14.

[18] Versnel, J.*et al.* (2011). International and national factors affecting school-to-work transition for at risk-youth in Canada: An integrative review. *The Canadian Journal of Career Development/Revue canadienne de développement de carrière,10* (1).

[19] Whiston, S.C. (2000). *Principles and applications of assessment in counseling*. USA: Brooks/Cole.

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ADVANCEMENTS IN CONCRETE TECHNOLOGY

Shri Purvansh B. Shah[1] , Shri Prakash D. Gohil[2] ,Shri Hiren J. Chavda[3], Shri Tejas D. Khediya[4]
[1,2,3,4]*Lecturer, Civil engineering Department, Sir Bhavsinhji Polytechnic Institute-Bhavnagar*

Abstract - Developing and maintaining world's infrastructure to meet the future needs of industrialized and developing countries is necessary to economically grow and improve the quality of life. The quality and performance of concrete plays a key role for most of infrastructure including commercial, industrial, residential and military structures, dams, power plants. Concrete is the single largest manufactured material in the world and accounts for more than 6 billion metric tons of materials annually. Initial and life-cycle costs play a major role in today's infrastructure development. There have been number of notable advancements made in concrete technology in the last fifty years.So to meet Advances in Concrete Technologywe should have to maintain Concrete Materials, Workability of Concrete, Concrete Mixture Proportioning, Concrete Mechanical Properties, Concrete Durability Properties, Concrete tests, Concrete Construction Controland to meet advancements made in concrete technology we should have to use latest technologies and various applications of concrete technologies like Use of recycled materials in concrete , High Performance Concrete, Air Void Analyzer, Concrete Composition Technologies, Self compacting Concrete.

Key Words: *Concrete Technology, Advancements in Construction Technologies, Development of Construction Technologies*

I. INTRODUCTION

The use of cementing material dates back to several hundred years. The ancient Egyptians used claimed impure gypsum to grout the space between huge rocks of stone in pyramid.

The Greeks and Romans used claimed limestone and later learned to add to lime and water, sand and crushed stone or brick and broken tiles. This was first concrete in History.

Lime mortar does not harden under water, and for construction under water the Romans ground together lime and a volcanic ash or finely ground burnt clay tiles. Roman builders used volcanic tuff found near Pozzuoli village near mount Vesuvius in Italy. This Volcanic tuff or ash mostly siliceous in nature thus acquired the name pozzolana, having nearly the same composition as that of volcanic tuff or ash found at Pozzuoli.

Some of the structures in which masonry was bonded by mortar, such as the Coliseum in Rome and the Pont du Gard near Nimes, have survived to this day, with the cementations material still hard and firm. In the ruins at Pompeii, the mortar is often less weathered than the rather soft stone. The superiority of Roman mortar has been attributed to thoroughness of mixing and long continued ramming.

It is learnt that the Romans added milk, blood and lard to their mortar and concrete to achieve better workability. Hemoglobin is a powerful air-entraining agent and plasticizer, which perhaps is yet another reason for the durability of roman structures Probably they didn't knew about the durability aspect but used them as workability agents.

In India, the South India Industrial ltd, first manufactured Portlands cement near madras in 1904.

In 1912, the Indian Cement Co. Ltd. Was established at Porbandar (Gujarat) and by 1914 this company was able to deliver about 1000 tonnes of Portland Cement.

Prior to the manufacture of Portland Cement in India, it was imported from U.K. A three storeyed structure build at Byculla, Bombay is one of the oldest RCC structures built using Portland cement.

The Cement Corporation of India, a government owned company is set up with the aim of surveying prospecting and providing limestone deposits in the country and establishing cement manufacturing capacity.

II. LITURATURE OF CONCRETE TECHNOLOGY

Concrete :-Concrete is comprised of Portland cement, fine aggregate, coarse aggregate, water, pozzolans, and air. Portland cement got its name when it was first used in the early nineteenth century in England, because its product resembled building stone from the isle of Portland off the British coast. Portland cement is made by grinding a calcareous material, such as limestone or shell, with an argillaceous (clayish) material such as clay, shale or blast furnace slag. These two finely ground materials are heated in a giant rotary furnace to the point where they begin to fuse. The resulting product is called a clinker. The clinker is cooled and reground to a fine powder to form Portland cement.

While the clinker is being ground, small amounts of additional ingredients are added to produce the various types of cement :

-Standard setting
-Slow setting (low tri-calcium aluminates)
moderate sulfate resistance
-Fast setting - High early strength
-Slow setting - Low heat of hydration
-High sulfate resistance

When cement is mixed with water the resultant product is referred to as PASTE. This is if Substance that binds all other ingredients together. Aggregates are divided into two categories and are comprised of a large number of naturally occurring and manufactured products. The basic distinction is as follows:

- **Fine aggregate**– 4# sieve to pan (1/4" to powder)
- **Coarse aggregate** - 3/8" to 1-1/2"

The addition of fine aggregate to the PASTE transforms the product to a MORTAR. The Subsequent addition of coarse aggregate results in CONCRETE.

III. ADVANCES IN CONCRETE TECHNOLOGIES

A. Concrete materials :
The development of chemical admixtures has revolutionized concrete technology in the last fifty years. The use of air entraining admixtures, accelerators, retarders, water reducers and corrosion inbitititors are commonly used for bridges. The use of Self-compacting concrete is beginning (mostly used for precast elements). Shrinkage reducing admixtures are rarely used for bridges. Supplementary cementitious materials e.g. fly ash, ground granulated blast furnace slag and silica fume are routinely used.

B. Workability of Concrete :
Workability of fresh concrete depends on its rheological properties. This rheological behavior is defined by two characteristics of the concrete, i.e. yield stress and plastic viscosity. Yield stress is the effort needed to initiate movement of the fresh concrete, and correlates well with slump. Plastic viscosity is the flow characteristics of the concrete while moving and for low stiffness concretes can be determined by various rheometers currently available.

C. Concrete mixture proportioning :
Continuous gradation and consideration of workability during laboratory testing are slowly gaining acceptance in practice.

D. Concrete mechanical properties :
Higher strength concrete for bridges is commonly used for columns and beams. Higher strength concrete usually provides higher abrasion resistance and where appropriate this is considered in the bridge deck and pavement designs.

E. Concrete tests :
The utilization of advanced test procedures e.g. various shrinkage tests, air-void analyzer and non-destructive tests have become widespread. Workability test for stiff concrete mixes is being evaluated by several organizations.

F. Concrete construction control :
In-situ concrete testing, effective curing practices and utilization of computer software to monitor concrete strength development as well as minimizing cracking potential are used on major transportation projects.

IV. LATEST TECHNOLOGY AND APPLICATIONSOF CONCRETE TECHNOLOGIES

A. LATEST TECHNOLOGY :

- Use of recycled materials in concrete

The use of recycled materials generated from transportation, industrial, municipal and mining processes in transportation facilities is a issue of great importance. Recycled concrete aggregates and slag aggregates are being used where appropriate. As the useable sources for natural aggregates for concrete are depleted utilization of these products will increase. Utilization of fly ash and ground granulated blast furnace slag in concrete addresses this issue in addition to improving concrete properties. The replacement of Portland cement by fly ash or GGBFS reduces the volumes of cement utilized which is a major benefit since the cement manufacture is a significant source of carbon dioxide emissions worldwide. Silica fume is a comparatively expensive product and it is added in smaller quantities in concrete mixture rather than as a cement replacement.

B. APPLICATIONS :

1.HIGH-PERFORMANCE CONCRETE(HPC)

The term "HPC" was first introduced by NIST,FHWA, COE and ACI in early 1990s. Concrete meeting special performance requirements that cannot always beachieved routinely using conventional constituents and normal mixing, placing, and curing practices. Many conferences and publications since 1990s were conducted for HPC.

Performance Requirements for HPC :

- Placement & Compaction w/o Segregation
- Early-Age Strength
- Enhanced Mechanical Properties
- Volume Stability
- Enhanced Durability & Service Life:
  - Low Permeability
  - Abrasion Resistance
  - Fire Resistance

General Characteristics of HPC :

- High Strength
- Good Workability
- Good Durability

Benefits of HPC :

The direct advantage of HPC construction schedule is the early stripping of formwork. In addition, the greater stiffness and higher axial strength allows for the use of smaller columns in the construction. This will improve the construction schedule by reducing the amount of concrete that must be placed. These factors combined lead to construction elements of high economic efficiency, high utility, and long-term engineering economy

- Reduction of structural steel allows for greater flexibility in designing the shape and form of structural members
- Superior ductility and energy absorption provides structural reliability under earthquakes
- Reduction of structural steel allows numerous structural member shape and form freedom
- Superior corrosion resistance

Applications of HPC:

- Off-shore structures
- Long-span bridges
- HPLC (Floating offshore platforms)
- Repair materials (early strength)
- HP Shotcrete

Fig.1 HPC bridge

- HPC bridge – 8 spans
- Normal strength – 9 spans
- HPC strength –75-101 MPa in 56 days
- Unit cost of the HPC bridge was 16% higher than that of the normal strength concrete

Fig.2 HPC bridge in Texas

- HPC bridge in Texas Span length = 41 m
- Girder Spacing = 4.8 m
- Strength =110 Mpa
- Unit cost was similar to that for normal strength concrete

2.Air Void Analyzer (AVA)

AVA device can characterize the air void structure (volume, size and spacing) of fresh concrete. The clear advantage of the AVA is its ability to characterize the air void structure on fresh concrete in less than 30 minutes. With this information, adjustments can be made in the production process during concrete placement.

Fig.3 Air Void Analyzer

3.Concrete Composition Technologies

Addition to increasing the comprehensive strength of the concrete, available admixtures can improve other characteristics, such as low permeability, limited shrinkage, and increased corrosion resistance. These changes can also reduce the curing time required by reducing the required thickness of concrete members as well as the reducing the number of special construction steps involved in curing. Admixtures are used to improve a specific characteristic of the concrete for a specific application. The advantages are a more place able concrete for improved construction productivity without performance tradeoffs. Additionally, this product can be used in combination with a super plasticizer without modifying its properties.

4.Self-Compacting Concrete(SCC)

SCC provides improvements in strength, density, durability, volume stability, bond, and abrasion resistance. SCC is especially useful in confined zones where vibrating compaction is difficult. The reduction in schedule is limited since a large portion of the schedule is still controlled by the time required to erect and remove formwork. Although the schedule reduction is limited, it is still sufficient that the reduction in labor costs overcomes the higher material costs.Self-compacting concrete may be especially beneficial when used in combination with steelplate reinforced concrete structures, which requires a flow-able concrete due to the complicated geometries.

V. CONCLUSION

Significant advances have been made in concrete technology during the last fifty years. This paper has highlighted some of the significant advancements in technologies and their effect on the design and preservation of infrastructure. While it is not the definitive state-of-practice for design and preservation, it does bring to the forefront some of the technologies that are being considered by professionals. As with all new technologies, long term performance monitoring identifying both successes and failures, will prove to be invaluable for advancing the concept of long-life pavements. Some of the successful examples are discussed in this paper. Many of the innovations have been incorporated in the routine practice.

VI. REFERENCES

[1] M.S.Shetty "Concrete Technology (Theory and Practice)" S. Chand Publishing
[2] M.L.Gambhir "Concrete Technology" Tata McGraw-Hill Education
[3] Online sources:
(1)**http://www.foundationsakc.org**
(2)**http://nptel.ac.in**

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Synergistic Study on the Effect of Flame Retardants on Timber

Nwajiobi, C.C, Eboatu, A.N., Odinma, S.C*, and Emeruwa C.N.
(Department of pure and industrial chemistry,Nnamdi Azikiwe University, P.M.B. 5025, Awka Anambra State, Nigeria)
**(Department of Industrial Chemistry, Caritas University Amoji Nike Enugu, Enugu State Nigeria)*

ABSTRACT:- *the fire characteristic proportion of Halleacilliata has been carried out. The timber was treated with different concentrations of ammonium chloride (0.01, 0.05, 0.10, 0.15, 0.50, and 0.55) mol/dm^3 and borax (0.01, 0.03, 0.05, 0.07, 0.10, and 0.12) mol/dm^3. Flammability tests such as ignition time, flame propagation rate and after-glow time were carried out and the results showed that the flame retardants drastically reduced the flame propagation rate and after-glow time while ignition time and percentage add-on (%) increased. Synergy was observed when the two flame retardants were mixed at different concentrations which gave better retarding properties than when treated individually. These results are interpreted as arising from the fact that on heating, these flame retardants evolve molecules that interfere with the chemistry and pyrolysis of combustion of timber.*

Keywords: *-combustion, synergy, flame retardant, Timber*

I. INTRODUCTION

The utility of timbers in various applications is as a result of its indispensable properties that give good aesthetics and structural design. Wood is a renewable, sustainable and easily workable material that has been used in building industry for thousands of years. Its use remains wide spread ranging from structural frames to floors, paneling, doors, interior and exterior wood work and furniture [1]. However, the deficiency of this polymeric material in the presence of heat has made it more vulnerable to destruction. This has engulf lives, properties, damages and will still do more if precautionary measures are not implemented. The method by which the flammability of polymers e.g. textile, roughing thatch,foam etc. can be reduced by chemical means has been extensively investigated and documented [2-4]. In this paper we reported the synergism using ammonium chloride (NH_4Cl) and borax ($Na_2B_4O_7.10H_2O$) on the flame characteristics of timber known as Halleaciliata.

II. EXPERIMENTAL

2.1 Materials

The timber studied is *Halleaciliata*which is referred by its local names as ‘owen’ or ‘abura’. Ammonium chloride (NH_4Cl) was procured from BDH Laboratory Supplies Poole, BH151 TD, England and assay as: ex. Cl (98%), SO_4 (0.01%) and Fe (0.05%): disodium tetraboratedecahydrate or borax ($Na_2B_4O_7.10H_2O$) procured from BDH Laboratory poole and essay as: Pb (0.001%), Cu (0.001%), Fe (0.0003%), Ca (0.005%), PO_4 (0.002%), SO_4 (0.01%), Cl (0.002%). All chemicals were used as supplied by the manufacturers.

2.2Method

(a) Preparation of material: the timber was sized, cut into wood splints to the length of 30cm, width of 0.5cm, breadth 0.5cm and subjected to further analysis.

Flame-retardant treatment: The timber was dried in the electric oven at 105-110^{o}C to constant weight using weighing balance. Weight of the dry sample were completely immersed in equal volumes but different concentration of flame retardants contained in 1000cm^3 measuring cylinder for a resident time of 48hrs. On removal from the dope, the sample was dried again to relative constant weight in the electric oven (105-110^{o}C). The weight of flame-retardant absorbed by sample was determined, using the expression [5]:

$$\text{Add-on}(\%) = \frac{[Y - X]}{X} * \frac{100}{1}$$

Where Y= weight of the sample after treatment.
X= weight of the sample before treatment.

(b) Combination treatment: Equal volumes ($500cm^3$) of each of the prepared flame retardant solutions was mixed and impregnated into the wood splint for 48hrs and dried at the temperature 105-110^oC to constant weight using weighing balance.

The individual and combined effect was compared using the expression [6]:

Neilson's additivity equation:Theoretical = observed * mole fraction

$$\left[F_{a1} * \frac{a}{(a+b)}\right] + \left[F_{b1} * \frac{b}{(a+b)}\right]$$

Where a= concentration of ammonium chloride
b= concentration of borax
F= observed values

(c) Determination of ignition time (IT): the sample was clamped vertically by its upper end and ignited at the base with a cigarette lighter having a constant flame height and a constant distance (i.e. 4cm apart) between its lower tip and small cigarette lighter. Ignition time was recorded as the time interval between the lighter touching wood tip and a tiny visually perceptible flame on the sample[7]. Three readings per sample were taken and the average calculated.

(d) Determination of flame propagation rate [F.P.R]: the flame propagation rate was determined by clamping vertically the sample and igniting at the base in a drought-free room. The distance travelled at a stipulated time interval by the char-front was measured and the average readings were recorded [7].

The rate of propagation was calculated as the distance transverse per second.

Flame propagation rate (cm/s) = [distance moved by char-front (cm)]/ [time(s)]

(e) Determination of after-glow time: this was taken as the time between flame-out and the last visually perceptible glow [7]. The test was carried out for three times and the average was recorded for accuracy.

III. RESULTS AND DISCUSSION

Table I: fire characteristics of the treated timber

Conc (Mol/d m^3)	Ammonium chloride NH_4Cl				Conc (Mol/d m^3)	Borax or disodium teraboratedecahydrate $Na_2B_4O_7.10H_2O$				Conc (Mol/d m^3)	Combined (NH_4Cl+ $Na_2B_4O_7.10H_2O$)			
	Add-on (%)	IT (s)	F.P.R cm/s 10^-1	A.G.T (s)		Add-on (%)	IT (s)	F.P.R cm/s 10^-1	A.G.T (s)		Add-on (%)	IT (s)	F.P.R cm/s 10^-1	A.G.T (s)
0.00	0.00	5.78	3.57	301.19	0.00	0.00	5.78	3.55	301.20	0.00	0.00	5.78	3.58	301.21
0.01	0.36	8.78	3.06	95.20	0.01	2.08	6.59	2.73	217.32	0.01	0.44	19.38	1.23	282.91
0.05	0.47	10.90	2.16	5.00	0.03	6.59	8.99	2.35	206.54	0.04	0.81	19.90	1.01	201.93
0.10	1.57	15.46	1.79	2.93	0.05	6.81	9.49	1.68	167.92	0.08	0.61	24.31	1.04	198.39
0.15	1.45	16.41	1.56	2.07	0.07	6.81	11.82	2.25	135.82	0.11	0.97	27.39	0.67	2.18
0.50	2.35	21.29	2.11	0.98	0.10	7.38	12.98	1.46	125.25	0.30	2.53	29.62	0.94	0.98
0.55	4.37	24.09	1.41	0.11	0.12	7.78	15.16	1.35	100.96	0.34	2.84	31.66	0.21	0.07

The result of the percentage add-on of the flame-retardants is shown in Fig. 1. It is evident that the quantity of flame retardant absorbed by the wood depends on the liquor concentration. In the type of system, i.epolymerics, including cellulosics, the manner of chemisorption is well represented by the Fick's laws. The fick's first law is: J= D [(dc) / (dx)], where J= rate of accumulation of the reagent per unit area of the reference plane orientated normal to the x-axis, D= diffusion coefficient and c= local reagent concentration at a point distance x from the origin of coordinates. A second differential of the first law expression with respect to time is the Fick's second law: $[(dj) / (dt)] = D[(d^2c)/ (dx^2)]$; which implies that the rate of accumulation of the reagent to the surface and hence its penetration into the wood matrix would essentially be linked to the bath concentration [8]. On the basis of this fact the observation highlighted in Fig.1 is in accord with theoretical considerations.

It is observed [Fig.2] that these flame retardants delays ignition with respect to increase in concentration.

The systematic reduction [Table1] in the flame propagation rate [Fig.3] and After-glow time [Fig.4] with the flame retardant treatment is as follows:

Disodium tetraboratedecahydrate (borax): At high temperatures, it decomposes according to the equation:

$2Na_2B_4O_7.10H_2O_{(s)} = 4NaBO_{2(s)} + 2B_2O_{3(s)} + 10H_2O_{(g)}$ ----------(1)

Ammonium chloride: appears to sublime upon heating. However, this process is actually decomposition into ammonia and hydrogen chloride gas.

$NH_4Cl \rightarrow NH_3 + HCl$----------(2)

$HCl \rightarrow H^{\cdot} + Cl^{\cdot}$----------(3)

The flame inhibiting property of disodium tetraboratedecahydrate and ammonium chloride are interpreted in terms of vapour and liquid mechanism as the case may be. In the case of borax when heated these formulations decompose to form glass-like coating around cellulosic fibres. Long time exposure to heat causes the coating to dehydrate, generating water. The boron residues also react with the hydroxyl groups of cellulose to generate additional quantities of water and to form difficulty ignitable char. The evolution of water cools the flame as well as dilutes the concentration of flammable pyrolysis products. The glassy coatings not only deflects heat away from the substance but also diminishes aggress of combustible volatile pyrolysates into the combustion zone [9].

The free radicals $H^{\cdot}$ and $Cl^{\cdot}$ have the ability to scavenge the $^{\cdot}OH$ and $^{\cdot}O$ radicals that are essential for the sustenance of combustion. The gaseous products NH_3 and HCl contribute as diluents of the pyrolysate concentration.

From figs 2-4, synergy is observed from the graph, with the experimental value (observed) greater than the theoretical value. In figs 4, there is more decrease of after-glow theoretically at lower concentration but as it tends to higher concentration, the effect of synergy emerges with more decreasing observed after-glow. This can be due to the factors that affect the anisotropy of wood which is the arrangement and orientation of the wall materials in the cell making up the woody tissue, the kind, size, proportions and arrangement of the cells making up the woody tissue and thermal conductivity of wood which is depends on direction of heat flow with respect to the grain orientation in the wood, moisture content of wood and specific gravity of the wood [10].

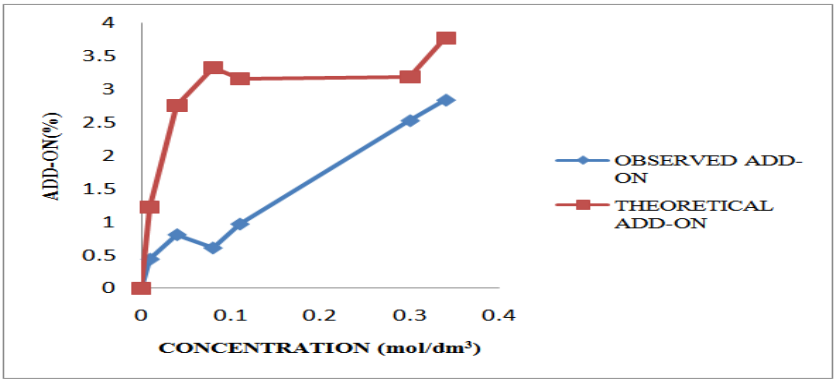

Figure 1: The observed and theoretical effect of concentration of flame-retardants on Add-on

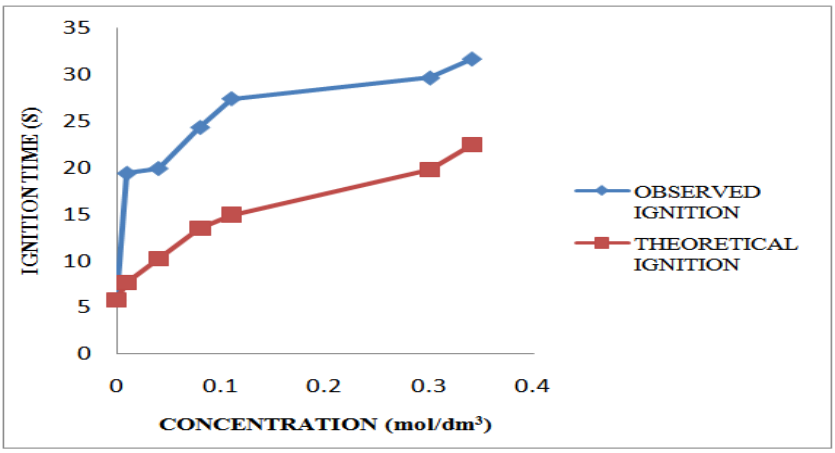

Figure 2: The observed and theoretical effect of concentration of flame-retardants on I.T

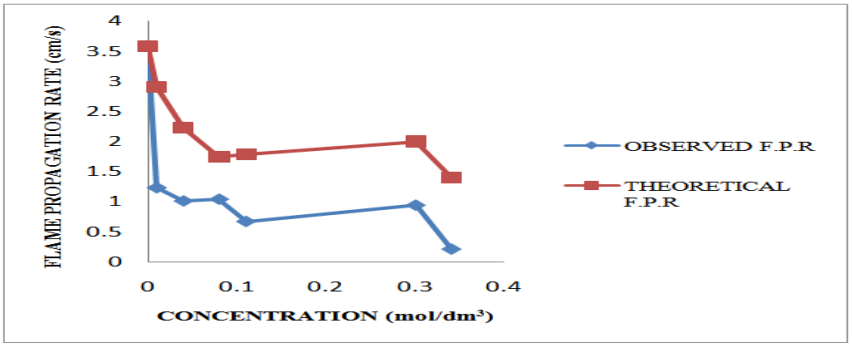

Figure 3: The observed and theoretical effect of concentration of flame-retardants on F.P.R

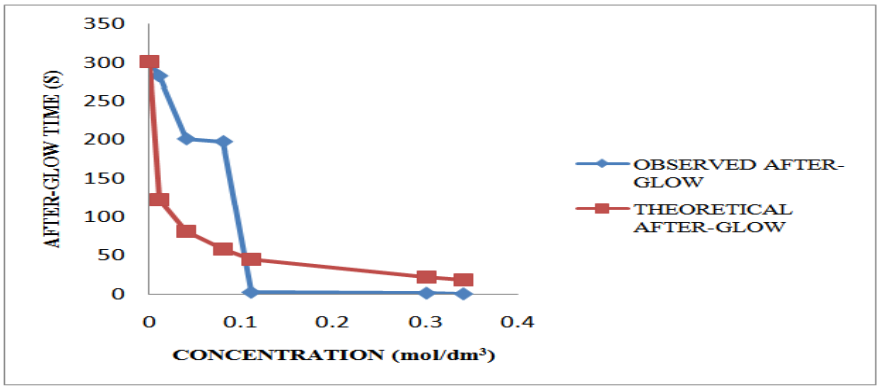

Figure 4: The observed and theoretical effect of concentration of flame-retardants on A.G.T

IV. CONCLUSION

It is concluded from this investigation that ammonium chloride and borax function as good fire-retardants in delaying and resisting ignition,flame propagation rate and after-glow time, though there was remarkable improvement when the wood was treated individually with each of the flame retardants but it was more pronounced when the two flame retardants was combined at different concentration depicting the effect of synergy.

REFERENCES

[1.] Lowden, L.A and Hull, T.R., (2013). Flammability behaviour of wood and a review of the methods for its reduction. University of Central Lancashire, Preston, UK. Fire Science Reviews 2013, **2**:4, doi:10.1186/2193-0414-2-4.

[2.] Momoh, M., Eboatu, A.N. and Abdulruman, F.W. (1990). Effect of Flame-Retardant Treatment on the Thermal Behaviour of Cotton Fabric. Tent. Res. J.pp 556-560.

[3.] Onuegbu, T.U., Umoh E.T. and Iwuchukwu, I.E. (2012). Flame-Retardants Effects on Flexible Polyurethane Foam treated with PottasiumAluminiumSulphate. Journal of Science and Technology **2:** 1097-1102.

[4.] Odinma, S.C., Okoye, N.H and Okoro, V.E. (2013). Comparative Study on the Effect of Three Flame Retardant Compounds on Flame Behaviour of a Roofing Thatch. International Journal of Engineering Science Invention. Volume 2 Issue 6. pp 56-60.

[5.] Eboatu, A.N., Alhaji, S.M and Okoye, P.A.C., (1995). Studies on Fire Treatment of Timbers of Sudan Savannah, Journal of Thermal Analysis, **5**: 207-211.

[6.] Neilson, L. E. (1963) Mechanical Properties of Polymers, Reinhold, New York. pp 220

[7.] Eboatu, A.N. and Garba, B. (1990). Effect of Flame-Retardants Treatment on the Thermal Behaviour of some Tropical Timbers. Journal of Applied Science, **39:**109-118.

[8.] Eboatu, A.N., Birnin- Kebbi, F. and Shehu, D., (1992c). Fire-Retardant Treatment of Roofing Thatch. Fire and Material, **16**: 155-158.

[9.] Boryo, D.E, Aiyedipe, R.I., Ezeribe, A.I. and Biri, H.B.(2013). Effects of Urea. Borax and Ammonium Chloride on Flame Retarding Properties of Cellulosic Ceiling Board. Chemical and Process Engineering Research **14**: 1-6.

[10.] Simpson, W. and Tenwolde, A. (1999). Physical Properties and Moisture Relations of wood. Wood Handbook – University of New Brunswick. NY: Robert E. Krieger Publishing Company. pp.1-25

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Studies on Respirable Particulate Matter and Heavy Metal Pollution of Ambient Air in Delhi, India

[1]Pramod R. Chaudhari, [2]D.G. Gajghate, [3]Dheeraj Kumar Singh
[1,2]*National Environmental Engineering Research Institute, Nehru Marg, Nagpur (Maharashtra) (India)*
[3] *Grass Roots Research and Creation India (P) Ltd., F-375, Sec 63, Noida 201301 (U.P.) (India)*

Abstract : *Delhi is the large metro city and capital of India which has been reported to be having worst air pollution as per urban data base released by the World Health Organization in September 2011. Ambient air quality survey of Respirable Particulate Matter (PM10) and heavy metal pollution of air was carried out in Delhi in industrial, commercial and residential area in 2006 and 2011. Vehicular emission, dust emanated from heavy traffic and construction activity and industrial activities were found to be responsible for air pollution in Delhi. In this paper, PM10 and heavy metal pollution of air in Delhi were observed to be increased in 2011 many more times above the recommended standards or guidelines for protection of public health as compared to 2006 level with the increase in human activity. Heavy metals are observed to be associated with RPM. Though, Delhi government has taken number of measures to reduce the air pollution, more efforts will be required in future to control emission of air pollutants due to increasing population of Delhi and supporting facilities like industries, transport, construction etc.*
Key Words : *Delhi, Industrial, Commercial, Residential, RPM, Heavy Metals*

I. INTRODUCTION

Most of the developing countries are facing the problem of air pollution and public health problems due to pressure from increasing population, transport, industrialization and other activities. The latest World Bank report on leveraging urbanization in South Asia has identified air pollution as a big challenge for major cities in the region, including Delhi. Delhi is reported to be the worst amongst 381 cities from developing countries by World Health Organization in September 2011. The report also mentions that under-five mortality is higher in urban areas than in rural setting. Air pollution is a pernicious problem and its health impacts set to worsen as several regions of the world urbanize rapidly. The major urban air pollutants i.e. NOx, SO_2, Ozone, particulate matter & CO, and their impacts have been studied widely in the ambient air of Delhi. Though heavy metals in air were analyzed in the some air monitoring programme but were not interpreted comprehensively.
Ambient Respiratory Particulate Matter, RPM (PM10), may be the carriers of toxic species like heavy metals which have adverse effect on environment as well as human health [1]. Understanding the types of heavy metals and their spatio-temporal patterns of urban air pollution and their relation with PM10 is crucial to exploring its implications for human and ecosystem health. Therefore, dynamics and interrelationships of RPM and heavy metal concentrations in the air of Delhi was studied in 2006 and 2011 to understand the spatial and temporal variation with increasing population and human activity in the environment of metro city of India.

II. MATERIALS AND METHODS

Ambient air quality monitoring was carried out at three sites in Delhi, viz. Mayapuri Industrial area (West Delhi), Commercial area (Chandni Chowk area, North Delhi), & Residential area (Sarojini Nagar, South Delhi). RPM was collected from the locations using samplers operated at a rate of 1.5 m^3/min for 24 hours on pre-weighted glass fibre filter of 20x25 cm size and reweighted after sampling in order to determine the mass concentration of the RPM collected. The concentrations of particulate matter in ambient air were then computed on the net mass collected divided by the volume of sampled air. Twelve circles of 1" diameter were punched out from the filter paper and digested in concentrated nitric acid. The content was filtered through Whatman paper No. 42 and final volume made-up to 100 ml by double distilled water. The filtrate was used to determine the metals Cr, Cd, Fe, Pb, Zn and Ni by atomic Absorption Spectrophotometer. The RPM and each metal concentration were averaged for month in 2006 and 2011.

III. RESULTS AND DISCUSSION

Sampling Stations

Delhi is the capital city of India. This metro city is increasing fast in size and industrial, commercial and transport activity. Three sampling sites representing residential area, commercial area and industrial area were selected for the study.

The first sampling station Mayapuri Industrial Area (West Delhi) was used to be a major hub of small scale industries, but following recent government sanctions, most of the heavy metal industries moved out. The place is now a combination of residential flats, light metal factories and automobile service stations. Apart from these, the area has three malls, bus terminal of Delhi Transport Corporation (DTC). One of the main businesses at Mayapuri is the recycling of metal scraps and sale of salvage vehicle parts. It is the biggest market for used automotive and industrial spare parts in India. Many small workshops specialized in different metals are active in the Mayapuri area. The presence of toxic heavy metals and of harmful chemicals in the waste generated by these activities presents a direct threat for the health of the people living in the area.

The second sampling site is commercial area around Chandni Chowk in North Delhi. This area is densely populated with heavy traffic, famous for diverse market goods like books in Nai Sarak area; pearl, gold and silver jewellery and natural perfumes at Dariba Kalan; spice-lover in Khari Baoli; cloth market, areas for electric equipments and allopathic medicines, shawls and pearls.

The third sampling site is Sarojini Nagar in South West Delhi. It is large residential area with very large market and is one of the places in the city to buy clothes and fabrics. The area comprises a large number of large sized showrooms, apart from street side shops which sell garments of all sizes, designs and colors. The vicinity of Sarojini Nagar Market is very much developed. The back-streets of market are also crowded by the most famous Export Market for clothes.

Climatic Conditions

Delhi has humid sub-tropical bordering semi-arid climate with extreme temperatures during summer and winter. There are four seasons, winter (December to February), summer (March to May), rainy season or monsoon (June to September) and post-monsoon (October to November). In summer, the average temperature is 32 ^{0}C (90 ^{0}F) and highest temperature close to 45 ^{0}C (114 ^{0}F). The total rainfall in monsoon is 797.3 mm and the temperature ranged from 25 ^{0}C (78 ^{0}F) to 32 ^{0}C (90 ^{0}F) with average temperature around 29 ^{0}C (85 ^{0}F). The average temperature during post-monsoon season remains around 21 ^{0}C (71 ^{0}F). In winter, the average temperature ranges around 12-13 ^{0}C (54-55 ^{0}C). The lowest temperature may go up to -2.2 ^{0}C certain times [2] (Table I).

Respirable Particulate Matter

Air quality monitoring was carried out for RPM and heavy metals in air in 2006 and 2011. RPM recorded in 2006 and 2011 in industrial, commercial and residential areas of Delhi are given in Table II and in Figure 1 and 2. In 2006, RPM Concentrations were observed to be higher in all the months in industrial area ranging from 75 to 295 µg/m^3. Though RPM values in commercial and residential areas are more or less similar, the RPM values in residential area were slightly higher in most of the months ranging from 48 to 253 µg/m^3. RPM values in commercial area ranged from 45 to 220 µg/m3. This indicates that the human activity was more in industrial area followed by residential and commercial area, leading to considerable dust pollution in Delhi. The highest RPM concentration was observed in January month. The RPM concentration was lowest in July month and then gradually increased through August and September and attained maximum in October, December and January. A slight reduction in RPM concentration was noticed in February and March and in November. Therefore, the RPM showed bimodal peak during the year, one in November-December-January and another in April. When compared with AAQM standard of 100 µg/m3, the RPM concentration was lower than the standard in commercial and residential area during July to September period and in industrial area during July to August period, while it was well above the standard in all other months at all stations.

In the year 2011, highest RPM concentration was recorded in commercial area, followed by industrial and residential area in decreasing order (Table II, Figure 2). The range of RPM was recorded to be 87 to 449 µg/m^3 in commercial area, 88 to 433 µg/m^3 in industrial area and 53 to 405 µg/m^3 in residential area. Another important observation was that the highest RPM values were observed during November and December. Seasonal dynamics of RPM concentration was otherwise more or less similar to the observations recorded in 2006. Lowest RPM concentration was observed during July to September, then showed gradual increase and attained highest value in December. Other lower values were observed during February and March. Thus, the RPM showed bimodal peak, one in December and another in April-May. When compared with AAQM standard of 100 µg/m^3, the RPM concentration was lower than the standard in residential area during June to September period, in industrial area during July to September period and in commercial area during July to August period, while it was well above the standard in all other months at all stations.

Comparison of seasonal spatial and temporal variation of RPM is shown in Table II and Figure 3. In general, the RPM concentration range was found to be lower in the year 2006 than the range of RPM found in 2011 at all stations. This is clearly evident in Total-Annual RPM values which are lower in 2006 and higher in 2011. Winter was most critical showing highest concentration of RPM followed by post-monsoon and summer season. The percentage increase/decrease in RPM Concentrations in 2011 as compared to those in 2006 is presented in Figure 4. The Total-Delhi value for RPM in different seasons showed 23.45% to 83.65% higher values over that in 2006 values in different seasons, monsoon has highest value over monsoon of 2006 followed by post-monsoon, winter and summer. The Annual mean also showed increase by 29.78%. Commercial area showed higher values in all the seasons as well as with respect to annual mean. It was followed by residential area showing higher values in summer season followed by winter season and post-monsoon season. Industrial area showed higher values in post-monsoon season followed by winter season and monsoon season. Industrial area showed reduction in RPM in summer and residential area in monsoon season. Overall annual mean were less in industrial area and residential area. This shows that the human activity was very much intensely increased in commercial area in 2011. Human activity was also more in residential area due to presence of famous market in residential area which is visited by most of the people from different areas of Delhi and other parts of India. However, industrial activity is not much increased and do not have much impact on RPM in 2011 as compared to the value of 2006, though the values of RPM are mostly above the stipulated standards in this area.

The values of PM10 in the air of Delhi (66 to 365 µg/m3) were considerable higher than that in Bhopal (102-159 µg/m3) [3], however lower than those values recorded in Lucknow (113 to 396.2 µg/m3) (Barman et al., 2012). This shows that the Lucknow is competing Delhi for being highly polluted.

The Air Quality Index (AQI) based on RPM was calculated using the method [4, 5]. For AQI (Q), the air quality rating of each pollutant was calculated by following formula:

Q = 100 x V/Vs ---------- (1)

Where, Q is quality rating, V the observed value of the pollutant, and Vs the standard recommended for that pollutant. The categories of air quality based on AQI are presented in Table III. The Standard for RPM is 100 µg/m3; therefore, as per above equation (1), the RPM values themselves represent Air Quality Index in different months (Table II). The category of air quality in 2006 and 2011 is shown in Table IV. The values of RPM / AQI (>100) in January to June and from October to December indicated Severe Air Pollution of RPM. During monsoon months of July, August and September, the level of air pollution was observed to be lower (Heavy Air Pollution) in the year 2006 and in residential area in both the years. Industrial area and commercial area showed AQI ranging from 75 to 114 (Heavy to Severe Air Pollution) in 2006 and AQI from 88 to 99 (Heavy Air Pollution) in 2011. Commercial area showed Heavy Air Pollution (AQI: 45 to 66) in 2006 and Severe Air Pollution (AQI: 87 to 101) in 2011. However, residential area showed Heavy Air Pollution (AQI: 48 to 87) in 2006 and Moderate Air Pollution (AQI: 53 to 63) in 2011, indicating some degree of improvement in air quality. In short, the air quality was Heavy Air Pollution in monsoon season in 2006, while it changed to Severe Air Pollution in 2011.

Urban areas in general have been experiencing a higher concentration of air pollution due to extensive vehicular movements and other activities concentrated in urban area. Comparatively similar areas and the cities have been divided into four categories on the basis of Exceedence Factor (EF), which is the ratio of annual mean concentration of a pollutant with that of its standard. The standard four categories of air pollution based on EF are given below:

1) *Critical pollution (C): when EF is > 1.5*
2) *High pollution (H):when EF is between 1 and 1.5*
3) *Moderate pollution (M): when EF is between 0.5 and 1.0*
4) *Low pollution (L): when EF is < 0.5*

The values of EF were determined on annual average values of RPM. Highest EF was recorded in Industrial area in 2006, while the highest in 2011 was in Commercial area, indicating tremendous increase in commercial activity and some reduction in industrial activity. Residential area also showed slight lowering of air pollution The Exceedence Factor (EF) for RPM (Table V) also support the conclusion based on Air Quality Index, that the RPM concentration indicated Critical Pollution in industrial and residential areas during both the years, while in commercial area, RPM level showed High Pollution in 2006, which changed to Critical Pollution in 2011.The above analysis of category of air pollution due to RPM indicates that the air quality is highly risky in Delhi throughout the year including the rainy or monsoon season. This is in conformity with earlier report that exposure to PM10 results in aggregated respiratory and cardiovascular diseases and in some cases premature death [6, 7]. During Budget session of the Rajya Sabha in 2012, the MoEF minister Jayanti Natarajan answered to one question that contribution of transport sector to PM10 pollution in Delhi was between 9-21% of the total. Even if the CNG introduction has been successful intervention as far as reducing pollution from the transport sector is concerned, it accounts for at most a fifth of the pollution in Delhi [8].The traffic generated gaseous and particulate matter emission and trends over Delhi from 2000 to 2010 was studied [9] and observed

that emission of PM10 decreased in 2001 and 2002; however, it is continuously increasing after 2002 due to rapid rise in the annual rate of increase in vehicles.
Delhi city has shown history of many fluctuations in the level of pollution along with measures taken for its control. Delhi has carried out up measures to reduce vehicle emissions, in terms of fuel quality (introduction of CNG for commercial vehicles) and vehicle pollution reduction technologies and other measures like shifting polluting industries outside in industrial area, introduction of alternate transport Metro, conversion of coal based power plants in Delhi into gas based plants [8]. Though these initiatives helped to improve the air quality in early 2000s, they fall short the controlling air pollution due to increasing number of passenger vehicles on road, lack of enough public transport buses and increase in freight movement and construction material and debris by trucks passing through the city, the lack of maintenance of trucks and buses, increase in in-situ generator sets due to increased demand of electricity and industrial growth

Heavy Metals in Ambient Air
A total 6 heavy metals were recorded in the ambient air of Delhi. The dynamics of trace metals in ambient air is given in Table VI. The spatial variation in the heavy metals in the ambient air in the year 2006 is shown in Figure 5 and 6. The zinc and iron were observed in higher concentrations for most of the time followed by lead, nickel, cadmium and chromium. In 2006, a clear bimodal peak in the concentration of heavy metals in ambient air was observed, one during March – May and another in August –September. In 2011, Zn, Fe, and Pb showed relatively lower concentrations as compared to 2006 but highest amongst all other metals in 2011 (Figure 7 and 8). The heavy metals also showed bimodal peak, one in April – June and another in October – December, except zinc, which showed many peaks and furrows. The heavy metals showed similar pattern with RPM, indicating that the sources of emissions for both are same. In Delhi, the sources of emission of heavy metals were the commercial activity and the scattered industries. In Raipur, the source of Fe in air is the sponge iron industries in the area (Suresh et al., 2010-2011). The risk of heavy metal exposure is observed to be in summer and post – monsoon season.
Based on annual average values, the gradient of concentration of heavy metals in ambient air in 2006 and 2011 is given below:
Zn > Fe > Pb > Ni > Cr > Cd (2006)
Zn > Fe > Pb > Ni > Cr = Cd (2011)
The concentration gradients of heavy metals reported in other areas of India are given below:
Fe > Cu > Zn > Mn > Cr > Cd > Pb > Ni (Coal mining & non-mining area of Dhanbad) [10]
Fe > Zn > Mn > Cr > Pb > Ni > Co (Lucknow) [11])
Mn > Ni > Co > Cd > Pb (Jharia coal field)[12]
This shows that though the basic pattern of concentration gradient of heavy metals are same, the gradient differ slightly in different localities depending on local geology and type of human activity.
The compilation of heavy metals in the ambient air of Delhi and in other areas of India is given in Table VII. Coal mine area, Dhanbad showed higher concentration of Fe, Pb and Cr [9] than those recorded in Delhi. Moradabad with high traffic also showed higher concentrations of all metals [13] and similar is the case of Raipur [14]. In the ambient air of Lucknow, the maximum concentrations of Zn, Fe, Pb and Cr were lower than in Delhi with exception of Ni which was higher in the air of Lucknow by almost double the amount recorded in Delhi [11]. Fe was significantly high in the air of Delhi as compared to Lucknow, which may be due to lot of construction activity going on in Delhi.
The monthly percentage composition of heavy metals in RPM was evaluated on the basis of monthly total values of heavy metals (HM) and RPM, and was observed to be average 1.358% (range: 0.027% to 2.534%) in 2006 and average 0.882% (range: 0.276% to 2.73%) in 2011 (Table VIII). The lower concentration of Zn, Fe, & Pb recorded in 2011 as compared to those in 2006 as well as lower percent composition of heavy metals in RPM in 2011 might be due to emission of more dust due to increase in traffic and construction activity in 2011. Suresh et al. (2010-2011) reported the range of percentage of heavy metals in SPM as 1.17 to 1.87% in Raipur indicating larger industrial sources of heavy metals in ambient air in Raipur as compared to Delhi. These observations show that seasonal variation of climate and fluctuations in human activity are responsible for dynamics of RPM and heavy metal concentration in ambient air of Delhi.
The Pearson's Correlation Coefficient among trace metals and RPM are shown in Table IX. The table indicates that the RPM is moderately correlated with Fe (r: 0.4288) and Pb (r: 0.5056) and poorly with chromium and cadmium and negatively with Zn and Ni. Cadmium is strongly correlated (r: 0.62 to 0.88) with Ni, Cr, and Pb. Zinc is strongly correlated with Cr (r: 0.7351) and moderately with Pb (r: 0.4128). This is in conformity with the observation that the particulates in ambient air may include broad range of chemicals, ranging from metals to organic and inorganic compounds[15, 16]. Similar observations have been made [10] who recorded correlation between RPM (PM10) and heavy metals like, Pb, Ni, Fe, Mn, Zn and Cd. Strong correlation between Cd-Ni, Ni-Mn, and Cd-Mn was observed in Jharia Coal field of Jharkhand [12]. The inter

correlations of metals Pb with Mn, Fe & Cr, Zn with Ni & Cr, Ni with Cr, Mn with Fe, and Cu with Cr was observed in the air of Lucknow [17] .

Out of six metals, only three metals have guideline / standard for ambient air for protection of public health during exposure to polluted air (Table X). Cadmium has limit of 0.005 µg/m3 [18, 19], nickel has limit of 0.020 µg/m3 [18, 20, 19] and lead has limit of 1 µg/m3 [20]. The table also shows that cadmium is present in concentration above the stipulated standard during both the years; nickel exceeds the standard in 2011 while lead concentrations were below the standard in both the years. The values of AQI based on metal pollutants in air and category of heavy metal pollution in 2006 and 2011 are shown in Figure 9 and 10 respectively.

In 2006, all the metals were at Clean Air level in the ambient air for most of the time except cadmium and nickel showing abrupt rise in AQI in April and during the end of monsoon, post-monsoon and December. The AQI based annual mean (AM) showed Cd at Moderate Air Pollution level and nickel & lead at Clean Air status. Monthly dynamics of AQI of metals in ambient air (Figure 9) showed cadmium at upper threshold level of Moderate Air Pollution in April and August months and Severe Air Pollution levels in September, November and December months. Nickel reached Light Air Pollution level in August and Moderate Air Pollution level in September and December. Thus, the risk period with respect to exposure to heavy metals in ambient air is April, August to September and November to December.

In 2011, the ambient air pollution showed more deterioration on the basis of AQI. AQI based on Annual Mean (AM) showed that cadmium changed from Moderate Air Pollution (2006) to Heavy Air Pollution level (2011) and nickel changed from Clean Air (2006) to Light Air Pollution level (2011) but lead remained at Clean Air level (Figure 10). Cadmium was observed to be at Light Air Pollution level in August only, and Moderate Air Pollution level in March, April and July, Heavy Air Pollution level in June and October and Severe Air Pollution level in January, September, November and December. Nickel gained position of Light Air Pollution in May, June, August and October, Moderate Air Pollution level in November, December and Severe Air Pollution in February. Thus, the risk period increased to January-February, June, and September – December.

Above conclusion is also supported by the Exceedence Factor calculated for Cd, Ni, and Pb. The Exceedence Factors (EF) based on annual mean of heavy metals for Cd, Ni, and Pb are shown in Table XI1. The pollution status of cadmium and nickel was Moderate and Low in 2006 respectively which changed to High Pollution in 2011. However, lead was at Low Pollution status in both the years. This is due to lead-free petrol used in the vehicles. This indicates that urban air pollution of heavy metal is more severe. Shifting of some polluting industries to the outskirts of Delhi did not change the pollution status of the heavy metals in the air of Delhi.

Similar observations of urban air pollution in India are also noted by other worker [15] who studied the urban air pollution with village as control and found that heavy metal concentration in the environment of Lucknow was higher than control site by 52.3%, 271.8%, 406.9%, 75.81%, 62.7%, 487.54%, and 189.5% for Fe, Cu, Pb, Zn, Ni, Mn and Cr respectively. Higher concentrations of heavy metals have been recorded in ambient air in coal mining area of Dhanbad, Jharkhand [10] than control site, Cd by 1300%, Zn by 133%, Fe by 5484%, Pb by 137% and Cr by 8300% except nickel. The increase in night time concentrations of the metals Al, Zn., Pb & Cd on Diwali night was also observed at Kolkata by 5-12 times, Cu, Fe, & Mn by 25-40 times and Co & V by70-80 times as compared to normal night-time concentrations [23].

There are various sources emitting these elements into the atmosphere, e.g. fossil fuel combustion contributes Al, Fe, Ca, Mg, K, Na, As, Pb, Cd, Se, Hg [24], Pb and Zn by wood combustion [25], vehicular traffic contributes Cd, Cr, Cu, Ni, Pb, Zn [26], electroplating contributes Cr [27], metal alloy industries emit different elements like Cd, Cr, al, Fe, Ni, Zn, Pb, Cu etc in the air [28].

Impact of Air Pollutants on Public Health

Study was carried out to evaluate the direct health impacts in National Capital Territory of Delhi (NCT Delhi) in terms of mortality and morbidity due to air pollution [29]. About 11394, 3912, 1697, and 16253 excess number of cases of total mortality, cardiovascular mortality, respiratory mortality and hospital admission of COPD respectively were observed for entire NCT Delhi in the year 2000. However, within one decade in year 2010, these figures became 18229, 6374, 2701, and 26525. District wise analysis showed that North West District is having the highest number of mortality and morbidity cases continuously after 2002. Moreover, least excess number cases were observed for New Delhi District.

Short term but high emissions of trace elements such as As, Cd, Co, Cr, Ni, Pb, and Se which are animal and human carcinogens even in trace amounts have severe health impacts [30]. Pb can cause neurological and hematological impacts on the exposed population, Cd and Ni can cause carcinogenic effects in human through inhalation, occupational level of Cd exposure is a risk factor for chronic lung diseases [31, 32]. Cr(VI) has carcinogenic effect on the bronchial tree, increased Mn leads to neurotoxic impairment, increased level of Cu leads to respiratory irritations [31, 33, 34].

IV. CONCLUSION

Impact of big cities on local air quality has long been recognized but the fact that this will trigger the impacts on regional and global climate is just beginning to receive attention. Among the major air pollutants of public health importance, heavy metal is an important parameter from public health point of view which needs to be studied as emission from anthropogenic source. This presently neglected parameter may assume a great risk to public health in future and need to be controlled effectively. Delhi has taken several steps to reduce the level of air pollution in the city during the last 10 years. However, more still needs to be done to further reduce the levels of air pollution [35]. Integrated approach towards urban air pollution control is required including infrastructure development and motivation efforts of government and participation of the community for effective reduction of pollution like use of public transport starting from some car-free days, use of Metro rail with adequate number of feeder buses at Metro stations. More frequent checking of Pollution under Control (PUC) certificates and education of people to switch-off their vehicles when waiting at traffic intersections. The ever-increasing influx of migrants can be reduced by developing job opportunities in the suburban areas, and thus prevent further congestion of the already-choked capital city of Delhi.

REFERENCES

[1] C. Verma and D.K. Deshmukh, The ambient air and noise quality in India during Diwali festival: A Review, *Recent Research in Science and Technology, 6(1)*, 2014, 203-210.

[2] Indian Meteorological Department, *Ever Recorded Maximum and Minimum Temperatures up to 2010*, Indian Meteorological Department, Retrieved, 2015.

[3] Sadhana Chaurasia and A.D. Gupta, Concentration of atmospheric trace metals associated with respirable particulate matter (PM10) and Air Pollution Index (API) of Bhopal City, Madhya Pradesh , India, *3rd World Conference on Applied Sciences, Engineering & Technology*, 27-29 September 2014, Kathmandu, Nepal, ISBN 13: 978-81-930222-0-7, pp 161-166.

[4] C.P. Kaushik, K. Ravindra and K. Yadav, Assessment of ambient air quality in urban centres of Haryana (India) in relation to different anthropogenic activities and health risk, *Environ Monit Assess, 122*, 2006, 27-40.

[5] N. Tiwari and M. Ali, Air Quality Index for Calcutta and its monthly variation for various localities, *Ind J Environ Protect, 7*, 1987, 172-176.

[6] K, Balkrishnan, R.S. Dhaliwal and B. Shah, Integrated urban-rural frameworks for air pollution and health-related research in India: the way forward, *Environ Health Perspectives, 119*, January 2011.

[7] S.K. Chhabra, P. Chhabra, S. Rajpal and R.K. Gupta, Ambient air pollution and chronic respiratory morbidity in Delhi, *Archives of Environmental Health, 56*, 2001, 8.

[8] S. Guttikunda, Air pollution in Delhi, *Economic and Political Weekly, XLVII, 26 & 27*, 2012, 24-27.

[9] Rati Sindhwani, P. Goyal, S. Kumar and A. Kumar, Assessment of gaseous and respirable suspended particulate matter (PM10) emission estimates over megacity Delhi: Past trends and Future Scenario (2000-2020), Presented at *the 13th Annual CMAS Conference*, Chapel Hill, NC, October 27-29, 2014.

[10] B. Dubey, A.K. Pal and G. Singh, Trace metal composition of airborne particulate matter in the coal mining and non-mining areas of Dhanbad Region, Jharkhand, India, *Atmospheric Pollution Research, 3*, 2012, 238-246.

[11] Barman et al., Assessment of ambient Air Quality of Lucknow City during Pre-Monsoon, 2012. Findings of a Random Survey, Presented on *World Environment Day, 2012*. CSIR-Indian Institute of Toxicology Research, Lucknow, 5TH June, 2012.

[12] A.K. Mishra, S.K. Maiti and A.K. Pal, Status of PM10 bound heavy metals in ambient air in certain parts of Jharia coal field, Jharkhand, India, *Int. J Environ Sci, 4(2)*, 2013, 141-150.

[13] R. Pal, M.A. Gupta and A. Tripathi, 2014. Assessment of heavy metals in suspended particulate matter in Moradabad, India, *J Environ Biology, 35*, 2014, 357-361.

[14] S. Suresh and R.D. Patil, *Report on SPM Characterization for Heavy Metals Concentration*, Zonal Office (Central), Central Pollution Control Board, Bhopal, 2010-2011

[15] S.S. Park and Y.J. Kim, Source contributions to fine particulate matter in an urban atmosphere, *Chemosphere, 59*, 2005, 217-226.

[16] Y.I. Tsai and M.T. Cheng, Characterization of chemical species in atmospheric aerosols in a metropolitan basin, *Chemosphere, 54*, 2004, 1171-1181.

[17] S.G. Barman, N. Kumar, R. Singh, G.C. Kisku, A.H. Khan, M.M. Kidwai, R.C. Murthy, M.P.S. Negi, P. Pandey, A.K. Verma, G. Jain and S.K. Bhargava, Assessment of urban air pollution and its probable health impact, *J Environ Biology, 31(6)*, 2010, 913-920.

[18] EPA,, *Air Quality Standards*. U.S. Environmental Protection Agency, 2011.

[19] European Commission, *Ambient Air Quality Research Project (1996-2001) on Dioxins, Organics, Polycyclic Aromatic Hydrocarbons and Heavy Metals* (NSW EPA 2002), 2003.

[20] MoEF, *National Ambient Air Quality Standards*, Ministry of Environment and Forests Notification G.S.R. 826(E) dated 16th November, 2009.

[21] NEPC, this is the Australian goal for lead set in the National environmental Protection (Ambient Air Quality) Measure (NEPM). Measurement is based on TotalSuspended Particulates.

[22] WHO, Goals are based on guidelines for the risk of health impacts, 2000.

[23] A. Chatterjee, C. Sarkar, A. Adak, U. Mukherjee, S.K. Ghosh and S. Raha, Ambient air quality during Diwali festival over Kolkata – A mega-city in India, *Aerosol and Air Quality Research, 13*, 2013, 1133-1144.

[24] E. Furimsky, Characterization of trace element emissions from coal combustion by equilibrium calculations, *Fuel Process Technol, 63*, 2000, 29–44.

[25] J. Mohn, R. Figi, P. Graf, E. Gujer, R. Haag, P. Honegger, P. Mattrel, O. Nagel, P. Schmid, C. Seiler, C. Schreiner, E. Steinhauser, M. Zennegg and L. Emmenegger, Wood Combustion-Clean Energy In: *Proceedings of 5th International Conference on Emission Monitoring*, Odense, Denmark, 2002.

[26] Westerlund, *Metal Emissions from Stockholm Traffic, Wear of Brake Lining* (Stockholm Environmental Administration, 2001.

[27] W.L. Flower, L.W. Peng, M.P. Bonin, N.B. French, H.A. Johnsen, D.K. Ottesen, R.F. Renzi and L.V.A. Westbrook, Laser-based technique to continuously monitor metal aerosol emissions, *Fuel Process Technol, 39*, 1994, 277–284.

[28] R.M. Harrison, Metal Analysis. In: *Handbook of Air Pollution Analysis*, R M Harrison and R Perry (eds),Chapman & Hall, London, 215-277, 1986.
[29] A.S. Nagpure, B.R. Gurgar and Jc Martel, Human health risks in National Capital Territory of Delhi due to air pollution, *Atmospheric Pollution Research, 5*, 2014, 371-380.
[30] Y. Wang, G. Zhuang, C. Xu and Z. An, The air pollution is caused by the burning of fireworks during the lantern festival in Beijing, *Atmos Environ, 41*, 2007, 417-431.
[31] S.C. Barman, R. Singh, M.P.S. Negi and S.K. Bhargava, Ambient air quality at Lucknow City (India) during use of fireworks on Diwali festival, *Environ Monit Assess, 137*, 2008, 495-504.
[32] S. Benoff, A. Jacob and I.R. Hurley, Male infertility and environmental exposure to lead and cadmium, *Human Reproduction Update, 6*, 2000, 107-121.
[33] N. Manalis, G. Grivas, V. Protonotarios, A. Moutsatsou, C. Samara and A. Haloulakou, Toxic metal content of particulate matter (PM10) within the greater area of Athens, *Chemosphere, 60(4)*, 2005, 557-566.
[34] C. Santos-Burgoa, C. Rios, L.A. Nercadi, R. Arecguga-Serrano, F. Cano-Vall and R.A. Eden-Wynter, Exposure to manganese: health effects on general population, a pilot study in Central Mexico, *Environ Res, Sect A, 85*, 2001, 90-104.
[35] S.A. Rizwan, N. Baidalyne and S.K. Gupta, Air pollution in Delhi: Its magnitude and effects on health, *Indian J Community Med, 38(1)*, 2013, 4-8

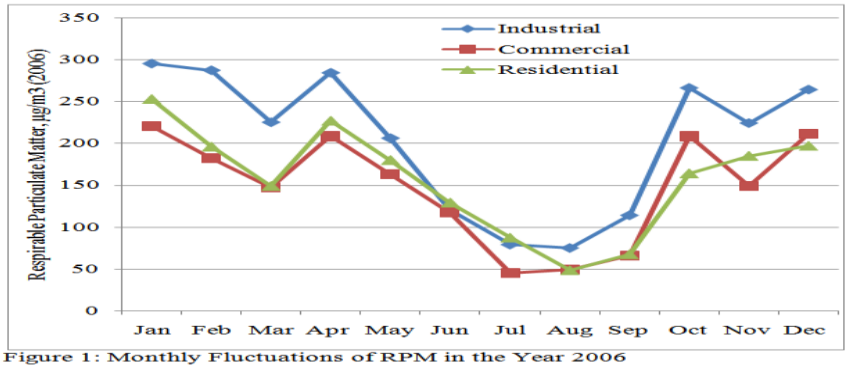

Figure 1: Monthly Fluctuations of RPM in the Year 2006

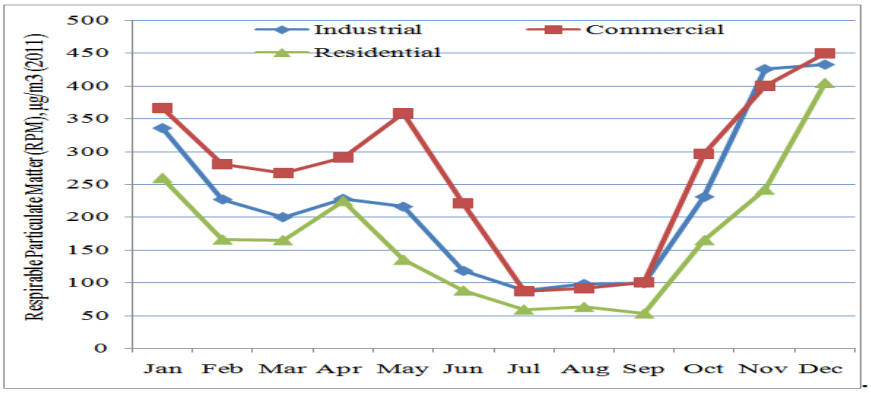

Figure 2: Monthly Fluctuations of RPM in the Year 2011

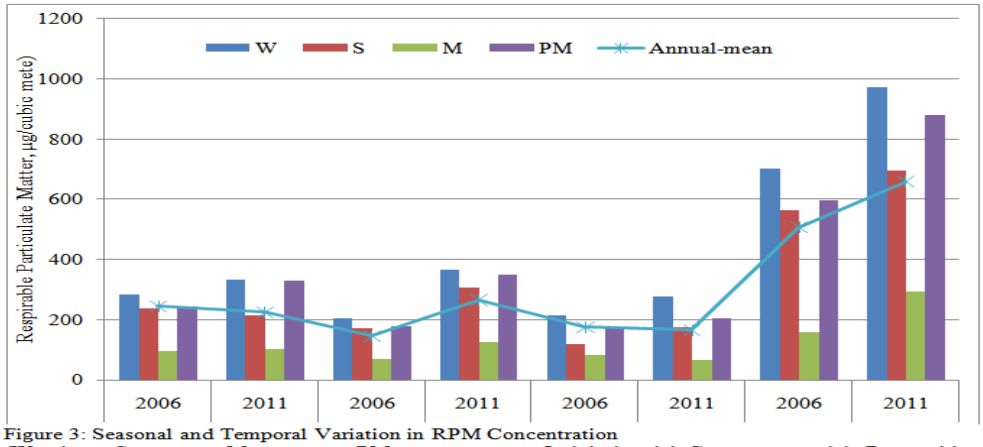

Figure 3: Seasonal and Temporal Variation in RPM Concentration
(W: winter; S: summer; M: monsoon; PM: post-monsoon; Ind: industrial; Com: commercial; Res: residential)

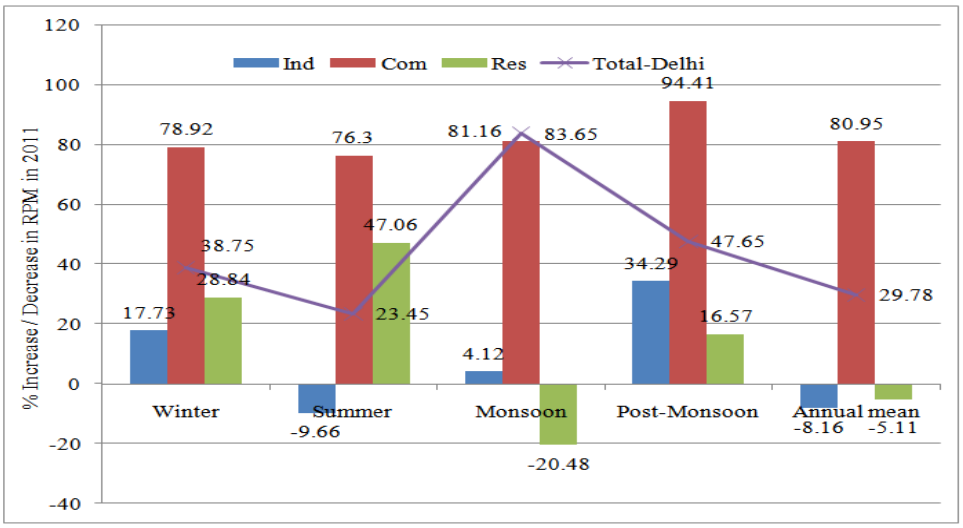

Figure 4: Percentage Increase in RPM Concentration in 2011 as Compared to 2006

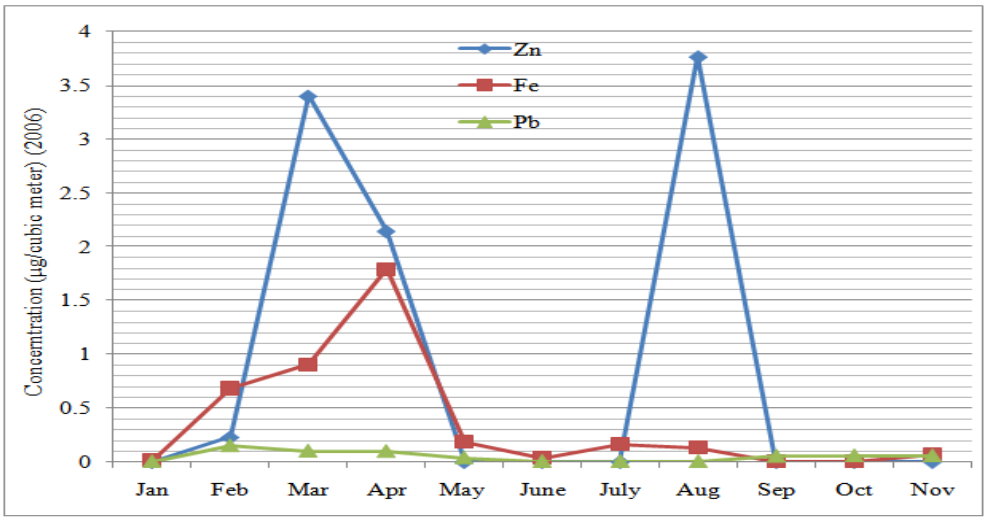

Figure 5: Trace Metal Concentration of Zn, Fe & Pb in Ambient Air in 2006

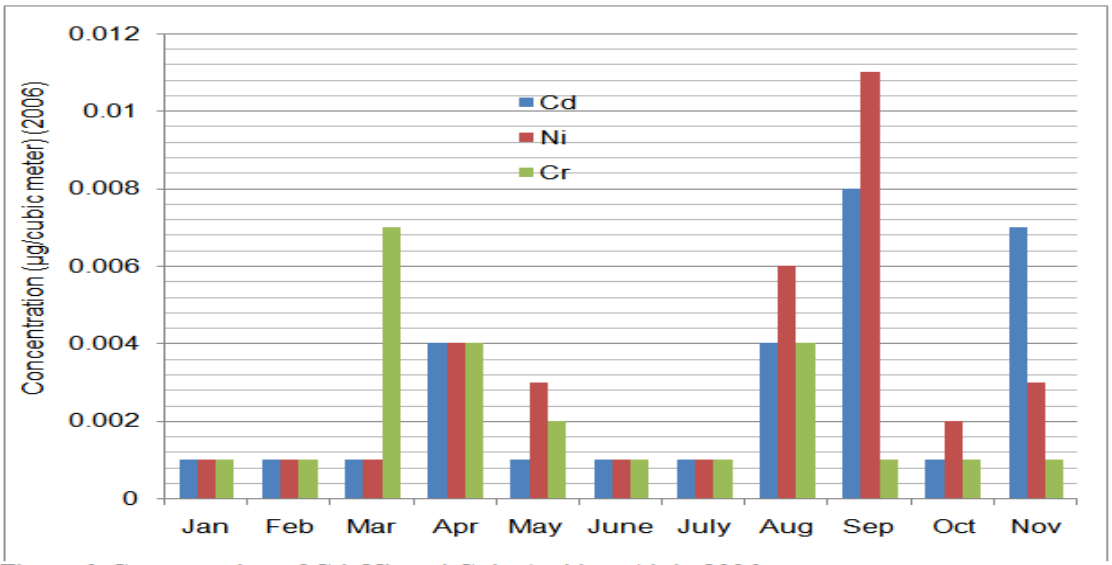

Figure 6: Concentration of Cd, Ni, and Cr in Ambient Air in 2006

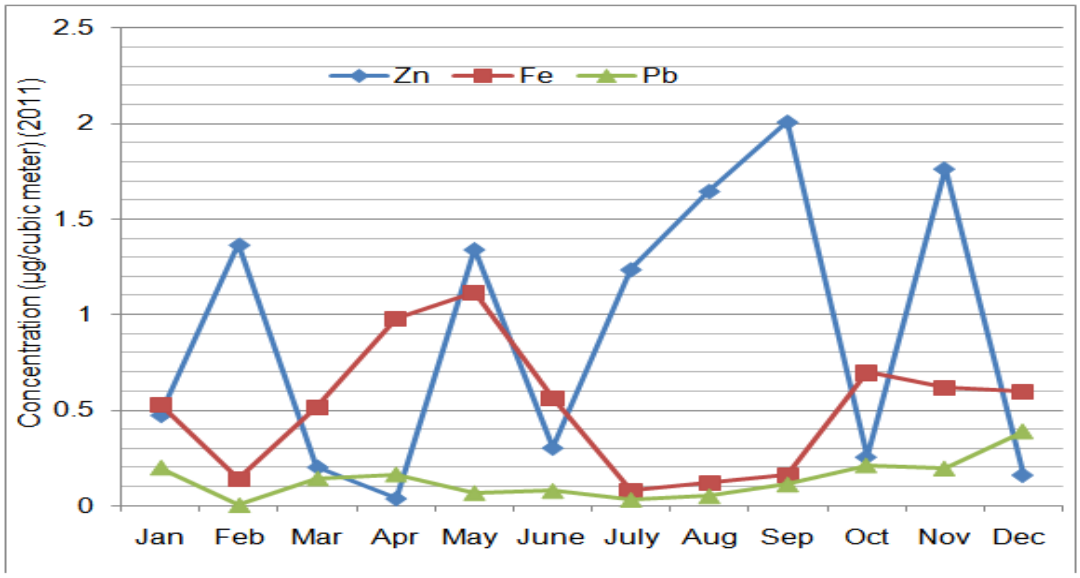

Figure 7: Trace Metal Concentration of Zn, Fe and Pb in Ambient Air in 2011

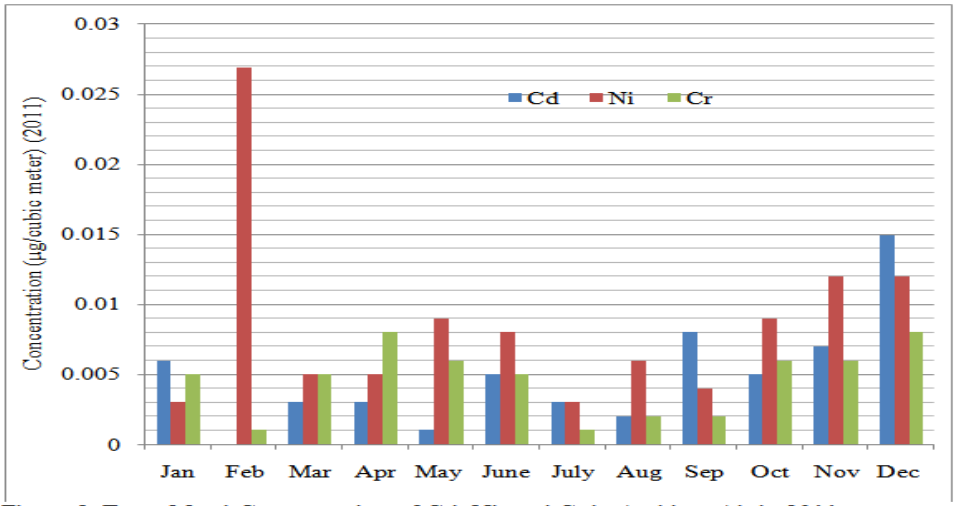

Figure 8: Trace Metal Concentration of Cd, Ni, and Cr in Ambient Air in 2011

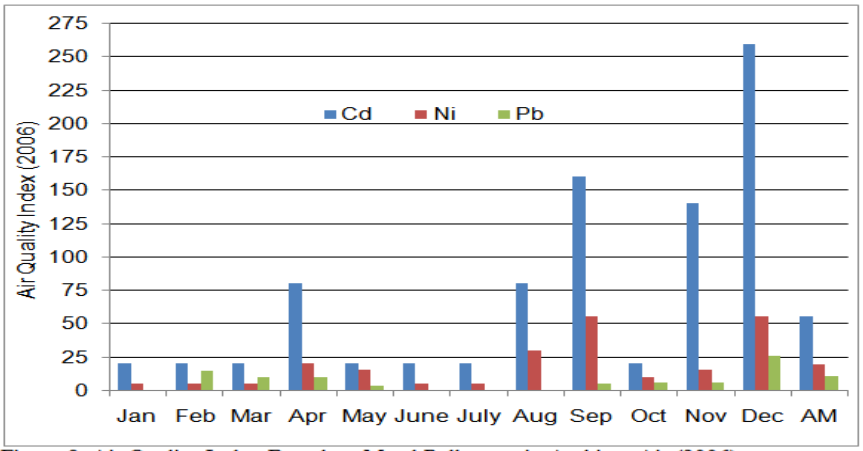

Figure 9: Air Quality Index Based on Metal Pollutants in Ambient Air (2006)
(≤10 – 25: Clean Air; 26-50: Light Air Pollution; 51-75: Moderate Air Pollution; 76-100: Heavy Air Pollution; >100: Severe Air Pollution)

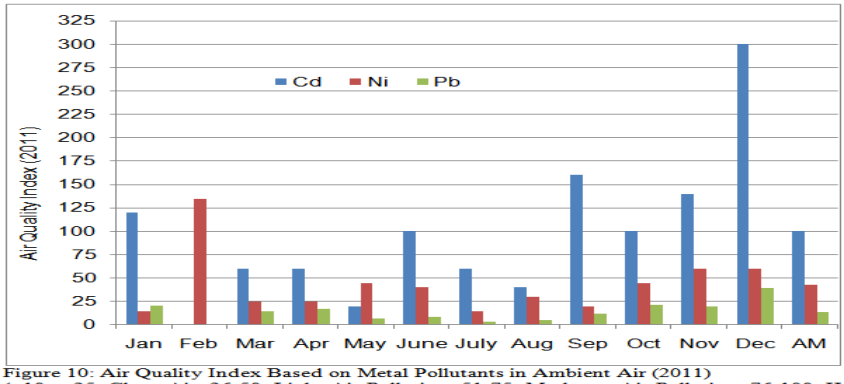

Figure 10: Air Quality Index Based on Metal Pollutants in Ambient Air (2011)
(≤10 – 25: Clean Air; 26-50: Light Air Pollution; 51-75: Moderate Air Pollution; 76-100: Heavy Air Pollution; >100: Severe Air Pollution)

Table I: Climate Data for Delhi (1971-1990)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record High $^0C(^0F)$	30.0 (86)	34.1 (93.4)	40.6 (105. 1)	45.6 (114. 1)	47.2 (117)	46.7 (116. 1)	45.0 (113)	42.0 (107. 6)	40.6 (105. 1)	39.4 (102. 9)	36.1 (97)	29.3 (84.7)	47.2 (117)
Average high $^0C(^0F)$	21.0 (69.8)	23.5 (74.3)	29.2 (84.6)	36.0 (96.8)	39.2 (102. 6)	38.8 (101. 8)	34.7 (94.5)	33.6 (92.5)	34.2 (93.6)	33.0 (91.4)	28.3 (82.9)	22.9 (73.2)	31.2 (88.2)
Daily mean $^0C(^0F)$	14.3 (57.7)	16.8 (62.2)	22.3 (72.1)	28.8 (83.8)	32.5 (90.5)	33.4 (92.1)	30.8 (87.4)	30.0 (86)	29.5 (85.1)	26.3 (79.3)	20.8 (69.4)	15.7 (60.3)	25.1 (77.2)
Average low $^0C(^0F)$	7.6 (45.7)	10.1 (50.2)	15.3 (59.5)	21,6 (70.9)	25.9 (78.6)	27.8 (82)	26.8 (80.2)	26.3 (79.3)	24.7 (76.5)	19.6 (67.3)	13.2 (55.8)	8.5 (47.3)	19.0 (66.2)
Record low $^0C(^0F)$	-0.6 (30.9)	1.6 (34.9)	4.4 (39.9)	10.7 (51.3)	15.2 (59.4)	18.9 (66)	20.3 (68.5)	20.7 (69.3)	17.3 (63.1)	9.4 (48.9)	3.9 (39)	1.1 (34)	-0.6 (30.9)
Average precipi-tation mm (inches)	19 (0.75)	20 (0.79)	15 (0.59)	21 (0.83)	25 (0.98)	70 (2.76)	237 (9.33)	235 (9.25)	113 (4.45)	17 (0.67)	9 (0.35)	9 (0.35)	790 (31.1)

Source : NOAA; Indian Meteorological Department (record high and low up to 2010)

Table II: Spatial and Temporal Variation of RPM in the Ambient Air of Delhi

Month	Industrial		Commercial		Residential		Total-Delhi	
	2006	2011	2006	2011	2006	2011	2006	2011
Jan	295±21	336±123	220±116	366±158	253±71	260±116	768	962
Feb	287±59	227±69	182±44	280±117	196±42	166±87	665	673
Mar	225±33	200±55	147±61	267±69	149±58	165±23	521	632
Apr	284±155	228±63	208±87	291±54	227±108	225±108	719	744
May	206±81	216±47	163±98	358±115	180±77	135±49	449	709
Jun	121±31	118±42	117±76	221±94	129±96	88±47	367	427
Jul	79±17	88±27	45±8	87±24	87±34	59±15	211	234
Aug	75±19	98±27	49±12	91±28	48±14	63±27	172	252
Sep	114±39	99±29	66±18	101±26	67±9	53±11	247	253
Oct	266±97	231±31	208±108	296±118	164±82	165±103	638	692
Nov	224±71	426±102	149±55	400±155	185±77	242±57	558	1068
Dec	264±83	433±133	211±82	449±107	197±86	405±124	672	1287

Table III: Category of Ambient Air Quality Based on Air Quality Index (Q)

Index Value	Category
≤10 - 25	Clean air
26 – 50	Light air pollution
51 – 75	Moderate air pollution
76 – 100	Heavy air pollution
>100	Severe air pollution

Table IV: Category of Air Pollution Based on Air Quality Index (Q) based on RPM

Seasons	Industrial		Commercial		Residential	
	2006	2011	2006	2011	2006	2011
Winter	Severe air pollution					
Summer	Severe air pollution					
Monsoon	Heavy to severe air pollution	Severe air pollution	Heavy air pollution	Severe air pollution	Heavy air pollution	Moderate air pollution
Post-Monsoon	Severe air pollution					
Annual Mean	Severe air pollution					

Table V: Category of Ambient Air Pollution Denoted by Exceedence Factor Based on RPM Annual Mean

Seasons	2006			2011		
	Industrial Area	Commercial Area	Residential Area	Industrial Area	Commercial Area	Residential Area
Annual Mean	245	147	176	225	266	167
Exceedence Factor (EF) & Pollution Status	2.45 Critical Pollution	1.47 High pollution	1.76 Critical pollution	2.25 Critical pollution	2.66 Critical pollution	1.67 Critical pollution

Table VI: Heavy Metal Concentration (24-H Average) in ambient Air of Delhi

	Cd		Zn		Ni		Fe		Pb		Cr	
	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011
Jan	0.001	0.006	O.44	0.475	0.001	0.003	0.0071	0.527	0.002	0.197	0.001	0.005
Feb	0.001	0.000	0.23	1.365	0.001	0.027	0.68	0.142	0.15	0.002	0.001	0.001
Mar	0.001	0.003	3.40	0.203	0.001	0.005	0.90	0.516	0.100	0.141	0.007	0.005
Apr	0.004	0.003	2.145	0.039	0.004	0.005	1.788	0.978	0.097	0.162	0.004	0.008
May	0.001	0.001	0.001	1.341	0.003	0.009	0.178	1.114	0.037	0.065	0.002	0.006
June	0.001	0.005	0.001	0.304	0.001	0.008	0.029	0.562	0.004	0.076	0.001	0.005
July	0.001	0.003	0.001	1.236	0.001	0.003	0.165	0.080	0.004	0.030	0.001	0.001
Aug	0.004	0.002	3.765	1.646	0.006	0.006	0.129	0.119	0.002	0.048	0.004	0.002
Sep	0.008	0.008	0.001	2.008	0.011	0.004	0.001	0.161	0.052	0.110	0.001	0.002
Oct	0.001	0.005	0.001	0.256	0.002	0.009	0.001	0.696	0.057	0.209	0.001	0.006
Nov	0.007	0.007	0.001	1.763	0.003	0.012	0.063	0.615	0.058	0.193	0.001	0.006
Dec	0.013	0.015	3.160	0.162	0.011	0.012	0.561	0.599	0.261	0.386	0.016	0.008
Av. ±SD	0.003 ± 0.003	0.005 ± 0.004	1.10 ± 1.542	0.9± 0.73	0.004 ± 0.004	0.027 ± 0.044	0.375 ± 0.537	0.51 ± 0.335	0.108 ± 0.151	0.135 ± 0.11	0.003 ± 0.004	0.005 ± 0.003

Table VII: Ranges of Heavy Metals in the Air of Delhi and Other Areas in India

	Cd	Zn	Ni	Fe	Pb	Cr
Delhi ambient air	0.0028 - 0.005	0.9 - 1.096	0.0038 - 0.027	0.375 - 0.51	1.108 - 0.135	0.003 - 0.005
Coal mine area of Dhanbad [9]	0.03 - 0.07	0.16 - 2.55	0.002 – 0.02	1.43 – 28.48	0.024 - 0.32	0.11 - 0.42
Lucknow [15}	--	0.0189 – 0.0999	0.0224 – 0.0525	0.506 – 2.434	0.023 – 0.249	0.0032 – 0.012
Lucknow, Annual Average [11]	--	0.0588 – 0.286	0.00336 – 0.036	677.24 – 3.645	0.0087 – 0.0867	0.024 – 0.0888
Moradabad (UP) Max conc in Ind. Area [13]	0.20 (heavy density traffic area)	21.24	0.03	18.43	2.72 (heavy density traffic area)	0.41
Raipur [14]		0.01 – 0.32	0.01 – 0.05	1.44 – 4.91		

Table VIII: Percentage of Heavy Metal Content in RPM Concentration

Months	2006			2011		
	HM	RPM	HM%	HM	RPM	HM%
Jan	0.452	256	0.160	1.213	321	0.378
Feb	1.063	222	0.479	1.537	224	0.686
Mar	4.409	174	2.534	0.873	211	0.414
Apr	4.042	240	1.684	1.195	248	0.482
May	0.222	150	0.148	2.536	236	1.075
June	0.037	122	0.030	0.96	142	0.676
July	0.173	70	2.471	1.353	78	0.453
Aug	3.91	57	6.860	1.823	84	2.170
Sep	0.022	82	0.027	2.293	84	2.730
Oct	0.063	213	0.030	1.181	231	0.511
Nov	0.133	186	0.072	2.596	356	0.729
Dec	4.022	224	1.796	1.182	429	0.276
Annual average			1.358			0.882

(HM: heavy metal)

Table IX: Correlation Coefficient among RPM-Total-Delhi (RPM-AT) and Trace Metals

	RPM-AT	Cd	Zn	Ni	Fe	Pb	Cr
RPM-AT	1						
Cd	0.039	1					
Zn	-0.0277	0.3407	1				
Ni	-0.1888	0.8829	0.3426	1			
Fe	0.4288	0.0538	0.4914	0.0122	1		
Pb	0.5056	0.6148	0.4128	0.4517	0.4743	1	
Cr	0.2336	0.6639	0.7351	0.5476	0.3539	0.7884	1

Table X: Standard / Guideline for Heavy Metal Concentration in Ambient Air for Protection of Public Health

Metal	Average of Samples (24-hour; µg/m3)		Range of samples (24-hour; µg/m3)		Standard/ Guideline (annual average; µg/m3)	References
	2006	2011	2006	2011		
Cadmium (Cd)	0.0028	0.005	0.001 - 0.013	0.00-0.015	0.005	[18]; [19]
Zinc (Zn)	1.096	0.90	0.001- 3.765	0.039- 2.008	Non-available	
Nickel (Ni)	0.0038	0.027	0.001- 0.011	0.003- 0.027	0.020	[18]; [19]; [20]
Iron (Fe)	0.375	0.51	0.001- 1.788	0.08- 1.114	Non-available	
Lead (BP)	0.108	0.135	0.002- 0.261	0.002- 0.386	0.500	[21]; [22]
					1.000	[20]
Chromium (Cr)	0.0033	0.005	0.001- 0.016	0.001- 0.008	Non-available	

Table X1: Ambient Air Quality Status based on Exceedence Factor For Heavy Metals in Ambient Air

Metal	Exceedence Factor (EF) and Pollution Status	
	2006	2011
Cadmium (Cd)	0.56 Moderate pollution	1.00 High pollution
Nickel (Ni)	0.19 Low pollution	1.35 High pollution
Lead (Pb)	0.108 - 0.216 Low pollution	0.135 - 0.27 Low pollution

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An Image Region Selection with Local Binary Pattern based for Face Recognition

Dr. V. S. MANJULA
Associate Professor & Head Information System & Network Engineering
St. Joseph University College of Engineering & Technology
Dar-Es-Salaam, Tanzania, East Africa

ABSTRACT: *In this paper, we present a novel framework for face recognition, namely Selective Ensemble of Image Regions (SEIR) is proposed and which considers both shape and texture information to represent face images. In this framework, all possible regions in the face image are regarded as a certain kind of features. This technique can be adapted to accurately detect facial features. However, the area of the image being analyzed for a facial feature needs to be regionalized to the location with the highest probability of containing the feature. By regionalizing the detection area, false positives are eliminated and the speed of detection is increased due to the reduction of the area examined. The face area is first divided into small regions from which Local Binary Pattern (LBP) histograms are extracted and concatenated into a single, spatially enhanced feature histogram efficiently representing the face image. The recognition is performed using a nearest neighbor classifier in the computed feature space. The FERET data tests which include testing the robustness of the method against different facial expressions, lighting and aging of the subjects. In addition to its efficiency, the simplicity of the proposed method allows for very fast feature extraction a method to accurately and rapidly detect faces within an image.*

Keywords*: Face Recognition, Region Selection, Multiple Eigenspaces, Ensemble learning, Selective Ensemble, PCA, Histogram Equation*

I. INTRODUCTON

In this paper we introduce a new approach for face recognition which considers both shape and texture information to represent the face images. Human faces are complex, changeful and high dimensional patterns. Although it is to recognize familiar faces, face recognition is a formidable task for machines. Even so, the vast potential applications, face recognition have become an active research area of computer vision and pattern recognition for decades. As opposed to the EBGM approach, a straightforward extraction of the face feature vector (histogram) is adopted in our algorithm. The face image is first divided into small regions from which the Local Binary Pattern (LBP) features [8,9] are ex-tracted and concatenated into a single feature histogram efficiently representing the face image. The textures of the facial regions are locally encoded by the LBP patterns while the whole shape of the face is recovered by the construction of the face feature histogram. The idea behind using the LBP features is that the face images can be seen as composition of micro-patterns which are invariant with respect to monotonic grey scale transformations. Combining these micro-patterns, a global description of the face image is obtained.

Despite these achievements, face recognition continues to be an active topic in computer vision research. This is due to the fact that current systems perform well under relatively controlled environments but tend to sober when variations in different factors (such as pose, illumination and etc.) are present. Therefore, the goal of the ongoing research is to increase the robustness of the systems against different factors. Ideally, to develop a face recognition system this mimics the remarkable capabilities of human visual perception. Before attempting to reach such a goal, one needs to continuously learn the strengths and weaknesses of the proposed techniques in order to determine new directions for future improvements. To facilitate this task, the FERET database and evaluation methodology have been created.

The main goal of FERET is to compare different face recognition algorithms on a common and large database and evaluate their performance against different factors such as facial expression, illumination changes, aging and etc. Among the major approaches developed for face recognition are Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA) and Eigenface is based on the global feature of face images, it uses the whole face image as training data. When there are gross variations in the input images that greatly. However, in this situation, local features such as eyes, mouth and nose are often less dejected. So these local features can help recognize faces. They used four masks respectively to get the regions of eyes, nose, mouth and the whole face.

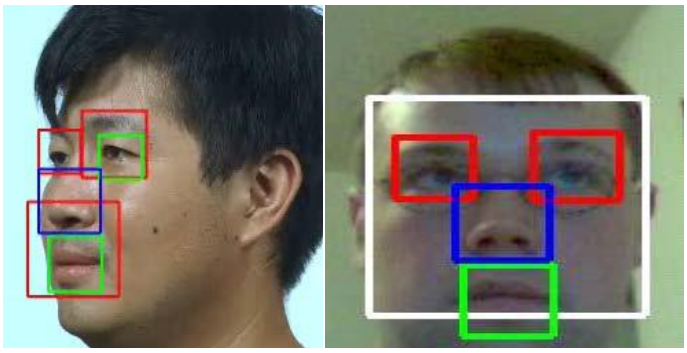

Figure1(a) Figure1(b)

Figure 1.Manually extracted facial feature regions

The face features detected of eyes, nose and mouth are shown in Figure 1(a). They claimed that local features could achieve better performance than global features. Figure 1(b), where the white rectangles show the regions of four local features, i.e. left eye, right eye, nose and mouth. They indicated that the Eigen features alone were sufficient in achieving a high recognition rate equal to that of the eigenface, and the combination of eigenface and Eigen features could achieve even better performance.

II. IMAGE REGION SELECTION:

In face recognition using multiple features can be re-explained from another point of view. In fact, each feature can be used to classify faces, i.e. each feature can be used to train a weak classifier. Then the multi-feature methods can be regarded as special ensemble learning methods. If the definition of features is extended to all possible rectangular regions in the face image, then using several features for face 2 recognition can be regarded as selective ensemble learning [7].

Figure 2. Original images and synthetic images

Several approached works on feature selection for face recognition, such as Local Feature Analysis (LFA) , and the Ada Boosted Gabor Features. However, until now there is no work on region selection for face recognition.

2.1 Image Region Selection Algorithm:

Given *K* example face images (each person has two images, one is gallery face and the other is probe face), *m* regions are to be selected from the exhausted set of *N* regions in the face images *R*1, *R*2, ….,*RN*.

1. For $i = 1 \ldots N$:
   (i). Train a classier based on the region *Ri* using the gallery faces as training set.
   (ii). Recognize all the probe faces using the classier, getting the recognition rate of *Ri*, denoted by *ri* .
2. Sort *Ri* according to descending order of *ri*. Get a sequence of regions: *Ri*1, *Ri*2, …*RiN* .
3. $S = \{Ri1\}$, $A = \{Ri2, \ldots, Rin\}$, where $m << n << N$.
4. For $t = 1 \ldots (m - 1)$:
   - For each region *Ri* in *A*, calculate *ci*, the number of the probe faces that *Ri* correctly recognizes but at least one of the regions in *S* doesn't.
   - Find the region with the largest *ci*, denoted by *Rl*.
   - Remove *Rl* from *A* and add it to *S*.
5. There are *m* selected regions in *S*.

III. FACE DESCRIPTION WITH LOCAL BINARY PATTERNS

The original LBP operator is a powerful means of texture description. The operator labels the pixels of an image by thresholding the 3x3-neighbourhood of each pixel with the center value and considering the result as a binary number. Then the histogram of the labels can be used as a texture descriptor. In Figure 2 for an illustration of the basic LBP operator. Later the operator was extended to use neighborhoods of divergent sizes [8]. Using circular neighborhoods and bilinear interpolating the pixel values allow any radius and number of pixels in the neighborhood. For neighborhoods we will use the notation (P, R) which means P sampling points on a circle of radius of R.

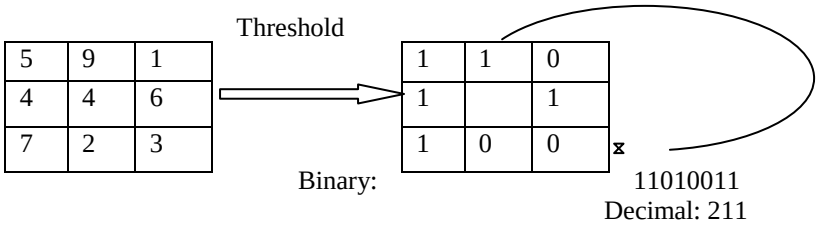

Figure 3. The basic LBP Operator

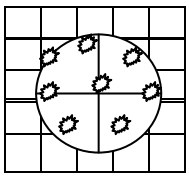

Figure 4 for an example of the circular (8,2) neighborhood.

The pixel values are bilinear interpolated whenever the sampling point is not in the center of a pixel transitions from 0 to 1 or vice versa when the binary string is considered circular.

For example, 00000000, 00011110 and 10000011 are uniform patterns. In this experiments with texture images, uniform patterns account for a bit less than 90 % of all patterns when using the (8,1) neighborhood and for around 70% in the (16,2) neighborhood.

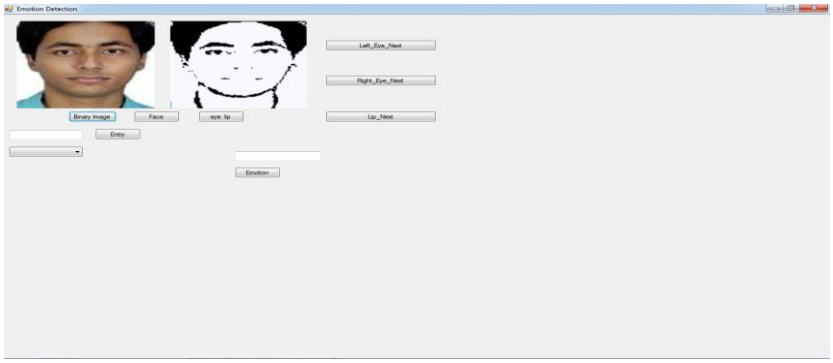

Figure 5. Original images and synthetic images

When viewing all possible rectangular regions in the face images as a kind of features, region selection becomes a nature idea to improve the performance of face recognition systems, just like other feature selection procedures. Nevertheless, neither eigenface nor eigenfeature seems to perform any selection procedure. In fact, the selection is unconsciously performed by the operators. It is up to the operators to determine which regions and how many of them should be used. Based on the common sense that facial features, such as eyes, nose and mouth, are crucial in face recognition, most algorithm designers choose to use the image regions around those salient facial features. But this is a very rough selection principal, which has at least two defects. First, although these facial features are salient in human faces, they are not guaranteed to be the most discriminative features. Second, even these features are the most discriminative ones, no one knows how to take full advantage of them. For example, it is uncertain whether the two eyes should be put into the same rectangle like Figure 1 (a), or Figure 1 (b). Consequently, automatic image region selection algorithm should be designed for face recognition.

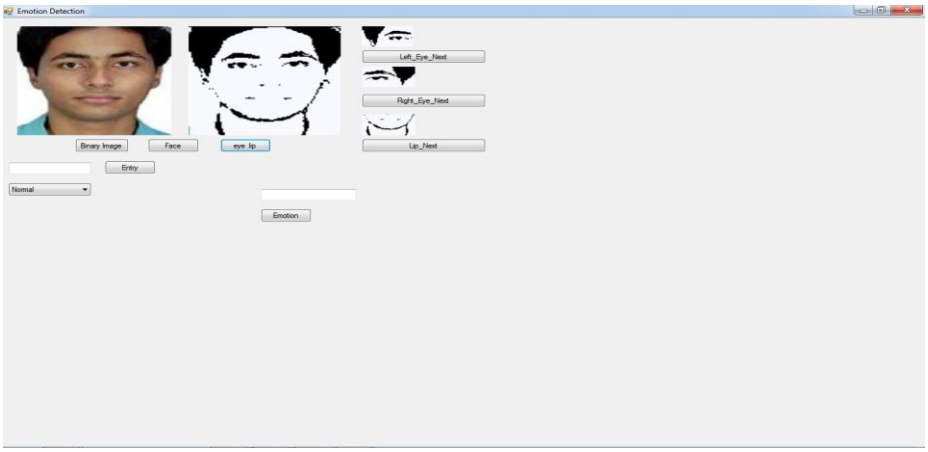

Figure 6. Face Detection and Tracking

The human face poses even more problems than other objects since the human face is a dynamic object that comes in many forms and colors. However, facial detection and tracking provides many benefits. Facial recognition is not possible if the face is not isolated from the background. Human Computer Interaction (HCI) could greatly be improved by using emotion, pose, and gesture recognition, all of which require face and facial feature detection and tracking [2]. Although many different algorithms exist to perform face detection, each has its own weaknesses and strengths. Some use flesh tones, some use contours, and other are even more complex involving templates, neural networks, or filters. These algorithms suffer from the same problem; they are computationally expensive [2]. An image is only a collection of color and light intensity values. Analyzing these pixels for face detection is time consuming and difficult to accomplish because of the wide variations of shape and pigmentation within a human face.

IV. LEARNING COMPONENTS:

However, it is not clear what exactly the size and shape of these components should be and whether there are other components which are equally important for recognition. Furthermore, this can be accomplished by an algorithm for learning components which was developed in the context of face detection. The algorithm starts with a small rectangular component located around a preselected point in the face. The component is extracted

from each face image build a training set. A component classifier is trained according to the one-vs-all strategy. The components of one person are trained against the components of all other people in the database. We estimate the prediction error of each component classifier by cross-validation. To do so, we extract the components from all images in the cross validation set based on the known locations of the reference points. Analogous to the training data, the positive cross validation set includes the components of one person and the negative set includes the components of all other people.

V. EXPERIMENTS & RESULTS:

5.1 Training Classifiers for Facial Features:

Detecting human facial features, such as the mouth, eyes, and nose require that Haar classifier cascades first be trained. In order to train the classifiers, this gentle AdaBoost algorithm and Haar feature algorithms must be implemented. The OpenCV library is designed to be used in conjunction with applications that pertain to the field of Human Computer Interaction, robotics, biometrics, image processing, and other areas where visualization is important and includes an implementation of Haar classifier detection and training [8]. To train the classifiers, two set of images are needed. One set contains an image or scene that does not contain the object, in this case a facial feature, which is going to be detected.

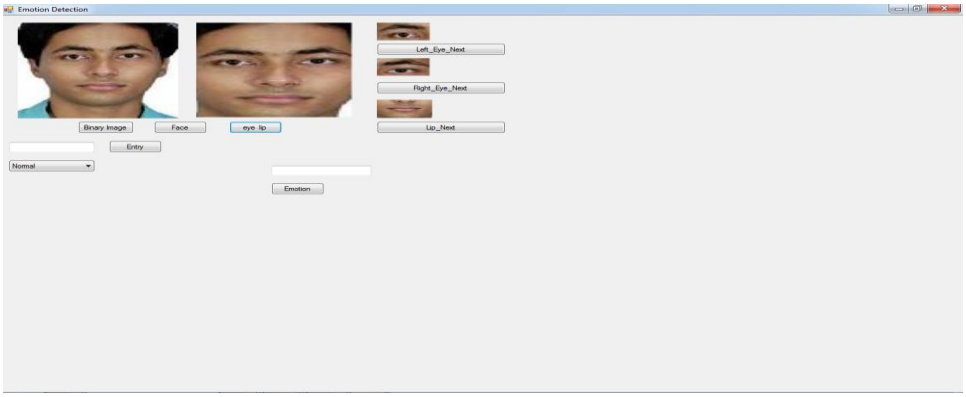

Figure 7. Robust facial feature detection

This set of images is referred to as the negative images. The other set of images, the positive images, contain one or more instances of the object. The location of the objects within the positive images is specified by: image name, the upper left pixel and the height, and width of the object. For training facial features 5,000 negative images with at least a mega-pixel resolution were used for training. These images consisted of everyday objects, like paperclips, and of natural scenery, like photographs of forests and mountains. In order to produce the most robust facial feature detection possible, the original positive set of images needs to be representative of the variance between different people, including, race, gender, and age. A good source for these images is National Institute of Standards and Technology's (NIST) Facial Recognition Technology (FERET) database. This database contains over 10,000 images of over 1,000 people under different lighting conditions, poses, and angles [10]. In training each facial feature, 1,500 images were used. These images were taken at angles ranging from zero to forty five degrees from a frontal view. This provides the needed variance required to allow detection if the head is turned slightly [1]. Three separate classifiers were trained, one for the eyes, one for the nose, and one for the mouth. Once the classifiers were trained, they were used to detect the facial features within another set of images from the FERET database and the accuracy of the classifier was then computed. With the exception of the mouth classifier, the classifiers have a high rate of detection. However, as implied by figure 7, the false positive rate is also quite high.

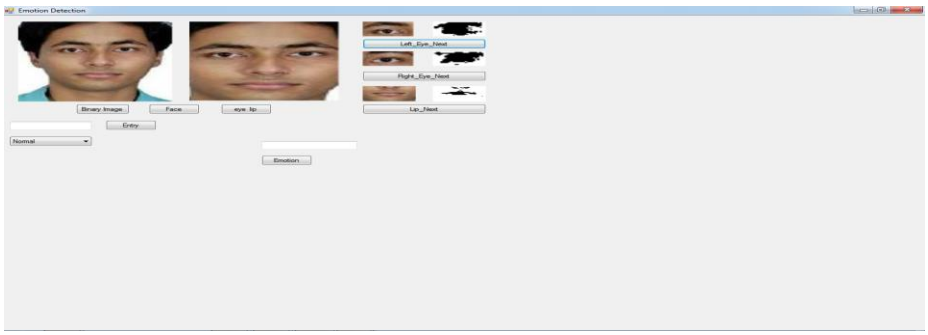

Figure 8. Classification of facial feature detection

Facial Feature	Positive Hit Rate	Negative Hit Rate
Eyes	93%	23%
Nose	100%	29%
Mouth	67%	28%

Table 1 Accuracy of Classifiers

VI. CONCLUSION

The first step in facial feature detection is detecting the face. This requires analyzing the entire image. The second step is using the isolated faces to detect each feature. Since each the portion of the image used to detect a feature is much smaller than that of the whole image, detection of all three facial features takes less time on average than detecting the face itself. Since a frame rate of detected feature using a much faster processor, regionalization provides efficiency in facial feature detection. Regionalization also greatly increased the accuracy of the detection. All false positives were eliminated, giving a detection rate of around 95% for the eyes and nose. The mouth detection has a lower rate due to the minimum size required for detection. By changing the height and width parameter to more accurately represent the dimensions of the mouth and retraining the classifier the accuracy should increase the accuracy to that of the other features. With the successful detection of facial features, the next goal is to research the ability for more precise details, like individual points, of the facial features to be gathered. These points will be use to differentiate general human emotions, like happiness and sadness.

REFERENCES

[1] Turk M, Pentland A. Eigenfaces for recognition. Journal of Cognitive Neuroscience, 1991, 3(1): 71-86.

[2] Moghaddam B, Pentland A. Probabilistic visual learning for object representation. IEEE Transactions on Pattern Analysis and Machine Intelligence, 1997, 19(7): 696-710.

[3] Jollie I T. Principal Component Analysis. New York: Springer-Verlag, 1986.

[4] Moghaddam B, Jebara T, Pentland A. Bayesian face recognition. Pattern Recognition, 2000, 33(11): 1771-1782.

[5] Pentland A, Moghaddam B, Starner T. View- based and modular eigenspaces for face recognition. In Proceedings of the IEEE Confer- ence on Computer Vision and Pattern Recognition, Seattle, WA, 1994, pp. 84-91.

[6] Brunelli R, Poggio T. Face recognition: feature versus templates. IEEE Transactions on Pat-tern Analysis and Machine Intelligence, 1993, 15(10): 1042-1052. 17

[7] Zhou Z-H, Wu J, Tang W. Ensembling neu-ral networks: many could be better than all. Arti¯cial Intelligence, 2002, 137(1-2): 239-263.

[8] Penev P S, Atick J J. Local feature analysis: a general statistical theory for object representation. Network: Computation in Neural Sys- tems, 1996, 7: 477-500.

[9] Yang P, Shan S, Gao W, Li S Z, Zhang D. Face recognition using Ada-Boosted Gabor features. In: Proceedings of the 6th Interna- tional Conference on Automatic Face and Ges-ture Recognition. Seoul, Korea, 2004, pp. 356-361.

[10] Krogh A, Vedelsby J. Neural network ensem- bles, cross validation, and active learning. In: Tesauro G, Touretzky D, Leen T, eds., Ad- vances in Neural Information Processing Systems 7, Cambridge, MA: MIT press, 1995, pp. 231-238.

Author Profile

Dr.V.S. Manjula has Completed MCA, M.Phil., B.Ed., Ph.D and She received Ph.D degree in Computer Science from Bharathiar University in 2013. She worked in Head in MCA Department, Gurushree Shantivijai Jain College, Chennai. At present she is working in Associate Professor and Head of the Department of Information System and Network Engineering in St. Joseph University College of Engineering & Technology, Dar-Es-Salaam in Tanzania, East Africa. She is a Research Supervisor in Information & Communication Technology (ICT) in St. Eugene University in Zambia and she is a member of Research Journal of International Association of Computer Science & Information Technology (IACSIT). She has published more than 11 International Journals and National & International Conferences.

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Determination of Heavy Metals in Fruit Spices

EZIGBO, VERONICA OBIAGELI
Department of Pure and Industrial Chemistry Anambra State University Uli, Nigeria

ABSTRACT: *The concentrations of some heavy metals such as lead (Pb), Cadmium (Cd), Cobalt (Co0 and Selenium (Se) present in common fruit spices available at local markets in Nigeria were determined using Atomir Absorption Sprectrophotometry (AAS). The study showed differences in metal concentrations according to the locations. The concentration of lead (Pb) ranged from trace to 12-30 mgkg^{-1} on dry weigh basis where as that of cadmium (Cd) was ranged from 1.20 mgkg^{-1} to 3.00 mgkg^{-1}.The concentration level of cobalt was from zero to 0.60 mgkg^{-1}. While variable levels of selenium were detected from zero to 12.05 mgkg^{-1}. Some of these concentrations are above the standard limit approved by WHO and FAO. No risk from daily intake of the most of fruit spices under study for hazardous Pb, Cd, Co and Se if the human take about 20g of spices per day. But there are dangerous from thyme and ginger for lead.*

Key words*: Atomic Absorption Spectrophotometer, Cadmium, Cobalt, Heavy metals, Lead, Selenium* **.**

I. INTRODUCTION

Spices are dried parts of plants, which have been used as diet components often to improve color, aroma, palatability and acceptability of food. They consist of rhizomes, barks, leaves, fruits, seeds, and other parts of plant [1] Most of these are fragrant, aromatic and pungent. The bulk of the dry material of spices contains carbohydrates, and organic compounds having diverse functional groups. The addition of spices that may be contaminated with trace and heavy metals to food as a habit may result in accumulation of these metals in human organs and lead to different health troubles.

The wide spread of contamination with heavy metals in the last decades has raised public and scientific interest due to their dangerous effect on human health [2] This has led researchers allover the world to study the pollution with heavy metals in air, water and foods to avoid their harmful effect [3] and to determine their permissibility for human consumption. Heavy metals are those with atomic weights from 63.546 to 200.590 [4] and specific weight higher than 4 (Connell *et al;* 1992). These metals may reach and contaminate plants, vegetables, fruits and canned foods through air, water, and soil during cultivation [5], [6], [7] and also during industrial processing and packaging [8] Thus several studies were done to determine the concentration of heavy metals in spices, dry fruits and plant must[1],[2],[5] and to study their dangerous effects. Subjecting to trace and heavy metals above the permissible affect the human health and may result in illness to human fetus, abortion and preterm labor, and mental retardation to children. Adults also may experience high blood pressure, fatigue and kidney and brain troubles (FAO 1984). Our country Nigeria cultivate spices among a lot of food stuff from. These spices may be subjected to contamination by way or more as described above. We are not aware of published data or results about the contamination and concentration of trace and heavy metals in spices available in the local markets of Ihiala except that of [9] and[10] , which were done for a very few kinds of spices. The objective of this work is to estimate the levels of some heavy metals (lead, cadmium, cobalt, and selenium that may be present in spices available in local markets in Ihiala town. Also, the levels of investigated metals were recommended by the international Organization FAO and WHO).

II. MATERIALS AND METHODS

Spices samples were collected from local markets, recognized and classified according to their English name, Scientific name (Table 1). Sample origin is not specified.

SAMPLE PREPARATION

Samples were cleaned and oven-dried at 80^{o}C for approximately 12 hours before chemical analysis. The dried samples were ground in a wooden morta till obtaining fine particles that pass through a 0.5mm mesh and kept dry for analysis.

Table 1: Scientific and Common names of Studied Spices

Common Name	Scientific Name	Family
Black pepper	Capsicum nigrium	Piperaceae
Ginger	Zingiber afficenalis	Zingibera Ceae
Garden sage	Salvia officinalis	Labiatae
Thyme	Thymus vulgaris	Labiatae
Nutmeg	Myristica frangrance	Myristicaceae

III. DETERMINATION OF METAL CONCENTRATION

For determination of heavy metal concentrations, a wet digestion of the dried samples was done according to the method described [10] using concentrated H_2SO_4 and 30% H_2O_2 mixture. To a 0.5g of dry ground sample placed in 100m beaker, was added 3.5m of 30% H_2O_2. The content of the beaker was heated to 100^{o}C and the temperature was gradually increased to 250^{o}C and left at this temperature for 30 minutes. The beaker was cooled and more 1ml of 30% H_2O_2 was added to the digestion mixture and the contents were reheated again. The digestion process was repeated more than one time until clear solution was obtained. The clear solution was transferred into 50ml volumetric flask, and completed to the mark with double distilled deionised water. A blank digestion solution was made for comparison. A standard solution for each element under investigation was prepared and used for calibration. Metal measurement was performed with a Perkin-Elmer Model 2380 Atomic Absorption Spectrometer, double beam and deuterium background correction. Hollow cathode lamps of Pb, Cd, Co and Se were used at specific wave length of every metal. Measurements were done against metals standard solutions. The daily intake (mg kg^{-1} day $^{-1}$) was calculated based on these suppose.

1. The human weight is 50kg and
2. The human intake from spices per day is 20g.

The daily intake (mg kg $^{-1}$ day $^{-1}$) = metal concentration in spice x 20/1000/50.

IV. RESULTS AND DISCUSSION

Table 2: Elements Concentrations (mg kg $^{-1}$) on dry weight basis of studied common spices Elements mg kg -1 on dry weight bases elements.

Spices Name	Pb	Cd	Co	Se
Capsicum nigrum	nd	nd	nd	nd
Zingiber afficenalis	0.58	0.06	0.30	nd
Salvia officenalis	nd	nd	nd	4.20
Thymus vulgaris	0.85	nd	0.63	6.60
Myristica fragrance	nd	0.04	nd	nd
Standard limit	0.30	0.20	0.40	3.50

nd= Beyond detectable limit

The contents of Pb, Cd, Co and Se in different common spices were presented in Table 2. The values of metal concentrations were compared with the maximum permissible concentration of 0.30, 0.2, and 3.50 mgkg $^{-1}$ for Pb, Cd, Co and Se respectively as recommended by Codex Alimentarius Commission [13] . The lead contents of different samples are given in Table 2. As comparing with standard limit the thymus vulgaris has the highest content of lead (0.85 mg kg $^{-1}$) that exceeds the standard level recommended by [13] (0.30 mgkg^{-1}). Sample of zingiber afficinalis also contained higher concentrations of lead (0.58 mg kg $^{-1}$) than that recommended by [13] However, zero readings were obtained for salvia officinalis and Myristica fragrance.

As shown in Table 2, the concentrations of Cadmium of all the samples under investigation were under the maximum permissible concentration (0.20 mgkg^{-1}) of cadmium [13] The amound of cadmium was in the range 0.04 mgkg^{-1} in myristica fragrance to 0.06 mgkg $^{-1}$ for zingiber afficinalis. This presence of cadmium might be due to the use of cadmium containing phospheha fertilizers, or from the practice of growing these plants on soil amended with sewage sludge, or both. However, other samples like capsicum nigrum, salvia officinalis and thymus vulgaris show no detectable amount of cadmium. These results agree with what was reported earlier [12] that lead concentration in food products ranged from undetectable levels to a few mgkg-1 of wet weight. Varied level of cobalt concentration were found as shown in Table 2. Samples of capsicum nigrum, Salvia officinale, and myristica fragrance are free from cobalt while the rest of the samples contained variable amount of cobalt 0.30 – 0.63 mgkg^{-1}.

The levels of selenium are given in Table 2. The data shows variation in concentration of selenium for the investigated spices. Thus zero readings were obtained for capsicum nigrum, zingiber afficenalis and myristica fragrance. The rest of samples contained amount in the range 4.20 mgkg^{-1} in salvia officenalis to 6.60 mgkg^{-1} in thymus vulgaris. The concentration of these two samples exceeded the recommended [13] level (3.50 mgkg-1).

The results in Table 3 showed that no risk from daily intake of the most of spices under study for hazardous Pb, Cd, Co and Se if the human intake is about 20g of spices per day. But there are dangerous from thymus vulgaris and zingiber afficenails for lead.

V. CONCLUSION

In conclusion, according to [14] the minimal risk levels for hazardous Pb, Cd, Co and Se through oral route and has acute effect are 0.0002, 0.0002, 0.01, 0.005 mg kg^{-1} day $^{-1}$ respectively. Whereas human needs from spices is very few grams per day there is no risk from used the spices under study in the food. And an also there should be thorough control for imported food stuff at customs to meet FAO/WHO recommendations and tolerable daily intake limits for heavy metals, and to avoid the passing for human consumption and prevent unknown disease.

Table 3: Daily Intake ($Mgkg^{-1}$ day $^{-1}$) more than 20g of metals of common spices effect based on 50g of human body.

Spices	Lead	Cadmium	Cobalt	Selenium
Capsicum nigrum	**No effect**	**No effect**	**No effect**	**No effect**
Zingiber afficenals	**Acute**	**No effect**	**No effect**	**No effect**
Salvia officenalis	**No effect**	**No effect**	**No effect**	**No effect**
Thymus vulgaris	**Acute**	**No effect**	**No effect**	**No effect**
Myristica fragrance	**No effect**	**No effect**	**No effect**	**No effect**

REFERENCES

[1] Wahid M; a Satter A, nd Durrani S. K. (1989) Concentration of selected heavy metals in spices, dry fruits and plant nuts. Pland Foods for Human Nutrition. 39 (3) 279 – 286.

[2] Gilbert, J. (1984): Analysis of food contamination Elsevier App. Sci. Pups London 1.

[3] Zakrzewski, S. F. 1991. Principle of environmental toxicology. ACS

[4] Kennish, M. J. 1992. Ecology of Estuaries. Anthropogenic effects. (RC Press, Inc. Boca Raton, F/. Nitrates, Nitrites and N-nitroso compounds. Geeneva, World Health Organization, 1978 (Environmental Health Criteria 5).

[5] Husain, A. Baroon Z. Al-klalafawi, S. Al-Ati T. and Sawaya W. (1995): Heavy metals in fruits and vegetables grown in Kuwait during the oil well fires. Arab Gulf J. Sci Research 13: (3) 535 – 542.

[6] Ozores Hempton M. Hanlon E; Bryan, H and Schaffer B. (1997): Cadmium, Copper Lead, nickel, and zinc concentrations in tomato and squash grown in MSW compost-amended calcareous soil. Compost Sci. and utilization 5: (4) 40 – 45.

[7] Geert, E. W. Van Loon Johannes, and T. Kars. 1989. Heavy metals in vegetables grown in the Netherlands and in domestic and imported fruits, Z Lebensm unters Forsch 190:34-30.

[8] Tsoumbaris, P. and Tsoukali – Papadopoulon H (1994): Heavy metals in common food stuff quantitative analysis. Bulletin of environmental contamination and toxicology. 53: part 1. Pp. 61-66.

[9] Selim, A. I. Al-Jasser M. S. and A-Eed M. A. 1994. The fatty acids composition and the chemical characteristics of some umbelliferae spices. Annals of Agric.

[10] Al-Eed, M. A., Al-Jasser M. S. and Selim A. L. (1997): The chromatographic determination of fatty acids content and the chemical characteristics of some Saudi spices. J. Agric. Sci. Mansoura. Univ; 22(5): Sci. Moshtohor. 32 (4): 1995 – 2004.

[11] Oehme, F. W. (1989): Toxicity of heavy metals in the environment. Marcel Dekker, Inc. New York, Part 1, 1.

[12] Waldraw, H. A. Stofen, D. (1974) Sub-dionical lead poisoning. Academic Press, London.

[13] FAO/WHO 1984. Joint FAO/WHO Food Standards Program, Codex Alinientarius Commission Contamination. CAC/Vol. XVII. FAO, Roma and WHO, Geneva

[14] ATSDR (2001): Agency for toxic substances and disease registry. From web of http://www.absdr.cdc.gov/mrls. html Professional reference book, Washington, DC,

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Characterization and Utilization of castor bean seed oil extract for production of medicated soap.

Abdulrasheed A.[1], Aroke U. O.[2], Muazu M.T.[3]
Department of Chemical Engineering Abubakar Tafawa Balewa University, P.M.B. 0248, Bauchi state, Nigeria.

ABSTRACT: *The research work is to investigate the potential utilization of castor bean seed oil extract in the production of medicated soap. The oil was extracted via soxhlet extractor using hexane as solvent. The characterization analysis reveals the acid value and saponification value of the oil which were between the ranges of values specified by ASTM. The soap produced gave a pH of (8.9), foam height (16cm), alcohol insoluble (3.45%), moisture content (4.2%) and free acidity of (0.10). The antibacterial activity of soap produced from castor oil on bacteria isolate (Staphylococcus Aureus) was promising with an inhibition zone of 15.5mm but at dilutions of 10^{-1}, 10^{-2} and 10^{-3} , were found to be 11.5mm, 9.5mm and 6mm respectively. This shows that as concentration decreases, the sensitivity of the soap to the bacteria isolate also decreases. The sensitivity of the medicated soap to the bacteria isolate is as a result of the presence of ricinoleic acid present in large proportion in the fatty acid composition of castor oil. It can be concluded that a highly effective soap can be produced from castor bean seed oil extract.*

Keywords *- castor bean seed, characterization, medicated soap, solvent extraction, and staphylococcus aureus.*

I. INTRODUCTION

Castor plant, *Ricinus communis*, is a specie of flowering plant in the spurge family, Euphorbiaceae. Its seed is the castor bean which, despite its name, is not a true bean. Castor plant is indigenous to the southeastern Mediterranean Basin, Eastern Africa, and India, but is widespread throughout tropical regions (Phillips & Martyn, 1999). Castor bean is cultivated for the seeds which yield viscous, pale yellow non-volatile and non-drying oil. It has been used only for industrial and medicinal purposes (Ogunniyi, 2006; Ramos *et al*, 1984). Castor oil is one of the few naturally occurring glycerides with high purity, since the fatty acid portion is nearly 90% of ricinoleic (Akpan *et al*., 2006).The crude oil has district odour but can easily be deodorized in the refining process like any other vegetable oil. Castor oil has an advantage over other mineral oils in that it is biodegradable, eco-friendly and renewable resource (Ogunniyi, 2006).

The presence of ricinoleic acids, oleic acid, palmitic acid, stearic acid and dihydroxylstearic acid in castor seed oil is an indication of good quality that can be utilized for use in cosmetics and soap industries. Compared with the common vegetable oils, castor oil is more viscous, less soluble in hexane and more soluble in ethanol, all as a consequence of the presence of the hydroxyl acid (Abitogun *et al*., 2009). Apart from soap, it is the earliest anionic surfactant (Gunstone, 2005). One of its uses is in the manufacture of transparent soaps (Kochhar, 1998). Its major fatty acids are the unsaturated fatty acid, hydroxylated 12-hydroxy, 9-octadecenic acid known familiarly as the ricinuleic acid (RNA). The fatty acid composition of a typical castor oil contains between 87-90% ricinoleic acid. Thus the oil can be used in the production of vanishes, lacquers, protective coatings, lubricants, soaps, paints, inks and it is a primary raw material for the production of nylon and other synthetic resins (Wiley and Oeitmann, 1991). The ricinoleic acid is anti-microbial and has antibacterial, antiviral, anti-fungal, anti-inflammatory and analgesic properties. Its antifungal properties in particular have been traditionally used to inhibit the growth of fungus and fight yeast infections (Robertus, 1991).

Seeds other than castor bean seed had been a source for production of medicated soap but with different anti-microbial properties as carried out by Abdulrasheed et al. (2015) where carrot seed was used due to anti-fungal properties specifically on Trichophyton rubrum. The objectives of this research are to extract oil from castor bean seed through solvent extraction using hexane as the solvent, determine physicochemical characteristics of the oil extracted, produce medicated soap from the extracted oil and carry out quality control assessment on the soap produced to ensure it is within stipulated industrial and market standard. The research gap is the utilization

of oil from castor bean seed which is non edible not just for soap production but one with medicinal efficacy specifically for bacteria growth inhibition.

A large variability of seed oil percentage was observed, ranging from 39.6% – 59.5%. Whereas Ogunniyi (2006) found out that mechanical pressing will remove about 45% of the oil present and the remaining oil in the cake can be recovered only by solvent extraction.

II. MATERIALS AND METHODS

A. Preparation of beans

The castor beans obtained were first cleaned which was done manually. Hand cleaning was performed to remove foreign materials such as sand, sticks, stems and leaves. The cleaned beans were dried in the sun until the casting splits and the seeds are shed. These beans were further oven dried at 90^{o}C to a constant weight which further reduces the moisture content initially by 5-7% (Doan, 2004). The next step is winnowing, where the chaff was separated from nibs (Cotyledon) by blowing in a tray to promote high oil recoveries. The seeds were then crushed and ground using mortar and pestle to rupture cell walls for easy and efficient oil extraction.

B. Oil extraction

About 5g of dry ground seeds were first oven-dried at 105°C for 1 hour. The samples were refluxed for 6 hours in mild temperature (55-60°C) in a Soxhlet extractor using hexane as solvent. The solvent was then separated from the oil extracted by evaporation in a rotary evaporator. The extracted oil was kept in an oven at 60°C for 30 minutes after which was accurately weighed. The extracted seed oil was kept in a closed container and stored in a refrigerator at 4°C for further use.

C. Oil Characterization

In the characterization of extracted oil, the following physicochemical properties of the castor seed oil extract were determined:

(1) Specific Gravity

The specific gravity was calculated by dividing the oil density by the density of water (1000 kg/m^{3}) as presented in Equation (1) (TSE, 1971).

$$Specific\ gravity = \text{density of oil} / \text{density of water} \quad (1)$$

(2) Oil yield

5g of the sample was placed in the thimble and about 250ml of normal hexane was poured into the round bottom flask. The apparatus was heated at 60^{o}C and allowed for 10 hours continuous extraction. The solvent was finally distilled and the percentage of oil extracted was determined.

(3) Boiling Point

The boiling point of the oil was determined by heating the oil in a beaker placed on a heating mantle. The oil was observed carefully in the presence of a thermometer, immediately the oil started agitating and bubbling, the temperature on the thermometer was read and recorded as the boiling point of the oil.

(4) Refractive index

Few drops of oil sample were transferred into the glass slide of the Refractometer. Through the eyepiece of the Refractometer, the dark portion viewed was adjusted to be in line with the intersection of the cross. At no parallax error, the pointer on the scale pointed to the refractive index. This was repeated thrice using different oil samples. The average was taken and recorded.

(5) Peroxide value

This value is determined by titration. 5g of oil sample was transferred into a conical flask. 30 mL solution of Chloroform and Acetic acid mixture in the ratio 2:3 were added to it. The test was performed in an oxygen starved environment by passing nitrogen across the sample to remove residual oxygen. The solution was then saturated with potassium iodide to release free iodine which was titrated against 0.01 mol/L sodium thiosulphate. The peroxide value was determined from the titration volume of sodium thiosulphate as calculated in Equation (2).

$$\text{Peroxide Value (meq/g)} = (EP1 - BL1) \times TF \times R/SIZE \quad (2)$$

Where EP1 = Titration volume (mL)
BL1 = Blank Level (0.00mL)

TF = Factor of Reagent (1.006)
R = Constant number (10)
Size = Sample size (g).

(6) Acid Value

5g of oil sample was weighed into clean conical flask and mixture of 25 ml diethyl ether and 25 ml ethanol was added and used to dissolve the oil in the mixed neutral solvent. 1 ml of phenolphthalein added and the solution was carefully titrated with 0.1N KOH.

The acid value is calculated as thus in Equation (3);

$$Acid\,Value = MW\ X\ N\ X \frac{V}{M} \quad (3)$$

Where MW= molecular weight of KOH (g).
N = normality of KOH (mol/L)
V = volume of KOH used (L).
M = mass of the sample (g).

(7) Saponification Value

Using Indicator method, 2g of oil sample was weighed into a conical flask; 25ml 0.1N KOH was then added. The content was constantly stirred and allowed to boil gently for 60minutes. A reflux condenser was placed on the flask containing the mixture. Few drops of phenolphthalein indicator was added to the warm solution and then titrated with 0.5N HCL to the end point until the pink colour of the indicator just disappeared. The same procedure was used for the blank (Saad *et al*, 2007). The expression for saponification value (S.V) is shown in Equation (4).

$$\text{Saponification Value} = MW \times N\ (V_0 - V_1)/M, \quad (4)$$

Where
V_0 = the volume of the solution used for the blank test (L).
V_1 = the volume of the solution used for determination (L).
M = mass of the sample (g).
N = Actual normality of KOH (mol/L)
MW = Molecular Weight of KOH (g).

D. Soap Production

Two types of soap: Test soap (TS) and control soap (CS) were produced following the same steps only that castor seed oil extract was incorporated into TS while CS was not fortified with the extract. A commercial Antibacterial soap (Dettol) regarded as standard soap (SS) was purchased.

Production Steps

The fully boiled process was applied in the process of the soap preparation. 100 g of oil mixture (40% castor oil, 60% coconut oil) was measured and placed into a 500cm^3 beaker. It was warmed at 60^0C in order to quicken the reaction between alkali and fat. A calculated amount of NaOH was weighed and a fixed amount of distilled water was added to prepare aqueous NaOH solution. The caustic soda was stirred well using a stirring rod until it blends and completely dissolves in the distilled water. The aqueous NaOH solution was poured gradually into the oil mixture in the beaker and stirred gently in one direction to enhance thorough mixing of the alkali and fat. The beaker was insulated to prevent the fat from hardening and then heated at 60^0C for 30 minutes in order to achieve complete saponification. Once the alkali-oil mixture becomes pasty and starts to boil, it was poured into the mould and left to solidify.

II. SOAP CHARACTERIZATION

Standard analyses carried out on the soaps are:

- ***PH VALUE***

The pH meter was calibrated using buffer solution of pH between 4.0 and 7.0, thereafter it was dipped directly into the sample while the reading was taken immediately (Moulay et al., 2005).

- ***MOISTURE CONTENT***

10g of soap was weighed and reweighed after open heating for about 30minutes. The difference in weight gives the moisture content which is expressed in percentage (Moulay et al., 2005).

- ***FREE ACID CONTENT***

6g of soap sample was dissolved in 70ml hot neutral alcohol and titrated against 2M H_2SO_4 using phenolphthalein indicator (Moulay et al., 2005).
The free alkali/acidity was calculated as;

$$\text{Free acid content} = \frac{3.1MV}{W} \quad (5)$$

where:
M – Molarity of H_2SO_4 solution, $mol \cdot L^{-1}$;
V – Volume of H_2SO_4 solution used in titration, ml;
W – weight of the soap sample

- ***FOAM HEIGHT***

2g of soap was dissolved in a liter volumetric flask and made to mark with tap water, 50ml of the solution was introduce into a measuring cylinder such that it followed the walls of the column to avoid foaming. 200ml of the solution was taken in a conical flask and poured into a funnel, which was already clamped with the outlet closed. The measuring cylinder was then put directly beneath the funnel while the level (height) of the foam generated was read from the cylinder immediately the funnel outlet was opened (Moulay et al., 2005).

- ***ALCOHOL INSOLUBLE***

5g of soap sample was dissolved in 50ml hot alcohol and quantitatively transferred to already weighed filter paper; the residue was dried in oven at 105^0C for 30minutes, cooled in desiccators and weighed again (Moulay et al., 2005).

- ***ANTIMICROBIAL TEST***

The microorganism used in this study was staphylococcus aureus and the isolate was obtained from Abubakar Tafawa Balewa University Teaching Hospital Bauchi, Nigeria. Three soap samples (TS, CS and SS) 1 g/10mL were prepared and dilutions to (10^{-1}, 10^{-2} and 10^{-3}). Mueller Hilton aggar media was prepared for 9 plates (three plates for each test sample). From each prepared concentrations, 2ml of soap solution was transferred into a 6 mm bored well in a solidified Mueller Hinton Agar (MHA) plate which has been inoculated with the test isolate via streaking technique. Plates were kept for 30 min before incubation at 37^oC for 24 hours.The extent of susceptibility was recorded as clear zones of inhibition around the wells. The experiment was repeated three times for each test and average recorded.

III. RESULTS AND DISCUSSION

A. EXPERIMENTAL RESULTS

Table 1: Physiochemical Characteristics of castor bean seed oil.

Parameter	Value	Standard (ASTM, 2002)
Specific gravity	0.910	0.957-0.968
Refractive index	1.469	1.476-1.479
pH	6.11	-
Boiling point (^{O}C)	131	131
Oil yield (%)	47	-
Colour	Amber	Amber
Moisture (%)	0.30	-
Acid value (mgKOH/g of oil)	1.14	0.4-4.0
Saponification value (mgKOH/g of oil)	177	175-187
Peroxide value (meq/kg)	9.73	-

Table 2: Characteristic tests on produced Test soap (TS)

Parameter	Value	Standard (SON) (Nangbes *et al*, 2013)
Moisture content (%)	4.2	-
Hardness	Very hard	-
pH	8.9	6.5-8.50
Alcohol Insoluble (%)	3.45	≤2
Free Acidity	0.1	-
Foam Height (cm)	16	-

Table 3: Antimicrobial Effect of Soaps on Staphylococcus Aureus.

	Diameter of zone of inhibition (mm)			
	Stock (1g/10ml of soap)	Dilutions		
		10^{-1}	10^{-2}	10^{-3}
TS	15.5	11.5	9.5	6
CS	9.5	5.5	2	
SS	19.5	14.5	13	10.5

B. DISCUSSION OF RESULTS

Table 1 presents the result of the yield and physic-chemical parameters of castor bean seed oil. The result obtained for the percentage oil yield was 47%. This value falls within the range value of 30-55% as reported by Aldrich, (2003). The moisture content of the crude oil was 0.30% the low moisture content is as a result of effectiveness of the distillation apparatus used for oil recovery. Again, the low moisture content is an indication of good shelf life characteristics. The specific gravity was 0.910, which was a little below the value (0.948) as reported by Salunke & Desai (1992). The refractive index analysis showed a value of 1.4686. Comparing this result with the ASTM values that ranges from 1.476-1.479 (ASTM, 2002), a little difference is noticed. However, this little difference can be considered being within an acceptable experimental error range that can be attributed to the presence of some impurities and other components of the crude oil mixture. Thus, the refractive index of the crude castor oil was in accordance with ASTM specification.

Also, the pH value of the crude oil which was found to be 6.11 indicates that the oil is a little slightly acidic. Its boiling point was found to be 131^0C. The saponification value of oil was 177 mg KOH/g oil. The saponification value reveals how many milligrams of base required to completely saponify 1 gram of the oil or fat. The oils with high saponification value are considered to make better quality soaps than those with low saponification value. This value means that 177 mg of KOH is required to saponify 1000 mg of castor oil. This projects the oil as good in areas of soap making and in detection of adulteration in the oil. However, it was within the range value of 156 to 185 mg KOH/g oil reported by Weise (1983) and is found within the range 175-187 as specified by ASTM. The peroxide value was found to be 9.73 Meq/kg. Acid value was also determined as 1.14. The low peroxide value of the oil shows that the oil is less prone to rancidity and thus, stable. The lower the acid value, the lower the deterioration or rancidity of the oil. An increase in acid value results to increase in rancidity. The saponification value and acid value were in conformity with the range of values specified by the American standard for testing and materials (ASTM, 2002).

Table 2 presents the characteristic properties and quality criteria of medicated soap produced. The pH value of the medicated soap produced was 8.9 indicating the alkalinity of the soap, this value was slightly above the range 6.5-8.5 as specified by standard organization of Nigeria (SON) (Nangbes *et al*, 2014), foam height in castor oil soap was 16 cm, and this could be trace to the type of oil (coconut oil) which is known for its high formability due to the presence of lauric acid which constitute 50% of the total fatty acid in the oil. The value of alcohol insoluble is 3.45 which show the crudity of castor oil soap because no much builder, ingredients was

incorporated in the soap production process, it was above the SON recommended value of ≤2.00 (Nangbes *et al*, 2014). The moisture content was 4.2% and the value of free acidity was also found to be 0.10. The soap produced was hard due to presence of coconut oil.

Table 3 shows the microbial sensitivity of different soaps considered on (Staphylococcus Aureus) bacteria that is a common cause of jock itch, and Ringworm. The diameter of zone of inhibition of the soaps were measured and subsequently at various dilutions. For the stock solution (1g/10ml of each soap sample), the Test soap was sensitive with diameter of zone of inhibition 15.5mm but at a dilution of 10^{-1} , 10^{-2} and 10^{-3} it was found to be 11.5 mm, 9.5mm and 6mm. This shows that as concentration decreases, the sensitivity of the soap to the bacteria isolate also decreases. Moreover, the sensitivity of the medicated soap to the bacteria isolate is also as a result of the presence of ricinoleic acid present in large proportion in the fatty acid composition of castor oil.

`Also from Table 3, the microbial sensitivity of Coconut oil which is the control soap on (Staphylococcus Aureus) was evaluated. The diameter of zone of inhibition of the control soap was measured and subsequently at various dilutions; the soap was sensitive with diameter of zone of inhibition 9.5mm for the stock solution but at a dilution of 10^{-3} it was not sensitive to the bacteria isolate. Comparing the results of Test soap and Control soap, it was observed that castor oil has antibacterial properties due to increment observed in the inhibition zone of the medicated soap as compared to that observed control soap (coconut oil soap) with insignificant zone of inhibition. The microbial sensitivity of standard soap (Dettol antibacterial soap) on Staphylococcus Aureus was shown in Table 3. The diameter of zone of inhibition of the soap was measured and subsequently of various dilutions; the soap was sensitive with diameter of zone of inhibition 19.5mm for the stock solution but at a dilution of 10^{-3} it was found to be 10.5mm. The high sensitivity of the standard soap is as a result of chemicals such as triclocarban used as antibacterial agent in the soap which is effective in fighting infections by targeting the growth of bacteria such as (Staphylococcus Aureus).

IV. CONCLUSION

Castor oil soap was prepared from oil extracted from castor bean seed due to its high antiseptic properties. Quality parameters such as, alcohol insoluble, free acidity content, pH value and hardness were found suitable for production of Toilet/Bathing Soap. Antimicrobial activity of castor oil soap was tested against a bacteria isolate (staphylococcus Aureus) and was found sensitive.

REFERENCES

[1]. Phillips, R. and Martyn, R. (1999). *Annuals and Biennials*. London: Macmillan. P. 106. ISBN 0333748891.
[2]. Ogunniyi, D.S. (2006). Castor Oil: A vital industrial raw material. *Bioresource Technology* 97(9):1086-1091.
[3]. Ramos, L.C.D., Tango, J.S., Savi, A. & Leal, N.R. 1984. Variability for Oil and Fatty Acid Composition in Castor bean Varieties. Journal of the American Oil Chemists' Society. 61: 1841-1843.
[4]. Akpan, U.G., Jimoh, A. & Mohammed, A.D. 2006. Extraction, Characterization and Modification of Castor Seed Oil. *Leonardo Journal of Sciences* (8): 43-52.
[5]. Abitogun, A.S., Alademeyin, O.J., and Oloye, D. A. (2009). Extraction and Characterization of Castor Seed Oil. International journal of Nutrition and Wellness. 8:(2) 1-5.
[6]. Gunstone, F.D. (2005). Vegetable Oils in Bailey's Industrial Oil and Fat Products, 6th Edition, vol.1. Edited by Fereidoon Shahidi. John Wiley & Sons, Inc. pp. 224-225.
[7]. Kochhar, S. L. (1998): Economic Botany in the Tropics. 2nd Edition, Macmillan India Ltd. pp 354-355.
[8]. Wiley, R.G., and Oeitmann T.N., (1991): Ricin and related plant toxins: Mechanisms of action And Neurobiological Applications. Handbook of natural toxins (vol) 6, pp. 346-348.
[9]. Robertus, J.D., (1991)."The structure and action of ricin, A cytoxic N-glycoside" Seminar in cell biology 2: 23-30
[10]. Abdulrasheed A., Aroke U.O., Sani I. M. 2015. Parametric Studies of Carrot Seed Oil Extract for the Production of Medicated Soap. International Journal of Recent Development in Engineering and Technology. 4(1): 1-5.
[11]. Doan, L.G. 2004. Ricin: mechanism of toxicity, clinical manifestations, and vaccine development. A review of Journal Toxicology. 42: 201-208.
[12]. TSE, 1971. Analysis Methods of Vegetable Oil. TS 894. Turkish Standard Institute, Ankara-Turkey (Türkiye).
[13]. Saad B., Ling C.W., Jab M.S., Lim B.P., Ali A.S.M., Wai W.T., Saleh M.I. (2007). Determination of free fatty acids in palm oil samples using nonaqueous flow injection titrimetric method. Food Chem. 102: 1407- 1414.
[14]. Moulay, S., Zenimi, A., Dib, M., 2005. Rosin/Acid oil-based liquid soap. Journal of Surfactants and Detergents. 8(2): 169-174.
[15]. Nangbes, J. G., Nvau, J. B., Buba, W. M., & Zukdimma, A. N. (2013). Extraction and characterization of castor (Ricinus Communis) seed oil. The International Journal of Engineering and Science (IJES), 2(9), 105 – 109.
[16]. Aldrich (2003): Handbook of Fine Chemical Laboratory Equipment, Aldrich Chemical Company. Milwaukee, WI.
[17]. Salunke D.K. & Desai B.B., (1992): Post- harvest Biotechnology of oil seeds. Chemical Rubber Company (CRC) Press, pp.161-170.
[18]. ASTM, 2002. Petroleum Products, Lubricants and Fossil Fuels. Annual Book of ASTM Standards. ASTM International, West Conshohocken, PA. USA.
[19]. Weiss E.A., (1983) "*Oil seed crops"*, Tropical Agricultural series, p. 31-53, Longman.

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The Importance of Management Information Systems in Decision-Making Process in Najran University

Mohamed Sultan Mahasneh
Department of Business Administration, Najran University, Saudi Arabia,

Abstract: *Management information systems is very important for organizations especially decision-making process. This study is to answer the question related to the Importance of Management Information Systems on Decision-Making Process in Najran University, by exploring the role of management information systems in providing the necessary information to make decisions, the role of management information systems in decision-making, exploring the relationship of management information systems with decision-making process , and the impact of management information systems on the decision-making process in Najran University. The research proposes a model to evaluate the impact of Management Information Systems on Decision-Making Process in Najran University. The model was tested by using survey data collected from 56 of 84 Deans, Vice Deasn, General Managers and Managers. Descriptive analysis and t-test show the importance of management information systems on decision-making Process. The results show that there is a strong relationship and impact of management information technology on Decision-Making Process.*
Keywords*: Management Information Systems, Decisions Making Process.*

I. Introduction

In an era of technological revolution and increase the size of the organizations and their need for a huge amount of information, it has become inevitably these organizations use the management information systems that depends on the computer, for data processing and the production of information provided by these systems, and use them in the decision-making process by the decision makers in the centers of decision in organizations. Good information needed by the organization to be used in the decision-making process must be characterized by honesty, modernity and Availability at the suitable time to decision makers. The decision-making process depends on the availability of efficient and effective management information systems produce the information that lead to take the appropriate and rational decisions. Based on the above, the present study describes the nature of the study of the problem through the following questions:
What is the importance of management information systems in decision-making in Najran University?

The sub-questions are as follows:

Is there a relationship between the quality of information provided by the management information systems and the effectiveness of decision-making in the organization under study?

Is there a relationship between the uses offered by the management information systems and the effectiveness of decision-making in the organization under study?

Do the development of management information systems contribute in increasing the effectiveness of decision-making in the organization under study?

(Abu Galedah, 2013) stated that the management information systems have a role in decision-making in the institutions ranging between medium and high percentage, and providing the necessary information to make decisions between a medium degree of approval and effective percentage. There is a connection between the use of management information systems and the effectiveness of decision-making in the institutions under study, and affect the development of management information systems to increase the effectiveness of decision-making in the institutions under study with a high percentage.
(Hassani, 2013) stated that there are statistically significant relationship and impact between the quality of information and the effectiveness of decision-making.

(Al-Murad, 2012) The availability of the characteristics of precision, timing, confidence, comprehensiveness, reliability in the management information system in the surveyed organizations, and this is what contributes to this organization to perform its activities efficiently and effectively. And it has been associated with the success of the management information system in which the nature of the available properties, as the timeliness of the information, accuracy and comprehensiveness and its potential reliability to take all decisions make him a successful system.

(Bakens, 2010) the use of a project management information system is in fact advantageous to project managers and that there is no adverse effect of project and information overload on the quality of information. Improvements on the impact on decision making through the quality of information from PMIS were observed in terms of improved quality of the decisions, reduced time in making decisions, better allocation of resources and monitoring of activities. This study found moderate and strong relationships between the quality of the information, the project manager's satisfaction with PMIS, the use of the information and the impact on decision making.

(Alkhaffaf, 2012) The results shows that the easiness variable had the highest variance to measure the relationship among information systems and the quality of decision making, while the accuracy had the lowest variance. The study found that the accuracy of information was the most usable variable in the bank, while the appropriateness was the lowest usable variable in the study population, however; the risk variable was more usable in the bank that the participation variable, as for the quality of the information; time dimension was the most variable used in the bank. The result show a great influence of risk in decision making, where the degree of risk increases when increasing the difficulties of using information systems, this difficulties is usually faces managers in the high organizational levels and needs intuition, prediction or guesswork. The results also shows a great importance of the participation in decisions making.

(Asemi, et al., 2011) It was found that MIS is best suited to identify problems and help management to understand them to make suitable decisions.
(Heidarkhani et al., 2013) one of the leading causes of inefficiency and failure of organizations is, poor or inopportune decision making of organization management due to lack of sufficient information. This could be because of no enough attention to information, not providing proper infrastructure, and weakness in production, organization, storage and dissemination of appropriate information, valid, reliable, timely and complete. Management information systems increase the knowledge of managers and even specialists in different levels of an organization, with new concepts not only develop knowledge of what they are able to do and what decisions will be made. Rather, help them in better performing their responsibilities and activities.

(Freihat, 2012) There is a statistically significant relationship and positive impact between all of the components of making information system and decision-making in Jordanian shareholding medicines producing companies.

(Hassan et al. 2014) Managers in all levels of organization hierarchy need precise and suitable data and information to make decisions, and the employment of management information systems improves the efficiency and effectiveness of the decision-making process in the organization. Also Information Systems can be used to obtain updated information that could rely upon to make the future decisions.

(Alhazaymeh, 2009) The information provided by the management information systems and the effectiveness of management decision-making in the institutions have an impact milestone in the advancement of the sector, achieve the desired development and to get rid of backwardness and its effects and accelerate the processes in which the address input is quickly than traditional methods, and then get the mature output at less time. The use of management information systems to provide decision makers with the right information at the right time the information is more valuable to the organization and useful in decision-making and operations process, and then the greater the usefulness of the information have increased in value, this has a significant impact in increasing the gross domestic product , meet the demands and needs of beneficiaries and achieve the public interest.

(Ahmed, 2013) The management information systems are used by decision makers effectively in making administrative decisions due to the quality of the information generated by these systems, where the results showed that the vast majority of decision makers are mainly dependent on information systems in the case of management decisions. There is also a relationship between the appropriate information provided by the management information system and using these systems by managers in making administrative decisions, the study showed that there is a strong relationship and this means scientifically that the more appropriate information provided by the system the greater the use of the managers of these systems in their making their decisions.

This study contribute in providing a conceptual framework defines the concept of the nature of management information systems and decision-making process, highlighting the role of management information systems in providing necessary information for decision-making and determine the extent of the contribution of the development of management information systems in decision-making.

The research aims to achieve the following:
1. know the extent of using management information systems in the departments under study.
2. know how the management information systems provides information to decision-makers at departments under study.
3. know the nature of the relationship between management information systems and decision-making in departments under study.
4. know the impact of management information systems on making decisions in the departments under study.

II. Literature Review

2.1 Management Information System:

(Laudon & Laudon, P. 17) Define Management Information System as: "a set of interrelated components that collect (or recover) and processed and stored and distributed information to support decision-making, coordination, supervision and control of the organization." He knew (O'Brian & Markus, p. 13) Management Information System that: "Organization group of people, hardware, software, and communications networks, and resources data, policies and procedures that store, and recover, and turning, and disseminate information in the organization."
Management information systems is a system based on a computer for the purpose of providing information for managers to make decisions correctly based on timely, accurate and correct information depending on the activity of the organization. This information is provided to beneficiaries in the form of periodic reports and mathematical models for the purpose of assisting the decision-maker to solve the problems of the institution, and depends on the management information system database to provide the necessary information to support the decision-maker.

2.2 objectives of management information systems:

Depending on the previous definitions of management information systems, the goals of information systems seeks to achieve are as follows:
• Linking sub-systems of the organization together in an integrated system to allow the flow of data and information between those systems and leading to the achievement of coordination between the activities of those systems.

• To assist in linking the sub-systems of the organization goals with the overall objective of the organization and thus contribute to the achievement of this goal.

• Assistance and support in decision-making process at all organizational levels through the provision of reports to ensure that the information required for those decisions in a timely manner.

• Provide necessary information for the purposes of planning and control at the right place, time and format.

• Controlling of data and information handling and preservation process.

2.3 Approaches to the study of information systems:

There are multiple views on information systems show that the study of information systems is a multidisciplinary field, and there is no one theory or just one perspective, and even accurately be studied information systems, they must know these approaches, namely:
1. Technical approach: technical approach of the information systems focuses on mathematical models for the study of information systems, in addition to material technology and official capacity of these systems. And disciplines that contribute to the technical approach is computer science, management science, and operations research.

2. Behavioral approach: There is an important part of the field of information systems concerned with behavioral issues which arise through the development and maintenance of information systems and sustaining in the long term. Such as strategic business integration issues, design, implementation and use. Behavioral approach does not ignore the technology, as the information technology systems are often stimulating behavioral problem or issue. But the focus of this approach is generally not on the technical solutions, and instead focuses on the changes in attitudes and management, regulatory policy, and behavior (Kling and Dutton, 1982).

3. Technical Social approach: The academics and practitioners experience leads us to believe that there is no single perspective effectively that embodies the reality of information systems. Since the problems with systems and solutions are rarely completely technical or completely behavioral. So we have to understand the technical and behavioral approachs. (Laudon & Laudon, 2013) (Sultan, 2005)

2.4 Information Systems Development:

Development is defined as: "the application of the behavioral sciences related to planned in advance strengthening and development of the strategies and organizational structures and operations in order to improve the effectiveness of the organization." (Abawi 2006)

Development of management information systems defined as: "actions that are being taken for the establishment of an information system which solves the organizational problem." Laudon, K., & Laudon, J. 2010)) These include system analysis, system design, computer programming / implementation, system testing, system conversion, production and maintenance. These procedures are usually arranged in this order specified.

The development process usually begins with collecting data and information and locating bugs that provide precisely the exact place of the problem that is necessary to focus on, and locate the change in the organization to reduce this problem, whether these places (structures, culture, processes and individuals). (Abu Galethah2013)

Besides, there are reasons and needs for the development and design of information systems, which we offer are as follows:

• there is an error in the current system as a result of the failure of the system to record some operations or crash repeatedly.

• vision of senior management at its strategic planning to introduce a new information system gives the institution a competitive advantage, or that competitors used the new technology of information which represents a threat to the institution.

• development of information technology.

• evolution in the application properties.

2.5 The role of information system in decision-making:

The management information systems provide the appropriate information on the internal and external levels of management at all levels, so you can make effective decisions and temporary and do planning, control and direction within the organization process. The decision-making core of the administrative work of the Organization process, and is the relationship between goals and problem-solving and decision-making in that managers are responsible for setting goals to do its investigation, but during achieved some problems that prevent this show, and as a result they take a lot of decisions to overcome these difficulties. (Abu Galedah 2013)

2.6 The decision-making process:

(Harris, 2012) defined decision-making process as "a study of identification and selection of alternatives on the basis of values and preferences of the decision maker, and to reduce uncertainty and doubt enough to allow for a reasonable choice of alternatives."

The decision-making process can be defined as: "a compound thinking process, aimed to perceived selection of better alternatives or solutions available to everyone in a certain position choice; in order to reach and achieved that goal by using some objective criteria."

Decision-making process is the nerve of whole human existence, individuals and its groups and organizations, it is play a key and pivotal role in the efficiency and effectiveness of organizations and almost a stone in mind in everything within the institution as its individuals, machineries, equipments, materials and everything related to changes or updates need to take a decision as in the case for administrative process of its core functionality, it needs to be the same resolution as well. (Sharif, 2013)

Through management information systems we can identify problems that faces the organization and then contribute to solving them. Since the management information systems achieve integration between the various functions of the organization, it provides database covering most areas of the organization, and therefore the management information system is an effective tool in front of senior management because it provides immediate, accurate and integrated information, so it is considered the most support for the decision-maker, as it provides for managers information needed by all needed by all of them.

2.7 Factors influencing the decision-making: (Kurdish 2000)

The pioneers of the traditional schools were not interested in the role of behavioral, social and environmental factors and their influence in the decision-making process, they focused on the physical aspects while the pioneers of behavioral schools, have focused their attention on the importance of factors psychological, social and environmental variables and their impact on this process, so their studies focused on the analysis of the decision-making process on psychological factors surrounding the organization, associated customs, traditions, social values, political and economic systems and environmental conditions. Many factors influencing the decision-making process, which is as follows: human factors, regulatory factors, and environmental factors.

2.8 Stages of the decision-making :(Salmi, 2005) and (Sabah, 1998)

- Definition and discovering of the problem: the problem defined in the area of decision-making process as a "deviation from the target set in advance or is a state of imbalance between what the object is and what it should be."
- Diagnose the problem: the diagnosis means to identify the causes of the problem and determine the dimensions and investigate the main reason for its appearance and knowledge of the causes and symptoms.

- Analysis of the problem: the problem analysis required to identify and classify data and information required to solve them and their sources, and means classification problem determine the nature, size and complexity and the quality of the optimal solution is required to address it.

- Find alternatives to solve the problem: it means workaround solution available to the Director to resolve the problem, or at another hand is a proposal or decision to be taken into account along with other proposed resolutions with a view to comparison and analysis in the sense even the best are selected and become the final decision.

- Evaluate the available alternatives to solve the problem: after the manager having seen of alternative solutions to the problem, he must then conduct a comprehensive evaluation of it, and this stage considered of the difficult stages, because the trade-off process between the alternatives are not clear and easy process because the advantages and disadvantages of each alternative does not appear as discussed but stand out when implementing the solution in the future, and from here the doubt and uncertainty about the validity of alternatives to resolve the problems comes.

- Choosing the appropriate solution to the problem: The final selection of the alternatives available process to resolve the problem of the most important steps that attaches managers their energies.

2.9 Role of information systems in decision-making: (Gana'em, Alshargawi, 1982)

The primary objective of the information system is the process of decision-making in the service of the organization, and will show us the role that could be played by information systems at each stage.

First stage (intelligence stage): The information systems store massive amounts of information that can be useful to the decision maker.

Second stage (prototype design stage): The role of information systems summarized by the need to identify possible alternatives to solve the problem, and the standard trade-off between them.

Third stage (the stage of research and selection): The information systems at this stage does not makes decisions, but provide a quantitative and mathematical models that contribute to the identification of possible solutions to resolve the problem and evaluated according to pre-defined criteria.

Fourth stage (the application stage): The implementation of the resolution requires persuading the parties involved specially parties which perform it.

2.10 Importance and role of information systems in decision-making in Najran University:

It has become increasingly important function of management information systems at the University of Najran, Faculties, Deanships and various departments for several reasons:

• Increased knowledge available to the deans and managers, which can be used in making their decisions in accordance with advanced scientific knowledge.

• Growth of the university and its faculties, departments and Deanships in size and complexity of its business, forcing those managers to rely increasingly on the way written information.

• Increased the degree of specialization and the direction of some departments, mostly to diversify its business.

• Increased technological complexity of society in general.

• Increased scarcity of some natural resources.

• Increased degree of environmental and technological change.

• Spread centralization departments and activities, increasing the need for advanced methods of control to secure the officials do their duties in accordance with what was agreed in the plan consciousness.

• Widespread uses of computers and low cost, making it an ideal way for data processing.

III. Research hypotheses

3.1 Scale of the study model:

Model's scale consists of (7) seven paragraphs to indicate the general characteristics of respondents, and (10) paragraphs to indicate the relationship of the quality of information provided by the management information systems with decision-making, (7) paragraphs to indicate the Uses relationship offered by the management information systems with decision-making, in addition to (6) paragraphs to indicate the impact of the development of management information systems with decision-making.

3.2 Study's Hypotheses:

* The first main hypothesis:

Ho1: There is no importance for management information systems in decision-making in the departments surveyed.

It is also divided into three sub hypotheses. The three sub hypotheses are:

Ho1a: There is no relationship between the quality of information provided by the management information systems and the effectiveness of decision-making in the departments surveyed.

Ho1b: There is no relationship between the uses of management information systems and the effectiveness of the decision-making in the departments surveyed.

Ho1c: The development of management information systems does not contribute in increasing the effectiveness of decision-making in the departments surveyed.

The study population consisted of Faculties, Deanships and Departments in Najran University in 2014, where numbered (35) departments. The study sample is a number of Deans, Vice-deans and General Managers that responded to questionnaires.

The questionnaires were conducted on Deans, Vice-deans and Managers, limited interviews to whom filled the questionnaires. The total questionnaires had been retrieved (56) out of the (84) questionnaire was distributed, and so the number of individuals who have been surveyed in the surveyed departments is (56 individuals) this represented a approx percentage of (66.7%). Simple random sampling method was adopted to select the sample. The sample of this study was conducted on Deans, Vice-deans and Managers working in senior management.

IV. Methods of Data Collection:

The secondary data, reviewing all researches, articles, books, and literature relating to the study, both available in the university's libraries or through access to Web sites, in order to clarify the basic concepts and the various dimensions of the subject of this study. The primary data, where the study conducted on to clarify the phenomenon throughout the collection of data as follows: interviews: structured interviews with some of the deans, vice-deans and managers to complete and clarify the study's variables addressed by the study, and to enhance the information that can be accessed, as well as to find out the relationship between management information systems and the decision-making process in the departments surveyed. Questionnaire was designed and contained general information about the deans, vice-deans and managers the departments surveyed, it also includes an independent variable management information systems, and the dependent variable is the decision-making process, in order to collect the raw data from management of departments surveyed.

Table (1): Internal consistency coefficient (Cranach's Alpha) of the different paragraphs of the measurement tool

No.	Dimensions of the Study	Number of Paragraphs	Alpha Values
1	The relationship of quality of information provided by the management information systems with the decision-making.	10	94.9%
2	The relationship of uses offered by management information systems with the decision-making.	7	87.9%
3	The impact of developing management information systems with decision-making.	6	81.6%
Total		23	93.2%

Resource: Bu Researcher Depending on SPSS Results.

Likert Scale was used, and the weights assigned for approval are: (5) very high (4) High (3) Medium (2) Low (1) very low. Where the study relied on specific criteria in the interpretation of the degree of approval depending on the values of the arithmetic average. The measurement had been tested in two phases: First stage is testing the validity measurement tool: through presentation of the questionnaire to a group of specialists in the field of information technology and business administration, were made the necessary adjustments, and then were presented to a group of arbitrators of specialists from academics and professionals, in order to make sure of the questionnaire validity, where all the notes were introduced into consideration until the appearance of the questionnaire in its final form. The researcher has conducted a preliminary study on four of the surveyed departments, so as to make sure that the paragraphs contained in the questionnaire is clear and understandable to measure the purpose of the study. Supplement No. (2). Second stage is testing the stability of the measurement tool: internal consistency coefficient though the use of (Cronbach's alpha), (SPSS Version 20.0) was used to extract the internal consistency coefficient of the different paragraphs of the measurement tool to find the total stability coefficient for the questionnaire, which is (93.2%) this percentage considered a strong indicator of the stability of the measurement tool, table (1).

4.1 Statistical Methods Used:

SPSS version 20.0 was used for the analysis of data collected through the questionnaire devoted to this study, descriptive statistics methods were used (frequency distribution, percentages, arithmetic mean and standard deviation).

Table (2): The verbal values of arithmetic mean

Value of the Arithmetic Mean	Verbal Explanation
0 - < 1.5	very weak
1.5 - < 2.5	weak
2.5 - < 3.5	Medium
3.5 - < 4.5	High
4.5 - ≤ 5	very high

The criteria have been identified to explain the degree of approval, depending on the values of the arithmetic average, as is shown in the above table (2).

Table (3): Standard Strength Answer

Correlation Coefficient	Strength of Answer
0- < 0.3	Weak
0.3- < 0.7	Medium
0.7- ≤ 1.0	Strong

The inference statistical techniques were used Nonparametric tests. The three criteria adopted for the classification of the relation's strength, are shown in the above table (3).

V. Analysis of Results

There is no importance of management information systems in decision-making.

Table (4): Arithmetic Means and Standard Deviations/ The relationship of quality of information provided by the management information systems with the effectiveness of decision-making.

No.	Paragraph	Mean	Std. Deviation	The degree of approval
1	Information provided by the management information system characterized by accuracy.	4.00	.54	High
2	Management information system helps by providing information suitable for decision-making.	3.79	.95	High
3	Management Information Systems provides most of the necessary information to make the decision.	3.57	1.25	High
4	Management Information Systems provide information in the suitable time to make decisions.	3.50	.83	High
5	Management information systems in gives historical information and relied upon to take future decisions.	3.57	1.59	High
6	Management information systems It helps in providing predictive information.	3.21	1.27	Medium
7	The introduction of management information systems gives the best form of information, making it easier to deal with it.	3.79	.95	High
8	Information provided by the Management Information System characterized by concise.	3.71	.80	High
9	Information provided by the Management Information Systems meets the needs of its beneficiaries to make decisions.	3.79	.56	High
10	Management information system provides the user with clear information to make decisions.	3.79	.56	High
General Arithmetic Mean		3.67		High

Resource: By Researcher Depending on SPSS Results.

As shown in the above table (4). It was explained that the arithmetic means of the relationship of quality of information provided by the management information systems with the effectiveness of decision-making paragraphs ranged from (3.21 to 4.00), it reflects an average and high degree of approval, the standard deviation of the different paragraphs demonstrates the severity of answers and that their agreement on the relationship of quality of information provided by the management information systems with the effectiveness of decision-making, it ranged between (0.56 - 1.59), which means that the most of answers were centered around the middle and not dispersion.

Table (5): Arithmetic Means and Standard Deviations/ The relationship of uses offered by management information systems with the effectiveness of decision-making process.

No.	Paragraph	Mean	Std. Deviation	The degree of approval
1	Management information systems helps to provide periodic reports to facilitate researching activities for problems.	3.50	.83	High
2	Expert systems helps in completing the various stages of decision-making.	3.36	.72	medium
3	Use of decision support systems at all stages of decision-making.	3.64	.98	High
4	Decision support systems Helps to solve complex problems easily.	3.64	.82	High
5	Management information systems provides quantitative methods for decision-making processes as an operational research.	3.29	.97	medium
6	Management information systems reduces the use of discretion in decision-making.	3.50	.83	High
7	Management information systems provides information in the graphical or mathematical form.	3.14	.75	medium
General Arithmetic Mean		3.44		medium

Resource: By Researcher Depending on SPSS Results.

As shown in the above table (5). It was explained that the arithmetic means of the relationship of uses offered by management information systems with the effectiveness of decision-making paragraphs ranged from (3.14 to 3.50), it reflects an average and high degree of approval, the standard deviation of the different paragraphs demonstrates the severity of answers and that their agreement on the relationship of uses offered by management information systems with the effectiveness of decision-making, it ranged between (0.72 - .98), which means that the most of answers were centered around the middle and not dispersion.

Table (6): Arithmetic Means and Standard Deviations/ The impact of developing management information systems with the effectiveness of decision-making.

No.	Paragraph	Mean	Std. Deviation	The degree of approval
1	Modern management information systems contributes to identifying the problem accurately greater than the	4.14	.65	High
2	Modern management information systems to provide appropriate information to help identify the real	4.21	.68	High
3	Modern management information systems contributes in identifying the real problem more quickly.	4.07	.60	High
4	Modern management information systems offer alternatives and solutions to the problems better and	4.07	.89	High
5	Old management information systems contributes to	3.50	.92	High
6	Modern management information systems contributes in achieving expected results better than the previous.	4.7	.71	Very High
General Arithmetic Mean		4.01		High

Resource: By Researcher Depending on SPSS Results.

As shown in the above table (6). It was explained that the arithmetic means of the impact of developing management information systems with the effectiveness of decision-making paragraphs ranged from (3.50 to 4.70), it reflects a high degree of approval, the standard deviation of the different paragraphs demonstrates the severity of answers and that their agreement on the impact of developing management information systems with the effectiveness of decision-making, it ranged between (0.60 - .92), which means that the most of answers were centered around the middle and not dispersion.

5.2 Test Hypotheses:

Ho1: There is no importance for management information systems in decision-making in the departments surveyed.

Table (7): Results of t-Test for the importance and the role of information systems in decision-making.

Paragraph	Arithmetic Mean	T-Value Calculated	T-Value Tabulated	Degrees of Freedom	Confidence Level (α)	Decision
Paragraphs of the Main Hypothesis **Ho1**	3.71	20.11	3.46	55	0.000	Significant

Resource: By Researcher Depending on SPSS Results.

Depending on the table No. (7) The value of t-calculated (20.11) is greater than t-tabulated (3.46), and the average calculated from sample data (3.71) is greater than the assumed average (3.00), and the level of significant (0.000) is less than 0.05, we reject the null hypothesis Ho1 and accept the alternative hypothesis.

First main hypotheses is also divided into three sub hypotheses. The three sub hypotheses are:

Ho1a: There is no relationship between the quality of information provided by the management information systems and the effectiveness of decision-making in the departments surveyed.

Table (8): Results of t-Test for the relationship of the quality of information with the effectiveness decision- making.

Paragraph	Arithmetic Mean	T-Value Calculated	T-Value Tabulated	Degrees of Freedom	Confidence Level (α)	Decision
Paragraphs of the Main Hypothesis **Ho1a**	3.67	34.75	3.46	55	0.000	Significant

Resource: By Researcher Depending on SPSS Results.

Depending on the table No. (8) The value of t-calculated (34.11) is greater than t-tabulated (3.46), and the average calculated from sample data (3.67) is greater than the assumed average (3.00), and the level of significant (0.000) is less than 0.05, we reject the null hypothesis Ho1a and accept the alternative hypothesis.

Ho1b: There is no relationship of the uses of management information systems with the effectiveness of decision-making in the departments surveyed.

Table (9): Results of t-Test for the relationship of the uses of management information systems with the effectiveness decision- making..

Paragraph	Arithmetic Mean	T-Value Calculated	T-Value Tabulated	Degrees of Freedom	Confidence Level (α)	Decision
Paragraphs of the Main Hypothesis	3.44	30.80	3.46	55	0.000	Significant

Resource: By Researcher Depending on SPSS Results.

Depending on the table No. (9) The value of t-calculated (30.80) is greater than t-tabulated (3.46), and the average calculated from sample data (3.44) is greater than the assumed average (3.00), and the level of significant (0.000) is less than 0.05, we reject the null hypothesis Ho1b and accept the alternative hypothesis.

Ho1c: The development of management information systems does not contribute in increasing the effectiveness of decision-making in the departments surveyed.

Table (10): Results of t-Test for the contribution of the development of information systems in increasing the effectiveness of decision-making.

Paragraph	Arithmetic Mean	T-Value Calculated	T-Value Tabulated	Degrees of Freedom	Confidence Level (α)	Decision
Paragraphs of the Main Hypothesis	4.01	41.85	3.46	55	0.000	Significant

Resource: By Researcher Depending on SPSS Results.

Depending on the table No. (10) The value of t-calculated (41.85) is greater than t-tabulated (3.46), and the average calculated from sample data (4.04) is greater than the assumed average (3.00), and the level of significant (0.000) is less than 0.05, we reject the null hypothesis Ho1c and accept the alternative hypothesis.

VI. Discussion of results

As a result of the application of a study's questionnaire on the departments surveyed, the study found the following results.

6.1 The importance and role of Management Information Systems:

The results show that management information systems available in the departments surveyed. management information systems provides the hysterical information that are suitable, necessary and predictive information at the suitable time to make the future decisions. Management information systems gives the best form of information, making it easier to deal with it, these information characterized by accuracy, concise, clear and meets the needs of its beneficiaries in decision-making.

6.2 Uses offered by management information systems:

Management information systems provides uses that helps in effective decision-making, provide periodic reports to facilitate researching activities for problems and reduces the use of discretion in decision-making,. also using decision support systems at all stages of decision-making because it helps to solve complex problems easily in a high rate, Management information systems provides quantitative methods for decision-making processes as an operational research, provides information in the graphical or mathematical form. and Expert systems helps in completing the various stages of decision-making in a medium rate.

6.3 Continuous developing of management information systems:

Continuous developing of management information systems represents by the emergence of new techniques and methods more effective in processing information accurately greater than the previous, the old management information systems contributes to choose the best alternative solution, but Modern management information systems to provide appropriate information to help identify the real problem, contributes in identifying the real problem more quickly, offer alternatives and solutions to the problems better and enough than the old management information systems and contributes in achieving expected results better than the previous in a high rate.

VII. Conclusions:

The importance of management information systems in decision-making process are the theoretical foundations of this study. The use of statistical analysis such as descriptive and t-test helped to clarify the relationship between the quality of information provided by the management information systems and the effectiveness of decision-making in the organization under study, the relationship between the uses offered by the management information systems and the effectiveness of decision-making in the organization under study and the relationship between the uses offered by the management information systems and the effectiveness of decision-making in the organization under study.

The experimental validation of the model is the importance of management information systems in decision-making process in a sample of 56 of 84 Saudi Deans and Managers in Najran University, showed the importance of management information systems with decision-making process. The results of the study confirmed the results of previous studies that have confirmed the positively impact of management information systems on decision-making process, and there is a relationship between the quality of information provided by the management information systems and the effectiveness of decision-making, the relationship between the uses offered by the management information systems and the effectiveness of decision-making and the relationship between the uses offered by the management information systems and the effectiveness of decision-making in the organization under study.

References:

[1] Abawi, Zaid Munir, Management of Change and Development, the first edition, Dar Anooz of knowledge for Publishing and Distribution, Amman, Jordan 0.2006, p 136.

[2] Abu Ghaledah, Elham, The importance ND the role of information systems in decision-making in the hydrocarbon sector Biskakdh, Researcher Magazine, No.13, University 20 August 55 Skikda, Faculty of Economic Sciences and the Science Steering and Commercial Sciences, Algeria, 2013.

[3] Ahmed, Imad al-Din, Management Information Systems and their Importance in the Decision-Making in the Department of Admission and Registration, (paper presented to the 33 Conference of the Arab Organization of the officials of Admission at Universities in Arab Countries), University of Khartoum, Sudan, 2013.

[4] Alhazaymeh, Ahmed, The Role of Information in Decision-Making Systems in Government Institutions - a field study in public institutions of Irbid Governorate, Damascus University, Journal of Economic Sciences and Law- Volume 25 - Issue October, 2009.

[5] Alkhaffaf, Maha, The Role of Information Systems in Decision Making: The case of Jordan Bank, Management Information Systems Dept, Applied Sciences University, Jordan, Computer Engineering and Intelligent Systems, ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online), Vol 3, No.10, 2012.

[6] Al-Murad, Nebal Younis, Management Information System Characteristics and its impact on its success indicators - reconnaissance study for the opinions of administrative units, officials in the Faculties of Dentistry and of Education, Board of Technical Education, Technical Institute, Mosul, Office Management Department, Mosul, Iraq, 2012.

[7] Alsabah, Abdul Rahman, Management Information Systems, Oman, The House of Culture in 1998, p. 78.

[8] Asemi, et al., The Role of Management Information System (MIS) and Decision Support System (DSS) for Manager's Decision Making Process, International Journal of Business and Management, Vol. 6, No. 7; July 2011.

[9] Bakens, Ralph, The effects of the use of Project Management Information Systems in the decision making in a multi project environment - empirical identification and quantification -, Master Thesis, Open Universiteit Nederland, School of Management, 2010.

[10] Center of Excellence for NGOs, Training Manuals, No. (32), April, 2003.

[11] Freihat, Sultan, THE ROLE OF MARKETING INFORMATION SYSTEM IN MARKETING DECISION-MAKING IN JORDANIAN SHAREHOLDING MEDICINES PRODUCTION COMPANIES, IJRRAS 11 (2) ● May 2012.

[12] Gana'em, Amr, AlSargawi, Organization and Business Management, Arab Renaissance Publishing House, Beirut, 1982, p. 126.

[13] Harris, Robert. Introduction to Decision Making, Part 1. 2012. http://www.virtualsalt.com/crebook5.htm.

[14] Hasani, Abdullah bin Hamoud, The Impact of Decision Support and Quality of Information and the Effectiveness of Systems of Decision-Making - a field study in the Ministry of Civil Service of the Sultanate of Amman, Master Thesis, Middle East University, College of Business, Department of Business Administration, Jordan, Management and Economics Magazine, Number of 90, 2012.

[15] Hassan, Mohamed Eslam, The Impact of the Sector Type on the Role of Management Information Systems for the Decision-Making Process: RNS-Sudan as Case Study, International Conference on Global Economy, Commerce and Service Science (GECSS 2014).

[16] Heidarkhani, Arash, The Role of Management Information Systems (MIS) in Decision-Making and Problems of its Implementation, Universal Journal of Management and Social Sciences, Vol. 3, No.3; March 2013.

[17] Kling, Rob & William Dutton, (1982). The dynamics of the local computing package. in Danziger, Dutton, Kling, and Kraemer, 1982.

[18] Laudon, K.,&Laudon, J. Management information systems: Managing the digital firm. (11th ed.). Upper Saddle River, NJ: Pearson Prentice Hall, 2010.
[19] Laudon, Kenneth C., Laudon, Jane P. & Elragal, Ahmed A., Management Information Systems-Managing the Digital Firm,1st. Ed. Arab World adaptation edition published by PEARSON EDUCATION LTD, ISBN: 978-1-4082-7160-5, 2013, P17.
[20] O'Brian, James A. and Markus, George M., Management Information Technology, 10th. Ed., McGraw Hill Irwin, ISBN # 0072906111, 2011, P13.
[21] Salmi, Alaa Abdul Razzaq, Decision Support Systems, Dar Wael for publication, the first edition, pp. 41-42,, 2005.
[22] Sharif, Omar, Control of Information Systems and Decision-Making style in the Organization, the University of Batna, 2013. (http://www.docstoc.com/docs/145256337)
[23] Sharkawy, Ali, The Administrative Process, The Functions of Managers, Dar University of modern publishing, Alexandria 2002, p. 150.
[24] Sultan, Ibrahim, Management Information Systems, Systems Introduction, University House, Alexandria, 2005, p. 15.

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A Regression Analysis for Base Station Power Consumption under Real Traffic Loads – A Case of Nepal

Madhu Sudan Dahal[1], Shree Krishna Khadka[2], Jagan Nath Shrestha[3], Shree Raj Shakya[4]

[1,2,3,4] *Center for Energy Studies (CES), Institute of Engineering (IOE) - Central Campus Pulchowk, Lalitpur Tribhuvan University (TU), Nepal*

Abstract- With the advent and rapid development of mobile and wireless technology, the field of Information and Communication Technology (ICT) has become so lucrative and expanding at an alarming rate. Correspondingly energy consumption is also growing at a staggering rate. With this note, mobile operators are already among the top energy consumer. As the mass deployment of 3G systems in developing countries and later 4G systems rolling out worldwide, mobile communication consume significant amount of energy with large electricity bills. More than 50% of the total energy is consumed by the radio access part, whereas 50-80% is used for the power amplifier. This paper critically analyses the power consumption of Base Stations (BSs) as per the traffic generated at various urban-dense location of Kathmandu, Nepal. It deals with real time traffic data on full load in per hour basis of ten BSs for consecutive ten days. The results revealed a linear relationship between the power consumption and traffic loads. As of findings, this paper vow an urgency to pursue an optimal capacity while designing wireless networks and also suggests an imperative pathways for energy efficient wireless communication.

Keywords-Base Station Traffic;Power Consumption Modeling;Regression Analysis; Energy Efficient Wireless Communication

I. INTRODUCTION

Telecommunication is playing significant role in daily life of people in today's globalization context. The tele-density has surged to 100% this year in Nepal [1]. Nepal had an annual GDP per capita of USD 696.9 in the year 2014 and for every 10% increase in broadband penetration provides a 1.38% increase in GDP [2]. The growing interest in new and reliable services in mobile communications has resulted in increased number of installed Base Stations (BSs) worldwide. In addition, the traditional concept of BS deployment assumes continuous operation in order to guarantee the quality of service anywhere and anytime. Both of these reasons have synergetically contributed during the last decade to the significant growth of the total energy consumed by BSs of cellular network operators. In the case of Italy, the average yearly consumption of a BS is ca. 35,500kWh, considering that in Italy there are about 60,000 BSs, the total average yearly consumption of the Italian BTS sys-tem is ca. 2.1 TWh/year, which is the 0.6% of the whole national electrical consumption. In terms of economic and environmental impact, the data correspond to ca. 300 million euro yearly energy costs and ca. 1.2 Mton of CO2eq emitted in the atmosphere every year [3]. Sim-ilarly, about 3% or 600 TWh of the worldwide electrical energy is consumed by ICT sector. It is estimated that energy consumption for ICT sector will grow up to 1,700

TWh by 2030. The total global carbon footprint of ICT industries in the order of 860 million tons of CO2 which is about 2% of the global emissions [4]. Nepal is severely facing energy crisis with an aver-age 12 hours of load shedding per day. So the challenge is to provide reliable and cost effective power solution. For this, a power consumption model is developed as per traffic generated. BSs are the most energy consum-ing part of cellular mobile network with more than 50% share in total network consumption [5]. It is however important to determine the consumption of the whole wireless access network and thus to model the power consumption of each part of this network. Within these networks, 10% of the energy is consumed by the user terminals, while 90% is caused by the BSs. These num-bers indicated that the power consumption of wireless access networks is going to become an important issue in the coming years [6].

In the exploding world of wireless communications and networking, improving the power efficiency of radio networks is an important research topic [7]. To evaluate the energy efficiency of today's mobile communication systems and to identify improvements for next genera-tions system, a high level energy efficiency evaluation (E^3F) has been developed with Energy Aware Radio and neTworking tecHnologies (EARTH) project [8]. This framework covers the complete system, including net-work and radios.

A power consumption model is developed based on the power consumption and the traffic generated by BSs. Energy efficiency at various loads viz. low traffic and high traffic are compared. The power consumption of BSs consists of two parts. The first part describes the static power consumption - a power figure that consumed already in an empty BSs and dynamic power consump-tion which changes with traffic load. Depending on the load situation, a dynamic power consumption part adds to the static. In this study, only dynamic power consumption with respect to the traffic load has been considered. A power model is derived for typical BSs that are installed here in Kathmandu valley. In response to characterize a relationship, this study provides an ample of knowledge between the traffic load and corresponding BS power consumption. The most remarkable contribution to this study can be found where power consumption modelling of BSs is developed with real time traffic load of various heterogeneous BSs of Kathmandu valley. To the knowledge of the authors, such study comprising of power consumption as per generated traffic with real time data has not been carried out yet in Nepal.

II. RESEARCH ELABORATIONS

For the relationship between the BS energy consump-tion and traffic load, extensive measurements were taken from a fully operated BS site located at various urban-dense area. The selected BSs sites are divided into most loaded, average loaded and least loaded city sites in terms of voice and data traffic. BSs of the GSM 900, GSM 1800, GSM 2100 were considered for the data collection. GSM 2100 is used for 3G services. LTE is not considered because it is in testing phase. GSM 900, GSM 1800 is the indoor type of cabinet located inside a protected room dedicated solely for keeping site equipment but GSM 2100 is outdoor type BSs. Antenna lines connect each BS cabinet with corresponding antennas located on either pole tower and self supported tower.

The site is connected with a backbone network using optical lines over a manageable link. The AC power grid is connected to 430/220V site. The rectifier is the medium for AC power grid and battery. The Battery is connected from the rectifier and BSs takes power from the Battery. The rectifier converts ACvoltage to DC voltage and it charges the battery. There are two banks of battery each of 2V and 600 Ahr. When the AC power grid is available then it will charge the battery and will then supply the DC current to the BS. If there is no AC power grid then BS will take power from charged battery. The battery voltage ranges from 44V to 56V. The rectifier has fused up to 100 A. The electric current is drawn by each BS on hourly basis. Similarly, the traffic generated by each BS is also measured on hourly basis so that it would be easy to model the power consumption of BS as per traffic generated.

Here, in this research, 10 GSM BSs are taken for particular concern. Real time traffic load is monitored and collected for continuous 10 days on hour basis for the consistency. Networks are designed for maximum traffic and are optimized for operation at full load. But in real scenario, real network are not fully loaded. In fact, most networks are busy for some hours only in a day. Also traffic depends on spatial location and time. High traffic was measured during day at commercial area while high traffic were seen during morning and night time at residential area. In network level, an important approache for reducing energy consumption is a dynamic management of network resources, which allows shutting down of entire BSs during a low traffic load. In such a scenario, neighbouring BSs must provide coverage and take over the traffic load of those BSs that are turned off [9]. This can be combined with dynamic transmitter power selection, antenna tilting, multi-hop relaying or by coordinated multipoint transmission and reception [10].

III. METHOD

An important parameter to investigate is the energy efficiency of a BS. The energy efficiency is here defined as the power consumption (PC) needed to cover a certain area (in W/m2). PCarea per covered area is then defined in equation (1).

$$PC_{area} = P_{el}/\pi R^2 \text{ --- (1)}$$

Where, Pel is BS Power Consumption and R be the range of BS coverage [11]. Lower the PCarea, the more energy-efficient the BS is. BS is defined as the equip-ment needed to communicate with the mobile stations and with the back-haul network. The area covered by a BS is called 'CELL' which is further divided into a number of sectors. Each sector is covered by a sectored antenna, which is a directional antenna with a sector-shaped radiation pattern.

To determine the load, measurements are performed for an actual micro BS in the urban area of Kathmandu - Nepal. During 10 days (including weekend days), the power consumption of the BS is measured. The group of load-independent components i.e., the rectifier, the air conditioning and the microwave link are not included in this measurements. For the equipment considered, the voltage is constant (i.e. approximately 54V) and thus the current is measured. The power consumption P(t) (in Watt) at a certain time 't' is then determined as in equation (2).

$$P(t) = V.I(t) \text{ --- } (2)$$

Where, V is voltage (in Volt) and I be the current at any time t (in Ampere). The current is measured with an AC/DC current clamp. Every second, the value of the current was saved which results in 864000 samples for he measurement period of 10 days. For the week days, it is noticed that the power consumption during the night is lower than that of the day because during day-time more people are active. In weekend days, power consumption iffered by small compared to weekdays. The power consumption/hour for both weekdays and weekend are collected. It is found that the mea-sured equipment consumes between 1016 W and 1087W. Mostly, traffic is high during the weekdays (Sun-day to Thursday) and low during weekends (Friday and Saturday).

IV. DATA INTERPRETATION AND RESULTS

Figure:1 shows the power consumption and traffic load generation for a single day. The peak traffic of 230.137 Erlang with corresponding power 1.635 KWh was detected during 10:00 to 11:00 hours. When the traffic load is high, the correlation (R^2=0.83 to 0.94) between power consumption and respective traffic load is also high. Here, the power consumption pattern is a direct consequence of a daily traffic pattern variation. It was observed that the increase in the traffic results in an increase in the power consumption of BSs.

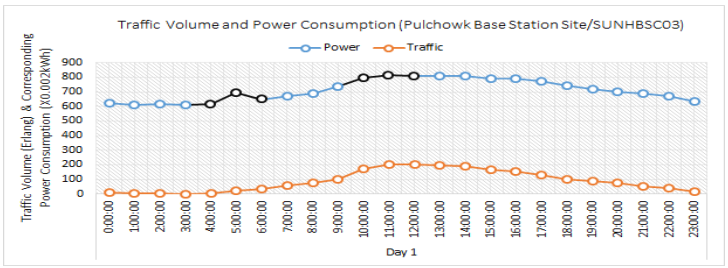

Figure 1: Traffic load and corresponding power consumption of Nepal Telecom – Pulchowk BS site in a day.

The relationship between the BS power consumption as per the traffic load is obtained. The power consumed by 10 different BSs and their respective traffic loads per hour for 10 days gave rise to 2400 records of a real event for this study. It was found that the traffic load is high during 08:00-11:00 and 18:00-20:00 hours. The high and low traffic load was recorded to be 143.6 and 3.3 Erlang respectively. It was found that the BS power consumption varies from 1.25 KWh to 1.63 KWh. The range did not vary so much as the traffic load varied largely. The peak power consumption was recorded between 08:0 to11:00 hours for each day whereas the least power consumption during 00:00 to 6:00 hours (Figure: 2).To test the statistical model and to correlate the variables, we have used R^2 -statistics. R^2 value is a number that indicates how well a statistical model/regression line fit the real scattered data values. It is also known as the coefficient of determination. 0% indicates that the model explains none of the variability of the response around its mean.

In this study, R^2 value varied from 0.765 to 0.949 for different urban-dense location, which indicates that the model explains good variability of the response data around its mean. Adjusted R^2 lets the percentage of variation explained only by the independent variables that actually affect the dependent variable. Here Adjusted R^2 varied from 0.7648 to 0.9489 (Table: 1).

Table 1: R^2 and Adjusted R^2 Values of Different BSs

BSs	R^2	Adjusted R^2
Dhapasi	0.7658	0.7648
Kalikasthan	0.7870	.7861
Maharajgunj	0.8042	0.8034
New Baneshwor	.8142	0.8134
Panipokhari	0.7931	.7922
Sinamangal	0.8167	0.8159
Sundhara	0.8890	0.8885
Babarmahal	0.8000	0.7999
Jawalakhel	0.8945	0.8940
Pulchowk	0.9491	0.9489

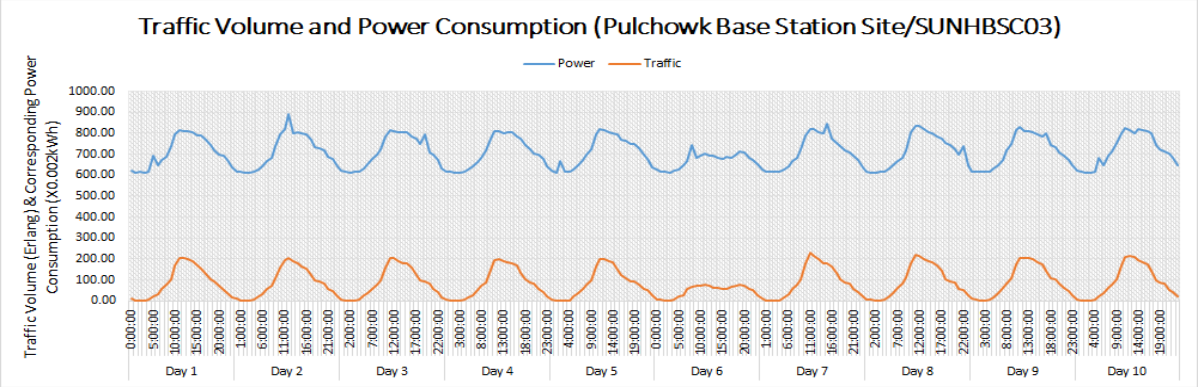

Figure 2: Observation Records for 10 Days of Power Consumption under Real Traffic Loads

Based upon the measured traffic load and corresponding BS power consumption, now the goal is to develop a power consumption model as per traffic generated. The developed model must express power consumption of each BS as a function of real time traffic load given by equation (3) [8].

$$y = \beta_1 f_1(x) + \ldots + \beta_p f_p(x) + \varepsilon \quad \text{----- (3)}$$

According to equation: 3, response y - Power Consumption is modelled as a linear combination of function of independent variable x - traffic load and a random error Ɛ. In this expression $f_j(x)$(j=1 to p) are the terms for the model, while β_j (j=1 to p) represents the weight correspond to $f_j(x)$. It is assumed that the model has up to p-different terms and corresponding coefficients. Uncontrolled factors and experimental erros are modelled in above equation by Ɛ and assumed to be uncorrelated and distributed with zero mean and constant variance.

This paper analyse BS power consumption under the real traffic loads as a major contributing factor, hence the above model reduces to $f_1(x)=1$ and $f_2(x)=x$. and for 'n' independent observations (x_1, y_1) to (x_n, y_n), equation (4) represents a linear regression equation for our concern. On its counterpart, cell geography (coverage), hours ofoperation (time) and population movement plus day-night shift (load variance factor) do also matter for BSpower consumption. But these factors again boost up thetraffic intensity, hence they are under the considerationof traffic loads rather to dealt separately.

$$y = X\beta + \varepsilon \quad \text{------- (4)}$$

Where, 'x' represents telecommunication traffic in Erlang, while 'y' acts as corresponding measured power, in Watt. Whereas, the coefficients of the regression line, Ɛ = b_1 [Watt] represents the intercept and b_2 [W/Erl] represents the slope of line. Calculations were performed in Ms-Excel with regression analysis under data function (Table:2). This give rise to the linear relationship between traffic load (x) and corresponding power consumption (y) as given by equation (5).

$$y = 1.274 + 1.713x \text{ ---------- (5)}$$

The developed linear model have been plotted as a linear regression line which tends to fit the data values with 95% of confidence interval (Figure 3).

Table 2: Regression Parameters Analysis

Base stations	Intercept (Ɛ)	x - Co-eff. (β)
Dhapasi	636.1630	0.8547
Kalikasthan	631.1256	0.7466
Maharajgunj	629.1695	1.9822
New Baneshwor	584.6320	1.0840
Panipokhari	685.4675	0.8905
Sinamangal	656.9946	5.10743
Sundhara	697.3975	2.7711
Babarmahal	602.7391	1.3878
Jawalakhel	626.3360	1.2840
Pulchowk	621.7678	1.0227
Weighted Average	637.1793	1.7131
PWA*	1.2743	1.7131

*PWA – Pure Weighted Average/Down Scaled Value

The linear dependence of the power consumption on the traffic load is observed from figure: 3. It is noted that the power level required goes hand in hand with increased traffic load, which is justified by the linerar regression line. When the traffic load is very low, the proposed linear models ensure some fixed amount of poewr consumption .

$$y = 1.22677 + 0.00057x \text{ --------- (6)}$$

Such that for a similar another event, the power consumption during very low traffic is out to be described by equation : (6). If we considere a null effect of low traffic demand (since, the weight of dependent variable is too small), the intercept value still ensures some residual power cosnumption. It means during no traffic, certain amount of power cosumption is always taken by BSs.

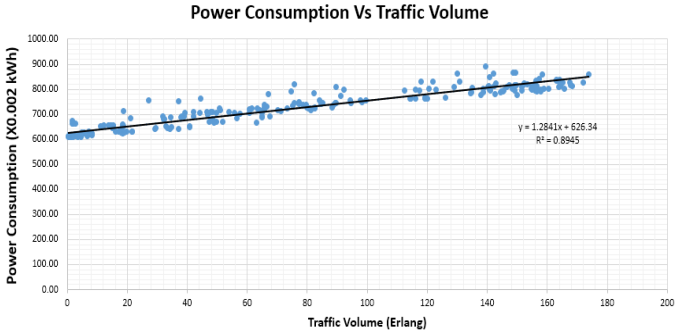

Figure 3: Fitting Data Values with Regression Line

A linear model developed for this particular study corresponds to the specific BS technology. Any other BS of different technologies, manufacturers and production years of configurations might have different linear models [6].

V. CONCLUSIONS

The main purpose of this research is to develop a model for the power consumption of BSs as per traffic generated. Hence, the impact of traffic on the BS power consumption is monitored. The traffic and power consumption data of 10 BSs were collected for 10 days for 24 hours on hourly basis with 2400 sample records in total. For each BS, the linear model has been developed where, R^2 value ranges from 0.765 to 0.949 with minimum error (standard error $\leq$ 25 per 240 observations for each analysis). Similarly, the regression line is about to fit the real data values and is justified with 95% confidence interval limit.

BS power consumption is found to be varied proportionally with the traffic loads showing a high correlation (R^2 value up to 0.94) between the variables, which means traffic loads could be a prominent source that the consumption of power heavily lies upon regardless of all other random constraints. Hence, the proposed model (a=95%) presents a significant results and can be accepted as a model for precise expression for BS power consumption under real traffic loads. During high traffic load, the developed linear model fits well but during low traffic, the model possess some indifference to fit the real data values (R^2 =0.0033 to 0.3123) and this limits the study. Later on, the developed model could be very useful forecast the required power level in order to justify high traffic demand. During no traffic (the least) also, BSs still let some energy (residual power) to maintain a tower in a standby mode for a continuous operation.

It is also noted that energy bill accounts for approximately 18 to 32% of the operation expenditure (OPEX) in the mature metropolitan cities like Kathmandu [12]. From the operators' perspective, energy efficient (EE) wireless communication is not only has great benefits and represents social responsibility in fighting climate change, but also has significant economic benefits [13]. Based on this research findings, further research on cell zooming as per the traffic, spectral efficiency, soft-handover strategies and quality of services are highly recommended. On the other hands, the rapid growth of ICT sector in Nepal also demands for larger energy requirement. So, it is urgent to shift towards energy efficient wireless communication with all possible measures in order to serve traffic on demand more dynamically.

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REFERENCES

[1] Nepal Telecommunication Authority. Management Information System (MIS) report. Technical report.
[2] Broadband commission for digital platform, 2014
[3] Technical Expert for Renewable Energy Application (TERNA). Technical report, 2007.
[4] C. Lubritto. Energy and environmental aspects of mobile communication systems. Energy, 2011.
[5] Luc Martens Margot Deruyck, Wout Joseph. Power consumption model for macro-cell and microcell base stations. Emerging Telecommunication Technologies, 2012.
[6] Power Consumption in Wireless Access Networks,2010.
[7] Liu X Niu Z Oh E, Krishnamachari B. Toward dynamic energy efficient operation of cellular network infrastructure. IEEE Communication, 2011.
[8] Wout Joseph Lue Martens Margot Deruyk, Em-meric Tanghe. Modeling the energy efficiency of microcell base stations. Green Communication and IT Energy-Aware Technologies, 2011.
[9] J. Gong Z. Yang Z. Nie, Y. Wu. Cell zooming for a cost-efficient green cellular networks. IEEE Communication, 2010.
[10] Goran Petrovic Josip Lorincz, Tonko Garma. Measurement and modeling of base station power consumption under real traffic loads. Sensors, 2012.
[11] W. Joseph L. Martens M. Deruyck, E. Tanghe. Modeling and optimization of power consumption in wireless access networks. Elsevier Computer Communication, 2011.
[12] Shree Krishna Khadka. Renewable energy technology solution for remote telecom towers of Nepal – a case study of Nepal telecom. Master's thesis, Center for Energy Studies - Institute of Engineering, Central Campus Pulchowk.
[13] Shree Raj Shakya Lochan Lal Amatya Shree Krishna Khadka, Jagan Nath Shrestha. Energy demand analysis of telecom towers of Nepal with strategic scenario development and potential energy cum cost saving with renewable energy technology options.International Journal of Research in Engineeringand Science (IJRES), 2015.

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Design and Construction of Manually Operated Biogas Plant for a Farm and Village Settlement in Nigeria

[1]Bitrus Auta, [2]Raymond O. Ikeleji and [3]Saudatu A. Jere
[1,3]*Applied Science Department School of Science and Technical Education*
College of Science and Technology Kaduna Polytechnic
[2]*Department of Mechanical Engineering, School of Industrial Engineering*
College of Engineering Kaduna Polytechnic

Abstract: *The biogas generating method involves filling the digester with cow dung, and is left to ferment for days; the result of the fermentation produces biogas in the digester. The gas is then passed through a rubber pipe to the gas holding cylinder. The compositions of the gases are mainly methane and carbon dioxide. The plant is manually operated and does not require high skilled manpower .It is basically expected to be use in farm houses in village settlements. This will cut down on environmental pollution, global warming and reduce the rate of cutting down trees in rural areas.*

Key words: *Biogas, digester, fermentation, biological waste.*

I. INTRODUCTION

Biogas is a combustible mixture of gases produced by micro-organisms when livestock manure and other biological wastes are allowed to ferment in a close system.

We have had it good for many years, using and misusing fuels supplies at will for decades. In some countries particularly Nigeria, the average consumption of fuel equates from two to three gallons per day. This makes an annual consumption of over 1 to 2 billion gallons that is for a population of close to 175 million people. This is probably the most wasteful of the nation but still not extremely far ahead of the others.

At the present consumption rate it is estimated that the known reserves of refine able crude oil will be exhausted in about thirty years to come. The constant effort of our oil companies to sell more and more of the black gold make it unlikely that today's consumption will not increase in the future.

One huge source that has barely used up to now is biological gas. Millions of cubic meters of methane in the form of subsamples gas or biogas are produced every year by the decomposition of organic materials both animals and vegetables. It is almost identical to the natural gas pumped out of the ground by the oil companies and used by many for heating and cooking. In the past however, biogas has been treated as a dangerous by-product that must be removed as quickly as possible, instead of been harnessed for useful purpose. On the other hand, it requires developments of new methods of production and use as a renewable energy sources to suit the economical and geographical requirement of the country.

The recent global energy crisis has generated interest in the use of animal waste for energy as a substitute for fossil fuel. Production of fuel gas (methane) from animal waste in oxygen free atmosphere is one of the most important possible alternatives and could eventually help in prevention of indiscriminate cutting of trees as a source of energy.

II. THEORETICAL BACKGROUND

Biogas in anaerobic digestion generally regarded as the most important product. The methane (CH_4) content of the gas produced varies between 50% and 80% depending on the nature of the organic materials. From animal waste, the gas generated is in the range of 65% - 75% methane. There may be additional small amounts of Nitrogen from air with hydrogen sulphide of less than 1% and hydrogen from microbial metabolism and traces of other hydrocarbons. The gas is wet and contains ammonia traces and volatile fatty acids. These can be produced by using a sealed container by the process of anaerobic fermentation of animal, human, wastes vegetation materials such as grasses, crops residuals, house hold garbage and organic industrial waste.

To facilitate optimum efficiency of production, conditions in the plant should be favorable to the bacteria involved, since the bacterial are sensitive to environmental changes. A number of factors such as organic waste nature, temperature, PH value among others are known to affect biogas generation.

The nature of feed stocks affects the volume of gas depending on their carbon-nitrogen ratio. In many cases, various substances should be mixed together in order to ensure a favorable gas yield while stabilizing the digesting process and promote gas production. This means the time for which any portion of the feed will remain in a continuous flow digester. Some comprehensive surveys that have been conducted by young suggest that retention time is the most useful single indicator of performance. Its units are hours or day (Dioha I.J. Gulma, 1989).

Anaerobic digestion takes place in an oxygen free environment to ensure this condition linked parts of the plant should be provided with perfect sealing to favour maximum gas production. The most important part of the plant begins the gas cylinder, plastic and butyls rubber bags have been suggested but water sealing of the gas holder or floating roof digester has also the advantage of acting as a safety valve if gas pressure is increasing by failure in some other parts the system as an excess gas will bubble out through the liquid seal if the gas production exceeds storage capacity. In hot weather, there is a tendency for slurry to stay out in the angular space between the digester tank and gas cylinder, the resultant solids tend to impede the vertical motion of the gas cylinder. The remaining part of the plant can be provided with thread tape as sealing element (Dangogo S. 1986). The complete anaerobic digestion of cow-dung or manure and chicken waste takes place in about 8 weeks at normal room temperature. One third of the total biogas will be produced in the first week, another quarter in the second week which the gas emission in volume within the remaining weeks.

Gas production can be accelerated and made more consistent by continuously feeding the digester with small amount of waste daily. This will also preserve the nitrogen level in the slurry for use as fertilizer.

In hot regions it is relatively easy to simply shade the digester to keep it in the ideal range of temperature, but cold environment present more of a challenge.

The first action, is naturally to isolate the digester with strew or wood shaving. A layer about 50-100cm thick, coated with water proof covering is a good start if this still proves to be in sufficient in winter, then heating cost may have to be added to the biogas digester.

It is relatively simple to keep the digester at the ideal temperature if hot water, regulated with a thermostat is circulated through the system. Usually is sufficient to circulate the heating for a couple of hours in the morning and evening. Naturally the biogas produced by the digester can be used for this purpose. The small quantity of the gas wasted in heating the digester will more than compensate for the greatly increased biogas production.

The pure gases collected are used for various heating process e.g. water heating, building heating, lighting and cooking. It can also be used in gas burning appliances, running of internal combustion engines, power pumps and crops processing machinery. It can also be used to generate electricity when produced in large quantity.

Furthermore, other benefits include saving of fossil fuel, reduction of fuel expenditure and conservation of forest and grasses among hygienic condition of rural areas. Finally the residuals of fermentation produce an excellent organic fertilizer, soil conditioner and essential ingredient.

Sludge or slurry is the end result of anaerobic digester of the biogas plant which is rich in nitrogen. It also serves as fertilizer, since it contains nitrogen, phosphorus, and potassium. The humus material formed improved physical soil properties. Sludge serves as a source of energy and nutrient for the development of microbial population, improves the solubility and thus availability to higher plant.

III. DESIGN AND CONSTRUCTION REQUIREMENT

The need to make continuously supply of 45kg of fresh dung per day is necessary which facilitates the installation of a 1.7m^3 gas daily. The daily dropping from a medium size cow, buffalo or bullock is about 10kg. Therefore, a famer should have at least five heads of cattle to install a biogas plant. He should have adequate space on the farm yard for the gas installation and space for output slurry pots, which are connected to the plant by means of channels. A sufficient quantity of water should be available since dung must be mixed with water before feeding into the plant. The mixture of waste material and water is in the ration of 1:16 feed into the digester to produce a certain amount of gas. The plant comprises of a digester for fermentation of cow dung, vegetables and other organic matters. A gas cylinder is assembled to the digester by means of a flexible hose to collect and direct the gas produced into the kitchen or where it is desired to be used of correct pressure. The out sherry can be waste and finely used as manure.

Design calculations.

$\pi = 3.142$

$h = height$

$d = diameter$

V_d=Volume of digester

V_f=Volume occupied by fluid

W = Quantity of waste
M_w = Amount of water
T_r = retention time
C = gas yield per unit day of whole input
V_b = Volume of Biogas
The volume of the digestion is given as

$V_d=\pi\frac{d^2}{4}h$ …….. (1)

Where:

$$\pi = 3.142$$
$$h = 560mm$$
$$d = 290.1mm$$

V_d = 37.02 m^3

$V_f=\frac{2}{3}xV_d$ …… (2)

V_f=24.68 m^3

The quantity of waste needed for initial feeding (w)and the feeding ratio 1:¼ water to waste.

$$W = \frac{V_f \times f.ratio}{2.25}$$
$$W = 13.71m^3$$

Therefore, the amount of water required:

$$M_w = \frac{V_f}{2.25}$$
$$M_w = 10.97m^3$$

The retention time 'T_r' when 24.68m^3sludge is feed daily is

$$T_r = \frac{V_d}{V_f} - - - - - - - - - - - - - - - - (3)$$
$$T_r = \frac{37.02}{24.68}$$
$$T_r = 1.5\ days$$
$$T_r = 36\ hours$$

The volume of the gas produced on daily basis (μb). Biogas yield per unit day of whole input (c).

$$C = \frac{0.35m^3}{kg}$$
$$Vb = c \times w$$
$$Vb = 0.35 \times 13.71$$
$$Vb = \frac{4.7985m^3}{day}$$
$$Vb = 4.8m^3/day$$

Biogas Digester

This is essentially a stainless steel circular drum with hemispherical shapes at the top and bottom of the cylinder made from stainless steel. The drum is 560mm high, and 290.1mm in diameter with thickness 1mm.

A pipe is welded at the side of the drum for the attachment of the hoses for collection of the gas, the drum has a cover that is made from the same material and hemispherical in shape which has two holes, one at the middle is for the stirrer and the other side hole is for the slurry inlet which is attach with a funnel for the easy entrance of slurry.

Gas Cylinder

The gas cylinder is also of stainless steel drum, which is connected to the digester through a flexible hose. The cylinder has a height of 500mm and diameter of 290mm.The gas produced in 'the digester rises through the slurry and is collected in the cylinder. The accumulated gas flows through the gas pipe to the kitchen or wherever it is desired to be used.

IV. MATERIAL SELECTION

The selection of material form an integral part of any design process. There are numerous metals, alloys and non-metals available for use as engineering materials, hence the materials selected where base on its ability to withstand hash environmental and weather condition.

Mild Steel Bars

MS bars are used to construct the covers of outlet tank and water drain chamber. For plants of 4, 6 and 8 cum, MS rods of 8 mm diameters are used and for plant of 10 cum capacity 10 mm diameter is recommended.

Main Gas Pipe

Gas stored in the gas cylinder is conveyed to the pipeline through this pipe which is placed in the topmost portion of the dome. The joint of reduction elbow with this pipe should be perfect and air tight to avoid gas leakage. The gas pipe should be properly galvanised and must be of sound quality. This pipe should be made up of light quality iron and MS rod welded at one end to embed it with the concrete during installation. The length of this pipe should be at least 60 cm.

Main gas valve

It controls the flow of biogas in the pipeline from the gas cylinder. It is opened when gas is to be used and closed after each use. If substandard quality of main gas valve is used there is always risk of gas leakage. This valve should be of high quality and approved by the concerned quality control authorities.

Pipes Fittings

The pipeconveying gas from gas cylinder to the point of application should conform to quality specification as per the standard of Pakistan. Light quality Galvanised Iron pipe is best suited for this purpose; however, high quality, PVC pipe could also be used. The pipe should be of at least half inch diameter. For pipe with more than 60 m length or (30 m if two burners are to be used at a time) %" diameter pipe has to be used. If GI pipe is to be used, a six meter pipe should weigh at least 6 kg. The fittings used in the pipeline of a biogas plants are socket, elbow, tee and nipples. These fitting should meet the required quality standard.

V. CONCLUSION

An obvious obstacle to the large scale production of biogas technology is the fact that the majority of the rural populace cannot afford the exorbitant cost of investment requirement without government involvement, hence the need for manually operated and low cost design and construction of a potable biogas plant.The ease of operation and availability of raw materials couple with minimal maintenance skill required makes it adaptable to the rural dwellers. Similarly as an alternative and renewable energy source it serves as a control of greenhouse effect by minimizing deforestation which is commonly found within the rural area in Northern part of Nigeria.

REFERENCES

[1] Alexandra Volta (1776), "Biogas comes from decayed vegetables" Hutchinson dictionary for scientific research. Page 126-137.
[2] Barnet A. (1978), "Biogas technology in the world Ottawa"
[3] Gupta Sujata (2010), "Biogas comes from the cold"
[4] Rajput RK. (2004),"A text book of fluid mechanics 'and hydraulics" S. Chand company limited New Delhi pages: 639, 643-645.
[5] Rogers G.F. and Mathew Y.R (1994),"Engineering Thermodynamics" Longman publishers, Singapore
[6] Sirohi R. S. and Krishna H.C. (2009),"Mechanical measurements" third edition, one world willey esteem limited, page 186-222.
[7] Tietjen C. (1975),"Biological review of European experience" page 274-275.
[8] Wieland P. (2011), "Production and energetic use of crops and waste in Germany". Applied biochemistry and biotechnology
[9] Williams Hurry (1806), "Methane gas from organic waste". Hutchinson dictionary of scientific research

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Efficient carry skip Adder design using full adder and carry skip block based on reversible Logic

Varun Pratap Singh[1], Shiv Dayal[2], Manish Rai[3]
[1]M.Tech. Student Uttarakhand Technical University Dehradun, Uttarakhand, India
[2]Prem Prakash Gupta Institute of Engineering, Bareilly, Uttar Pradesh, India
[3]Dept. Of Electronics & Communication Engineering MJP Rohilkhand University, Bareilly, Uttar Pradesh, India

Abstract: *In recent years, Reversible Logic is becoming more and more prominent technology having its applications in Quantum Computing, Nanotechnology, and Optical Computing. Reversibility plays an important role when energy efficient computations are considered. In this paper, binary full Adder with Design I and Design II are proposed. The performance analysis is verified using number of reversible gates, Garbage input/outputs, delay, number of logical calculations and Quantum Cost. According to the suitability of full adder design I and design II carry skip adder block is also constructed with some improvement in terms of delay in block carry generation. It is observed that Reversible carry skip Binary Adder with Design II is efficient compared to Design I.*
Keywords-*Fenyman gate, Fredkin gate, Reversible carry skip adder, Garbage Input/output, Quantum Cost*

I. INTRODUCTION

1.1 ***Reversible logic***

Reversible computing was started when the basis of thermodynamics of information processing was shown that conventional irreversible circuits unavoidably generate heat because of losses of information during the computation [5]. The different physical phenomena can be exploited to construct reversible circuits avoiding the energy losses. One of the most attractive architecture requirements is to build energy- lossless small and fast quantum computers.

A Reversible circuit/gate can generate unique output vector from each input vector, and vice versa, i.e., there is a one to one correspondence between the input and output vectors. Thus, the number of outputs in a reversible gate or circuit has the same as the number of inputs, and commonly used traditional NOT gate is the only reversible gate. In digital design energy loss is considered as an important performance parameter. Part of the energy dissipation is related to non-ideality of switches and materials. Landauer's [1] principle states that irreversible computations generates heat of K×Tln2 for every bit of information lost, where *K* is Boltzmann's constant and T the absolute temperature at which the computation performed. Bennett [2] showed that if a computation is carried out in Reversible logic zero energy dissipation is possible, as the amount of energy dissipated in a system is directly related to the number of bits erased during computation.

Since adders, subtractors [11], multipliers [8] are the important blocks for the computation and if these are designed using reversible gates, information loss in computation can be prevented up to the extent of feasibility of circuit based on reversible logic.

1.2 ***Carry skip adder***

In traditional carry skip adder design an adder block of multiple full adders is constructed. These adder blocks along with carry skip block can be combined to make a carry skip adder to add any number of binary bits.

This adder block receives input carry signal and provides output carry signal .This input carry signal may ripple through each stage of the adder block and appear at the output or it can be predicted by using carry skip block. The carry skip block predicts the intermediate carry output of each stage (full adder) of the adder block on the basis of a carry propagate signal. If carry propagate signal of first stage is one input carry propagate to next stage (full adder) as well as if all the propagate signals are one the input carry is propagated to the output. If any or all propagate signal is zero, input carry signal is not transferred to the output in this case the carry generated

after addition process in last stage is transferred to the output. The propagate signal of each stage in adder block is connected to an AND gate to provide block propagate signal .Now this block propagate signal is combined with the carry output of final stage by using an OR gate to generate final carry output. Figure 1 shows the 4 bit carry skip adder block.

The carry skip worst case delay is observed when the carry generated in very first full adder, ripples through each full adder stage in first block .Thus carry output generated by the first block skips all the intermediate blocks and then it ripple through the full adder stages of the last block[6].

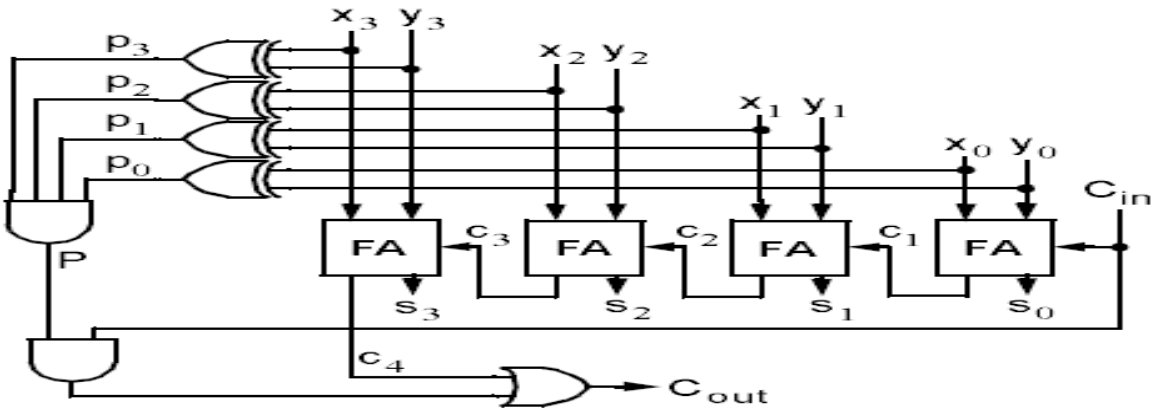

Figure1

II. BASIC REVERSIBLE LOGIC GATES

There are many reversible logic gates to perform reversible operation. These gates can be used to achieve desired output and optimization of the circuit. To achieve optimization in reversible circuit one should not allow any Fan-out and Loops or feedbacks along with this Garbage outputs, delay and quantum cost should be minimized. These reversible gates can perform various operations in different input conditions. This paper includes 2 basic reversible gates which are as follows.

2.1 Feynman(F) / CNOT Gate

The Fenyman gate is also called Controlled NOT (CNOT) gate it is 2 inputs and 2 gates as shown in Figure 2. This gate maps the input (X_1, X_0) to output $Y_1 = Y_0$ $Y_0 = X_1 \oplus X_0$ Quantum Cost of Fenyman gate is one [8]. It can also be used to generate fan out signal by keeping one input to ground according to Figure 3.

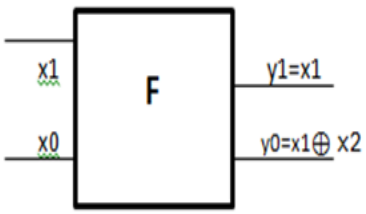

Figure 2

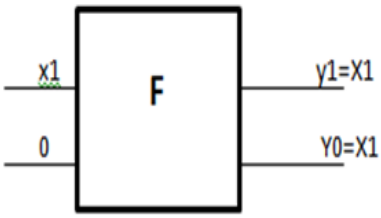

Figure3

2.2 Fredkin Gate (FG)

The Fredkin gate shown in Figure 4 is a Reversible 3×3 gate which maps inputs (X_2, X_1, X_0) to outputs $Y_2 = X_2$, $Y_1 = X_2X_1' + X_2X_0Y_0 = X_2X_1' + X_2X_0'$ .Its Quantum cost is 5[8]. The FG can be used to choose any one of the 2 inputs by applying control signal.

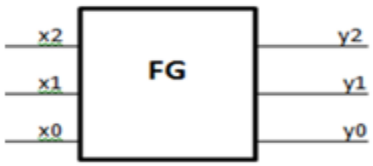

Figure4

$\mathbf{Y_2=X_2}$

$$\mathbf{Y_1}=\begin{bmatrix} X_1 & Y_2=0 \\ X_0 & Y_2=1 \end{bmatrix} \qquad \mathbf{Y_0}=\begin{bmatrix} X_1 & Y_2=1 \\ X_0 & Y_2=0 \end{bmatrix}$$

The FG gate can also be used to create the inverse and fan out function as in Figure5 [4]. 2 input AND gate can be generated by grounding one terminal as in Figure 6[4]. The 2 input OR gate can be generated by tying one terminal of FG to supply voltage according to Figure 7. Higher order AND and OR logic can be realized by using FG arranged in Binary tree .A B bit requires B-1 FGs. An input passes a maximum of $log_2 N$ FGs.

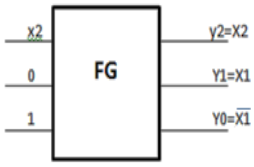

Figure5

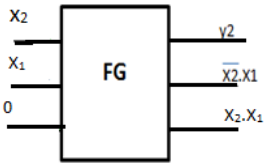

Figure6

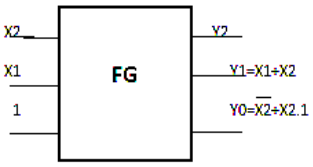

Figure7

III.PROPOSED MODEL

The Reversible gates such as F and FG are used to construct Design I and Design II full Adder. These design are applied to make carry skip adder. Further some delay improvement is also done in carry skip block by determining the state of each propagate signal one by one.

3.1 Design I

This design shown in Figure 8 represents one bit full adder which includes one fenyman gate (F) and 4 fredkin gate (FG).Fenyman gate provides the XOR operation of x1 & y1.The first FG is used to generate 2 signals x1⊕ x2 and complement of $X_1 \oplus X_2$.further if C_{in} is one the sum is $X_1 \oplus X_2$ and if C_{in} is 0 sum is $\overline{X_1 \oplus X_2}$.In each case sum and its complement appears at the output of this FG. On the basis of these signals, it can be decided that the value of C_{out} is $x1+C_{in}$ and $X1.C_{in}$.The total delay in generation of sum signal appears to be one F and 4 FG delay but as in [6] sum bit is the control bit to the 4th FGs hence the delay becomes to be equal to 3 FGs delay. The propagate signal is generated after the one F and one FG delay. This is faster than the design in [6].C_{in} is control bit in one FG but it transferred at the output after 2 FG delay , since it depends upon the sum and its complement hence total delay in generating C_{out} is one F and 4 FG. There are 2 constant input 3 garbage output and total quantum cost 21 along with total transistor count in design 22where design of fenyman gate includes 6 transistors and transistor used in FG design is 4[10] however the Verilog code for Fredkin gate used in this design includes 6 transistors.

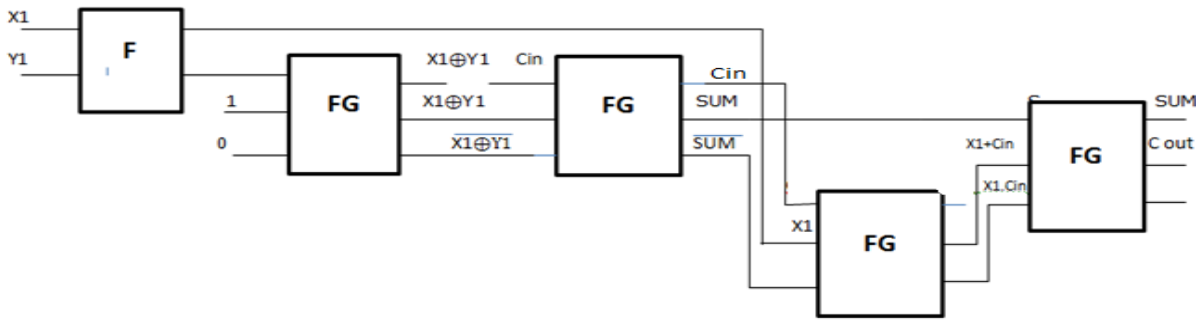

Figure8

3.2 Design II

As shown in Figure 9 proposed design II, 4Fs and 2 FGs are used. The sum is generated after 2 Fenyman gate and its complement is generated by using 1fenyman gate with 1input at logic 1. The propagate signal is generated after 2 F gate. Similar to design I carry is generated after sum signal hence the delay in C_{out} generation is 3 Fs and 2 FGs. Quantum cost of the design is 14. The garbage outputs are 3 and constant inputs are 2.

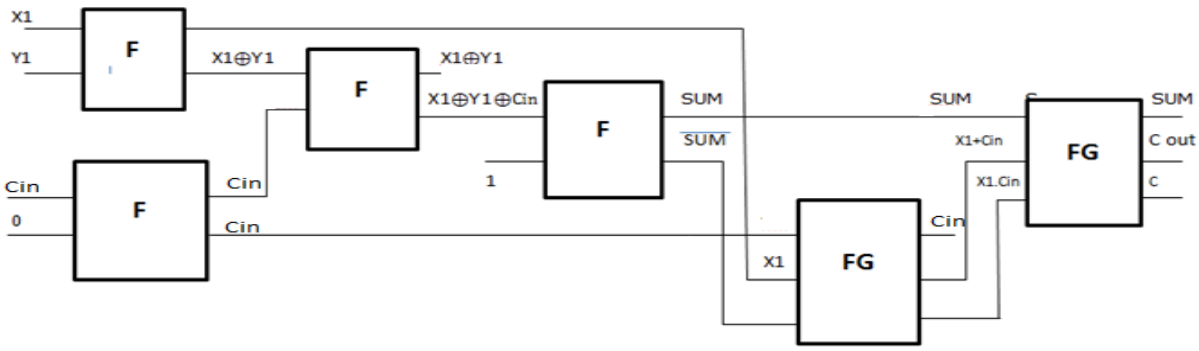

Figure9

3.3 Reversible 4bit carry skip Binary Adder

The Figure10 shows the circuit of carry skip adder block to add 4 binary bits. Add operation is performed by full adder due to any one of design I and design II. The AND -OR gate of carry skip block of Figure 2 is replaced by the fredkin gate carry skip logic. In this circuit instead of performing AND operation the fredkin gates provide decision making one by one to each carry propagate signal of each full adder. If first propagate signal is one, second propagate signal is examined and when it appears logic 1, AND operation is performed between last two propagate signal. Thus this design can avoid the delay in AND operation when either first or second or both propagate signals are 0.The total quantum cost of carry skip adder block for 4-bit adding operation is 76.The constant inputs are 11 and garbage bits are 19.

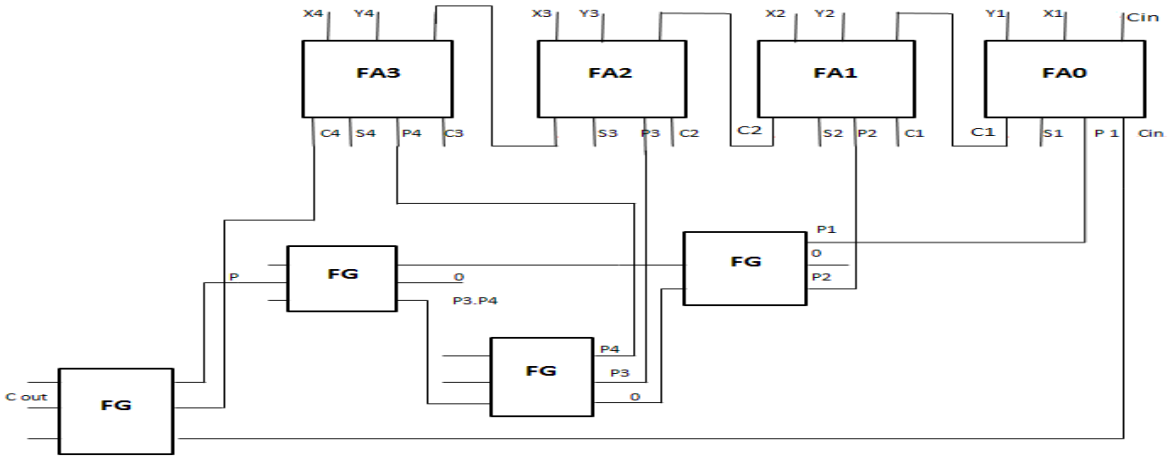

Figure10

To construct N bit adder these full adder block of B number of bit can be used. For worst case delay in output carry (C_{out}) generation it can be considered that the carry ripples in first and last B bit adder block and in all remaining B bit adder block delay in carry skip block is considered. In carry skip block worst case delay can be considered that all the propagate signals are one so delay of each FG in carry skip block can be considered. Total delay in carry generation in first and last B bit block is 2B per FG of carry transfer, delay of 2F in XOR operation of first two bit in each adder and carry of an adder stage also depends upon sum of previous stage so B F delay is included for final block carry generation. Hence total delay in first block is $2B\ FG + (B + 2)F$ as well as Delay in carry skip block is $\{(N/B) - 2\}$ 3FGs.

Hence worst case delay can be given as $T_{Carry} = 2\{3B\ FG + (B + 2)F\} + \{(N/B) - 2\}\ 3FG$

IV.RESULTS

4.1 Reversible Full Adder

Since number of transistor used in fenyman gate are 6 and transistor implementation of fredkin gate uses 6 transistors so the table 1 is sufficient to compare both the design.

Table I

Sr.No	*Design*	*Quantum cost*	*No. Of Transistor*	*Garbage output*	*Constant input*
1	I	21	36	3	2
2	II	14	36	3	2

Table II

Sr.No.	Design	Carry delay	Propagate signal Delay	Sum Delay
1	I	1F+4FG	1F+1FG	1F+2FG
2	II	3F+2FG	2F	3F

4.2 Reversible 4-bit carry skip Adder

The reversible carry skip full adder block for 4 bit is designed using the design II and some improvement in carry skip calculation is also done. The carry skip block receives first propagate signal P1and if this signal is one the propagate signal P2 is examined otherwise block propagate signal is set to logic zero value. The product of propagate signals P3 and P4 is taken on the basis of P1and if all the propagate signals are one the block propagate signal is generated. On the basis of propagate signals the decision of carry output is performed.

Table III

Sr.No	*Design*	*Quantum cost*	*No. Of Transistor*	*Garbage output*	*Constant input*
1	4 bit- carry skip Adder	76	152	19	10

Table IV

Sr.no.	*Design*	*Carry(worst case)*	*Propagate signal*
1	4 bit- carry skip Adder	$2\{3B\ FG + (B+2)F\} + \{(N/B) - 2\}\ 3FG$	2F

4.3 Simulation

Figure 11 shows the simulation waveform for each input combination of proposed full adder design I using Modelsim PE student edition 10.4

Figure11

Corresponding to proposed full adder design II the simulation waveform is shown in Figure 12.

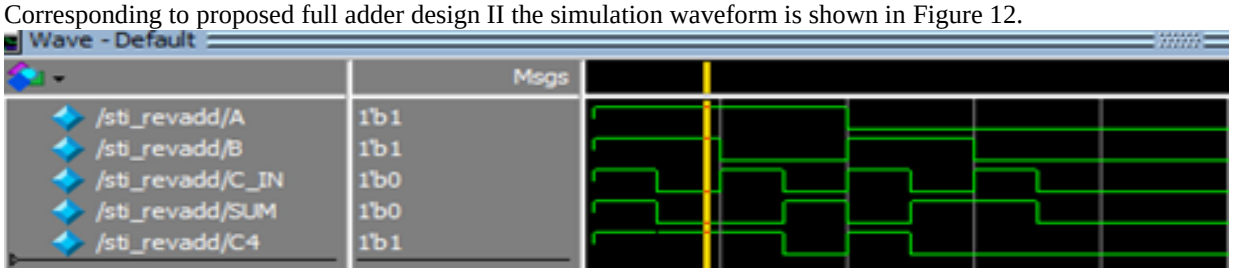

Figure12

Carry skip adder simulation result is shown in Figure 13, it is clear that when the block propagate signal (PR) is one, carry input (C_IN) propagates to the carry output (C_out) otherwise the ripple carry (C4) will be the carry output.

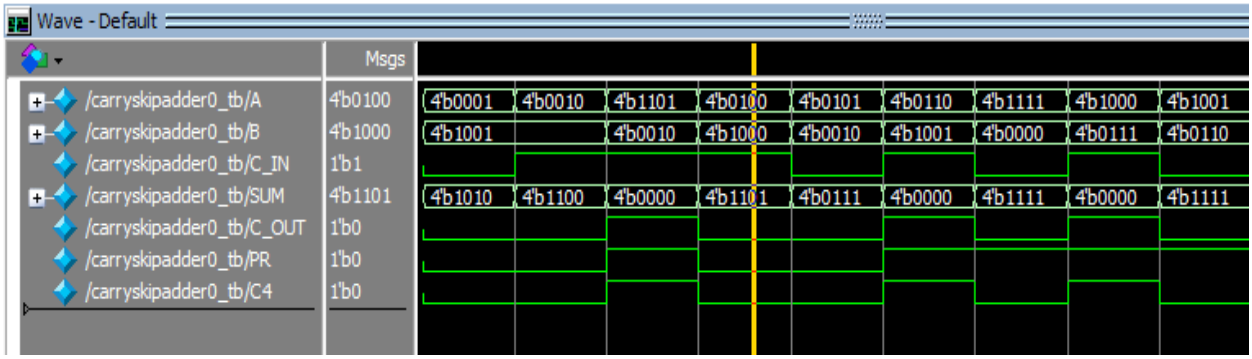

Figure13

V. CONCLUSIONS

Design I and design II both include the basic calculation of AND, OR and EXOR gate using reversible logic. The garbage count, number of transistor and delay are same for both the design but design II is better in point of view of quantum cost. The carry skip block also has some delay improvement over existing design because it checks the propagate signal of each full adder one by one hence reduces the delay in further calculations. The garbage output and constant inputs are reduced in carry skip adder block. In future, the design can be extended to any number of bits for Parallel Binary Adder & Subtractor unit and also for low power Reversible ALUs, Multipliers and Dividers.

REFERENCES

[1] *R Landauer, (1961) "Irreversibility and Heat Generation in the Computational Process", IBM Journal of Research and Development, vol. 5, no. 3, pp. 183-191.*

[2] *C H Bennett, (1973) "Logical Reversibility of Computation", IBM Journal of Research and Development, vol. 17, no. 6, pp. 525-532.*

[3] *T Toffoli, (1980) "Reversible Computing", Technical Memo MIT/LCS/TM-151, MIT Lab for Computer Science.*

[4] *E.Fredkin and T. Toffoli,"conservatie logic",Int. J. theoretical physics vol.21,nos 3-4,pp.219-253,1982.*

[5] *C H Bennett, (1998) "Notes on the History of Reversible Computation", IBM Journal of Research and Development, vol. 32, pp. 16-23.*

[6] *J.W. Bruce, M.A.Thorton, L.Shivkumaraiah, P.S.Kokate and X. Li," Efficient adder circuit based on a conservative Logic gate "Proceedings of the IEEE Computer Society Annual Symposium on VLSI (ISVLSI.02) 0-7695-1486-3/02.*

[7] *Hafiz Md. HasanBabu et al,"Synthesis of full adder circuit using reversible logic "VLSI Design, 2004. Proceedings. 17th International Conference.*

[8] *HimanshuThapliyal and M B Srinivas,(2006) "Novel Design and Reversible Logic Synthesis of Multiplexer Based Full Adder and Multipliers",Forty Eight Midwest Symposium on Circuits and Systems, vol.2, pp. 1593 – 1596.*

[9] *Himanshu Thapliyal and A.P Vinod," Design of Reversible Sequential Elements With Feasibility of Transistor Implementation", Circuits and Systems, 2007. ISCAS 2007. IEEE International Symposium on, 625-628.*

[10] *H Thapliyal and N Ranganathan, (2010) "Design of Reversible Latches Optimized for Quantum Cost, Delay and Garbage Outputs", Proceedings of Twenty Third International Conference on VLSI Design,pp. 235-240.*

[11] *Jaspreetkaur and Harpreetkaur ,"synthesis and designing of reversible adder/subtracter circuit", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 4, may 2014.*

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Bitumen in Coating Corrosion Protection of Steel-The Position and Prognosis of Nigerian Bitumen

T.N. Guma [1], S.Y. Aku [2], D.S. Yawas [3], and M. Dauda [4]
[1] *Department of Mechanical Engineering, Nigerian Defence Academy, Kaduna, Kaduna State, Nigeria*
[2, 3, 4] *Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Kaduna State, Nigeria*

ABSTRACT: *The paper discusses bitumen as an important cheap technological material that is supplied in a variety of grades that are not all good for specific wide range of its applications. Various grades of bitumen and their sources as well as conditions that govern their selection for corrosion protection services are reviewed. Problem of corrosion of carbon steel as a prime structural material in relation to Nigeria's solely petroleum dependent economy which is bedeviled by effects and costly management of corrosion is revisited. Benefits of using bitumen in coating corrosion protection of steel works and potentials of exploiting the country's vast reserves of natural bitumen, the second largest in the world whose compositional contents and quality vary from location to location; to sustainably and profitably combat her corrosion problem are explored. The exploration exposes Nigerian bitumen as generally undeveloped, uncharacterized and ungraded at various resource locations for proper exploitation due to a number of problems. The paper concludes that for engineering utilization of Nigerian bitumen, impediments to development of her bitumen resources must be sincerely and radically addressed to make her bitumen readily available. Extensive test-evaluation of relevant properties and performances as well as standard grading of the country's bitumen from various resource locations, and documentation of overall applicable coating codes of practice also needs to be properly undertaken beforehand.*

Key words: *Bitumen grades, selection, corrosion coat-protection of steel, Nigerian bitumen, development and exploitation, scarcity of relevant applicable information*

I. INTRODUCTION

Corrosion is an insidious material degradation process that jeopardizes safety and hinders technological progress to maximal attainments [1]. Corrosion is preponderant in the oil and gas industry. The cost of corrosion to the industry worldwide is huge and staggering. A figure of $300 billion was mentioned in the United States alone in 1998. It was estimated that only 15% of the amount was economically justifiable using the existing technologies of corrosion prevention. Several millions of American dollars are spent worldwide annually on researches on the science and methods of preventing steel corrosion, yet the up-to-date efforts and technological sophistication on the subject are far from utopian achievement[2-7]. The practicable technological achievements have been by various levels of cost-incurring control of corrosion. It is thus apparent that corrosion control is primarily an economic problem. Whether or not to apply a control method is usually determined by the cost savings involved. The method or methods utilized must be the optimum economic choice. Companies, business groups and individuals are not into business primarily to make any product-they are in business to make profit [8]. On this basis, paint or organic coatings have been the most important, versatile and widely used method for combating corrosion of steel-the most important, versatile, widely used available and cheap structural material in our engineering technological era. Corrosion of steel accounts to about 90% of all corrosion problems and make it critical to contend with technologically in all spheres. About 90% of all steel are corrosion-remediated by paints or organic coatings. The area of organic materials and coatings is wide and inexhaustible and engineers have been searching for better materials and various ways and levels of combining them to combat corrosion. It is the duty of the engineer to bring the idea and designs into reality by proper selection of the coating material and technology. To keep the challenges imposed on the engineer, it is desirable for them to have thorough knowledge of coating materials and processes for particular applications [9-12]. Organic coating materials vary greatly and include bitumen, epoxy resin, amino resins, polyamides, polyurethanes, cellulose derivatives, casein, polyolefin, acrylic polymers, drying oils, fossil resins and polyvinyl [13]. Bitumen is a

generally common, cheap and versatile material in today's technological world. It is widely used for roofing, pipe coating for corrosion protection; construction of roads, bridge decks, parking lots, airport pavements, reservoirs, canals, tunnels, and hydraulics; etc. It is however available in a variety of grades that are not equally good in terms of adhesive properties, effectiveness, availability, service performance and reliability, handling and processing, etc for coating and other specific engineering applications [14, 15 and 16]. Nigeria's economy is about 85% petroleum-dependent. The country is a developing nation that is searching for ways to catapult her to the status of an industrialized nation without necessarily preparing for it. No government in Nigeria has yet come to grips with the reality of the devastating effect of corrosion on the country's economy. The country is endowed with abundant critical and strategic resources that can help her to easily attain industrial status if managed properly but so far, the utilization of these resources as raw materials is dependent wholly on the industrialized economies. The petroleum industry upon which the Nigerian economy is so dependent is prone to effects of corrosion. About 80% of her refinery equipment and transmission pipelines are made of carbon steel particularly of the low carbon type. These pipelines pass through the sea, rivers, underground or surface water in urban and rural areas. Deterioration of these pipelines and other aspects of plants in the economy as a result of corrosion is a huge cost to the country in terms of subsequent wastages from oil leakage and spillage, product contamination, replacement of parts, protection and maintenance, contravention of environmental and safety laws due to pollution, fire and general losses. Yet all the materials of construction in the country are imported, and an enormous amount of foreign exchange is lost to corrosion in the country [12, 17 and 18]. There is therefore strong need for concern posed by professional, technological and economic challenges on how best to mitigate the problem.

Nigeria is however blessed with abundant bitumen from her resources that should be sustainably available at economical rate for exploitation for corrosion coat-protection of transmission pipelines and other aspects of plants in her petroleum industry compared to imported materials in the country. Bitumen was discovered in Nigeria over 110 years ago. The country has proven reserve of about 42.47 billion tonnes of bitumen, the second largest in the world, covering about 120 x 4.3km on the onshore areas of Eastern Dahomey (Benin) basin [19, 20, 21 and 22]. This is spread along the bitumen belt stretching from the country's Lagos and Ogun to Ondo and Edo States. Five distinct hydrocarbon types of occurrence have been identified within the Nigerian tar sands belt as; outcrop, rich sands, lean sands, shale and deep seated heavy crude. The bitumen content of the tar sands varies from location to location. Very rich natural bitumen deposits are found in Ondo State around the region of Idiobilayo, Foriku, Agbabu, Okitipupa, and Aiyibi. Generally tar sands are composed of bitumen, water and some mineral accessories. Tar sands with 5-10% by weight bitumen content are designated as good or medium grades. The average bitumen content of Nigerian tar sand is about 20%. Between 1904 and 1970, close to 40 wells, bore holes and exploration wells had been drilled within some areas of surface occurrence in the country [20, 21, 23 and 24]. The clay content of Nigerian bitumen deposit is very low averaging about 5% and heavy oil extracted from the area has API gravity between 5.00 and 14.6^{O}. Physical properties reported include softening point ($44\text{-}52^{O}$C), ductility (0.1-1.3), penetration (80-100mm), hydrocarbon content (7.2-18.2% by weight), resins (32.12-34% by weight), and sulphur (5.00-10.00ppm). Furthermore, the Nigerian bitumen possesses relatively large quantity of naphthalene aromatics and asphaltenes that are similar to the conventional oil. This makes Nigerian bitumen a very useful alternative source of petroleum hydrocarbon and a potential feedstock for petro-chemical industries [22 and 25]. On the other hand, Kaduna Refining and Petrochemical Company (KRPC), Kaduna, is the most important source of synthetic bitumen in Nigeria. The KRPC bitumen is produced by blending imported suitable crudes such as Lagomar from Venezuela, Light Arabian from Saudi Arabia, Basra from Iran, and from Kuwait with Nigerian crude which per se is predominantly light, nearly sulphur-free and poor in bitumen content as feedstock [26]. The objectives of this paper are:

i. To revisit the problem of corrosion of carbon steel as a prime structural material in relationship to the Nigerian economy.
ii. To review the benefits, main sources, grades, and applications of bitumen as an engineering material in relation to corrosion mitigation.
iii. To extract the position of Nigerian bitumen in combating corrosion in the country, any contending issues and approaches.

II. METHODOLOGY

Information presented in the paper was obtained from various literature sources, field surveys, discussions with professional colleagues and other competent workers in the field and refined with several years of teamwork experience as engineering professionals, academics, researchers and fieldworkers.

III. REVIEW OF BITUMEN AS A COATING MATERIAL

3.1 Desirable qualities of coating materials

It is not every material that can be used for coating treatment on metal or other substrates, either for protective, aesthetic, or test purposes. This is because some materials are generally known to posit unwanted effects that make the treatments economically wasteful and vain exercises. Economy demands that before coating treatment on any substrate is carried out for test or application purposes, the coating material should be satisfactorily indicative of suitable properties and performances, as may be determined from knowledge of its established properties and general service performance, or some appropriate preliminary tests. To ensure the integrity of coating during application, handling and in service, it is essential that the coating material meets a number of key requirements which ideally include the following [12, 27, 28, 229 and 30]:

i. It should be sustainably available at minimal cost.
ii. It should provide good adhesion to the substrate and completely inhibit any corrosion of the substrate to be protected with minimal coating thickness and surface preparation of the substrate.
iii. Its coating must have maximal resistance to disbondment and chemical degradation
iv. It should not pose any undesirable effects to the substrate under protection.
v. Coatings produced with it must be flexible to withstand deformations that can occur in bending, testing or lying, as well as any expansion or contraction due to changes in temperature. The coatings must also not develop cracks during and after application or curing.
vi. Its coating should be easy to repair at minimal cost.
vii. It must be possible to produce desired coating formulations with the material, and use the formulations to apply coatings in the factory or in the field at a reasonable rate and ease and handle the work reasonably quickly after the coating has been applied without damaging the coating.
viii. Its coating must be an electrical insulator and must not contain any conducting material, so as to prevent any corrosion due to electrical contact between it and environmental electrolytes.
ix. Its coating must be chemically and physically stable. In line with this, it must not develop aging effects such as denaturing due to absorption of lower-molecular weight constituents or hardening with resultant cracking from any cause such as temperature changes.
x. Its coating must be impervious, sound and of high integrity.
xi. It should always be in either proper liquid, solid, powdered, or gaseous states to facilitate its coat-application with various available methods; or it should easily be modified or changed to such state with minimal additives to it at minimal costs.
xii. It should have and maintain any desired aesthetic finishing and integrity.
xiii. The coating itself should be non-corrodible or have very high resistance to weathering.
xiv. Its coating should provide infinite protection of the substrate with minimal thickness in any service environment.
xv. Its coating should also have maximal resistance to abrasion, wear and environmental contamination.
xvi. It must be non-toxic or pose any health hazards to personnel handling it.
xvii. It must have chemical and physical compatibilities with a wide range of cheap and easily obtainable additives that can be used to enhance its properties.
xviii. It should be easy to get satisfactory coating from it using cheap available coating methods.
xix. It must be non-flammable or pose any other hazards to personnel.
xx. Its coating must be resistant to attack by environmental bacteria and other organisms.

It can be appreciated that no coating material has been found to possess all these and other ideal requirements. The level of performance of a coating material can be judged relative to the requirements. In practice, the choice of any coating material for a protective treatment on a given part, component, or structure, for a particular application is determined basically by the material's comparative degree of effectiveness and service life, initial and maintenance costs, method of coating and degree of automation involved, availability, aesthetics, feasibility of maintenance, applicability to mass treatment, minimum effective thickness, chemical composition and other properties of the substrate, and corrosivity level of the service environment [31 and 32]. Performance and economic factors have however been found to be of prime importance when choosing a coating material for protective application. The area of organic coatings is very wide and complex, and is one of the most important areas that engineers have been searching for optimal ways of preventing or controlling corrosion of steel in its service environments. The search can only be measurable if appropriate procedures and corrosion tests involving treatments of a considerable number of wide ranges of organic materials singly or in various combinations on the metal, are conducted and results properly established through the respective collation and data analyses [12 and 33].

3.2 General Record of Bitumen in Service Performance

Valuation of bitumen as a coating material can be made from its general record in usage in relation to the ideal requirements of coating material. Bitumen has been in use since ancient times as back as over 3,500 years before Christ. Documented accounts of the material show the following qualities which measure the level of its suitability as protective coating material and make any meaningful relevant research result on it applicable beneficial supplementary information [34, 35 and 36]:

i. Bitumen was used in ancient Egypt for mummification of Pharaohs-a form of corpse preservation that used to be effective for hundreds of years. This shows that it has preservative capabilities against bacteria or microbes, fungi and other organisms.
ii. It has been in use for satisfactory waterproofing and soundproofing. This is indicative that it is a sealant and can protect an underlying material from corrosion if applied atop its surface, by excluding the surface from environmental moisture, oxygen, chemicals, fungi, insects, dirt, leaves, paper, etc.
iii. It is a generally cheap material with average cost of about 25 Nigerian Naira per kilogramme (N25/kg) which is about 0.125 US dollars. It is also supplied in various standard grades around the world.
iv. Bitumen of different grades or physicochemical properties performs differently in service. It is important that the most suitable or convenient grade or quality of bitumen be selected for particular technological services.
v. It has been used either singly or in various combinations with some organic or inorganic products to improve its properties and performance to various levels.
vi. Improvement in service performance and durability is apparent where bitumen forms the main proportion of an applied material such as asphalt used in the construction of roads, airport and park pavements and buildings.
vii. Compared to some paints and other coatings, it has very minimal health problems to personnel during handling.
viii. It is also being widely used today to build vapour-proof and flexible bituminous or asphalt protective coat in accordance with its formulation and polymerization grade, for corrosion protection of structural steel, concrete, etc.
ix. Generally, bitumen is an abundant and cheap material with large proven reserve of over three metric giga tonnes worldwide.
x. Bitumen coatings are heavy bodied materials and have excellent resistance to industrial pollution. Bitumen of properly established properties and performances is used today in various coating forms such as enamels, bituminous wrappings, bituminous tapes, bituminous paints, etc to protect steel and other structural materials in corrosion-preponderant industries such as petroleum or other chemical and water industries.
xi. Different methods of bitumen coat-application ranging from jobbing to fully automated are exploitable.
xii. It is not every grade of bitumen that is good for coating protection and other specific engineering applications. For corrosion protection services; availability, hardness, consistency with respect to changes in temperature, adhesion and knowledge of minimum effective coating thickness are of paramount importance in choosing bitumen. It is contrary to engineering principles to harvest or obtain uncharacterized or ungraded bitumen and use it on the basis of general or average performance of bitumen for specific applications. Moreover, even graded and supplied bitumen can be contaminated during transportation or laying by even small amount of solvent, petrol, fuel oil or diesel and considerably alter their properties and service performances. Engineering principle therefore demands proper test information on any bitumen whose grade or quality is not certain before critical service applications.

3.3 Sources of Bitumen

Bitumen exists naturally in a number of locations worldwide. Bitumen obtained from different regional sources can have wide variation in chemical composition and other properties so can be widely different in grades and service performances. This is due to variations in geological factors and chemistry; hence sand and water contents, mineral accessories of bitumen, etc. It is also synthesized in different grades or qualities from crude of even the same source or properties by various manufacturing processes. This is because the types and levels of mineral accessories, sand and water contents, etc removable from crude by a particular manufacturing process in producing bitumen differ from different process so resulting in bitumen with different chemical and other properties [2].

Synthetic bitumen

A bulk of bitumen in most modern applications is produced by fractional distillation of crude oil; only a small amount comes from natural sources like Trinidad lake asphalt in Canada. Usually the distillation is done in two steps. First, the crude oil is heated up to 300-350^{o}C and introduced into an atmospheric distillation column. Lighter fractions like naphta, kerosene and gas oil are separated from the crude oil at different heights

in the column. The heaviest fractions left at the bottom of the column are called long residue. The long residue is heated up to 350-400^{o}C and introduced into a distillation column with reduced pressure called vacuum column. By using reduced pressure, it is then possible to further distillate lighter products from the residue because the equivalent temperature that is temperature under atmospheric conditions is much higher. By carrying out a second distillation under atmospheric conditions with increment in the temperature above 400^{o}C, thermal decomposition of the long residue occurs. The residue at the bottom of the column is called short residue and is the feedstock for manufacture of other bitumen. The viscosity and other properties of the short residue depend on the origin of the crude oil, the temperature of the long residue, the temperature and the pressure in the vacuum column and the residue time. Usually, the conditions are such that short residue is produced with a penetration between 100 and 300mm. Bitumen manufactured from short residue is called straight run bitumen or asphalt [14, 15 and 37]. Of the wide variety of crude oils that are commercially available only a limited number are considered suitable for producing bitumen of the required quality in commercial quantities. In general, these are heavy crude oils with high sulphur content. In modern integrated refineries, it is common practice to blend multiple crude oils to produce consistent quality high grade bitumen that meets precise engineering specifications. Synthetic bitumen is available in variety of grades around the world. Specifications vary to meet the needs of the consuming industries and are based on physical tests that define the safety, solubility, physical properties and durability of bitumen. The physical properties are designed to define performance characteristics that are required under climatic and loading conditions that the bitumen will experience. Although bitumen is produced and supplied in various grades around the world; each grade has particular uses, distinct handling and service performances [15].

Natural bitumen

Natural bitumen exploitation is very energy and capital-intensive and controversial because it causes considerable pollution and environmental damage. It devastates the forest and destroys wildlife habitat and causes deaths of birds, uses very large quantities of water that are not returned to the natural cycle and gas to heat the water into steam to heat the bitumen into extractable condition, causes acid rains that spread into nearby provinces and produces large amount of tailings that are toxic which keep on building up and are stored indefinitely and pollute rivers downstream. Also, producing a unit measurement of bitumen produces three times more greenhouse gases than a unit of conventional petroleum. Technologies of extracting bitumen from the ground vary widely, but basically two methods are used. The strip-mining technique (traditional extraction method) which is more familiar to the general public but can only be used for shallow bitumen deposits and insitu processes. The insitu processes are available with varying technologies and advantages and disadvantages which can be selected to extract bitumen. The more recent technique is the steam-assisted gravity drainage (SAGID). SAGID is enhanced recovery technology for producing heavy crude oil and bitumen. It is better suited to the much larger deep bitumen deposits that surround the shallow ones. It has the ability to extract bitumen deposits up to 200m beneath the surface. In the SAGID process, steam at about 232^{o}C is forced through injection wells which heats up the surrounding, making the bitumen less viscous and eventually cause the bitumen to flow freely via gravity to a production well below. The advantage of the insitu process is that only a small fraction of the land is used compared to surface exploration such as the strip mining technique. Some insitu processes do not use water but off the grid electricity to power its air compressors [38].

3.4 Grades of Bitumen

Since all bitumen grades are not good or used for coating, it is imperative to know the basic characteristics of various grades of bitumen for selecting the most suitable for specific applications. Generally, hardness and consistency determine the suitability of a grade for coating and are greatly correlated to the physicochemical properties of the bitumen. The principal grades of bitumen are [16]:

i. Penetration or paving grade bitumen. This is the most commonly and widely used bitumen for road engineering and industrial applications. It is essentially the parent bitumen or original form of bitumen from which the other forms of bitumen are produced by further processing to meet better service requirements that take into account different climatic conditions. The penetration grade bitumen is divided into Pen 40-50, 60-70, 80-100, 120-150 and 200-300 grades based on bitumen penetration test procedure in accordance with ASTM D5. Each of grade bitumen has other distinct properties such as viscosity, flash point, specific gravity, elasticity and/or plasticity, adhesion and cohesion, softening point, weather or oxidation resistance, breaking point, etc; so, their performances are different under the same service application. The differences in properties between high and low penetration grade bitumen are mainly caused by different amounts of molecule structures with strong interaction. Low penetration grade bitumen contains more of these molecule structures. This is the main reason why their properties are much higher than for the high penetration grade bitumen (Pen). Pen 40-50 is the hardest grade and is most suitable for application in hotter climates while the Pen 200-300 in cold climates. The hardness of bitumen decreases with increase in

its penetration, so the Pen 200-300 is the softest. For service performance by any parent bitumen of unknown grade, its properties need to be established for optimally using it according to engineering principles. Specifications of properties of penetration grade bitumen are documented in a number of standards such as the international standard IS-73:2006.

ii. Cut back bitumen. This consists of short residue (original form of bitumen) that has been diluted in solvent oil such as white spirit, diesel, kerosene, gasoline and gasoil to make it more fluid to reduce its viscosity for applications at ambient temperatures. Cutbacks are classified according to the time it takes for them to cure, or become solid due to evaporation of the diluents. Classifications are rapid curing (RC), medium curing (MC) and slow curing (SC).

iii. Bitumen emulsions. These are dispersions of about 30-80% by bitumen volume in water. Hot bitumen, water and emulsifier are processed in a high speed colloid mill that disperses the bitumen in water in the form of small droplets. The droplets are normally 5-10µm in size range but may be even smaller.

iv. Modified bitumen. These are formulated with additives to the original form of bitumen to improve their service performances by changing such properties as their durability, resistance to ageing, adhesive or cohesive strength, elasticity and/or plasticity.

v. Industrial or oxidized bitumen. This is made by blowing air through hot paving grade bitumen. The process results in bitumen that is technically more advantageous for applications in terms of durability, flexibility, chemical stability, water resistance, hardness, consistency and higher softening temperature than penetration grade bitumen. Industrial bitumen also has more rubber-like properties and their viscosities are much less affected by changes in temperature than is the case with penetration or paving grade bitumen.

vi. Multi-grade bitumen. This is chemically modified bitumen that has the properties of hard paving grade bitumen at high service temperatures coupled with the properties of soft paving grade bitumen at low temperatures. In other words, it has properties that span at least two grades. Multi-grade bitumen provide improved resistance to deformation and reduce the detrimental effects of high service temperatures, whilst providing reduced stiffness at low service temperatures than exhibited by a similar normal paving grade bitumen.

3.5 Bitumen in Coating Protection of Steel

Bitumen coatings have been in use for protecting steel and other structural materials from corrosion, and coatings based on suitable bitumen show excellent resistance to industrial pollution. Whilst bitumen itself does not possess any inherent corrosion inhibiting properties, it is effective because of its impermeability preventing water, oxygen, and other agents of corrosion reaching the metal surface. Bitumen is not totally impermeable to the agents for every thickness, but any desired degree of impermeability can be achieved by applying a sufficiently thick layer of hard grade bitumen. Proper engineering principles demands that such a layer must be applied with the understanding of the minimum thickness that is sufficient to completely inhibit corrosion of the substrate. When using available bitumen of known grade, such thickness may be obtained or worked out from documented standards such as the BS 4147(4). Proper engineering principle however demands series of relevant tests and standardization to establish the grade, minimum effective thickness, properties and service performance in using bitumen whose grade is not known for specific applications such as corrosion protection. Such information is also necessary to serve as control where the bitumen does not meet the required specifications but requires modification before using it [14, 15 and 16]. Because of its high viscosity, bitumen cannot be efficiently and economically coat applied at room temperature; so it is usually heated to 150 to 250^{o}C to lower its viscosity for industrial applications to metalwork by spraying, rolling and mopping methods [32, 34 and 39]. By adjusting the proportions of the various constituents of bitumen, it is often prepared with sufficient plasticity to prevent cracking under cold weather and a sufficiently low melting point; that it may also be applied to metalwork by hot-dipping at about 150-200^{O}C. As bitumen is not mechanically tough enough itself to withstand much wear or stress, it is usually applied by 'hot wrapping' in which a fiberglass swathe is passed through the cauldron of molten bitumen and then wound round the steel or other material to be protected. Inorganic or polymer weaves are not used for wrapping, ordinary sacking or hessian is subject to decay and in so doing creates conditions suitable for both direct acidic attack and bacteria corrosion. This mode of protection is particularly suited to exterior pipelines both above and below ground level, and by it much thicker coatings can be achieved than is possible with unsupported bitumen. A second technique that is used for producing thick coatings is by the addition of about 30% of inorganic filler such as powdered limestone or asbestos to the bitumen, the resulting composition is known as mastic coatings [33 and 34].

Bitumen used in the coating industry is coal tar and asphalt. Although these materials are distinctly different physically and chemically, in appearance they are identical black tar materials. Coal tar enamels or pitches are derived from coking of coal. Asphaltic coatings generally have much greater ultraviolet resistance than coal tar, so, they are suitable for above-grade, atmospheric weathering applications. However, coal tar coatings are vastly superior to asphaltic coatings in moisture and chemical resistance, so they are used most commonly below grade

or in water immersion services [34]. Thermoplastic bituminous coatings are applied as hot melts, solvent cutbacks, or water emulsions as follows [39]:

i. The hot melt method involves heating the bitumen to a temperature of approximately 177-246^{O}C to reduce viscosity for application. The hot melt can then be applied by mop or swap by brush, roller or spray, or by flow coating of the interiors of pipes and small vessel. In general hot melt applications provide the best moisture and chemical resistance, followed in order by solvent cutback and water emulsions.
ii. Solvent cutback method involves dissolving asphaltic or coal tar bitumen in a suitable aliphatic or aromatic hydrocarbon solvent to lower viscosity for application by spray, brush or roller. The solvent then volatizes and the bitumen re-solidify into a film. The coating thickness and moisture resistance of a solvent cutback generally are less than that achieved by hot melt application, but the convenience of not having to heat the bitumen at the job site immediately before application is a major advantage.
iii. Water emulsions are prepared by suspending minute particles of the bitumen in water using emulsifying agents together with inert fillers, such as coal dust, powdered silica, mica, and limestone dust. After application, the water evaporates and coalescence occurs to form a protective film. Emulsions of both asphalt and coal tar can be applied by brush, roller or spray.

Bitumen water emulsions are volatile organic compounds (VOC)-complaint. However some solvent cutback applications may not be VOC-complaint due to the use of solvents. While hot-melt bitumen generally is VOC-complaint, it may release volatile organic compounds into the atmosphere during heating and application. This depends on the type of bitumen and the heating temperature. Furthermore, volatile phenol-containing compounds produced during the heating of bitumen are considered carcinogenic and skin irritants. Therefore, suitable protective clothing and appropriate respirators must be used. Because of their chemical make-up, coal tar and asphalt coatings generally are incompatible and are not be used as mixtures or applied one over the other [39].

Problems in using bitumen for coating protection

Bitumen is a thermo-visco-elastic material where temperature and load application have a great influence on its behaviour. It is classified as rheological material since its viscosity; stress and strain response is both time and temperature dependent. The binder consistency and hence ability to sustain and hold its fundamental cementing mechanism changes depending on its viscosity. In most cases, bitumen is not used in its original form but modified or supported because of certain undesirable characteristics of the material [32 and 33]. These characteristics include [33 and 40]:

i. It's ability to exist in solid, semisolid, or very high and low viscous liquid state; and change its hardness or consistency with temperature. At 20^{O}C, the viscosities of some types of bitumen range from 10^{3} to 10^{8} Poise depending on the type; compared to water 10^{-2} Poise, diesel 10^{-1} Poise and engine oil 10 Poise.
ii. It's not being mechanically tough enough to withstand much wear or stress.
iii. It's ability to crack under cold weather.
iv. It's poor resistance to organic solvents.
v. The engineering properties of bitumen are dependent on temperatures, duration or time of loading, and the stress applied. In contrast to many traditional structural materials, such as steel, whose properties are for practical purposes constant, the behaviour of the material under stress varies from elastic to viscous according to the condition of stressing. Under stresses of short duration and at low temperatures, bitumen behaves purely elastically, whereas, under conditions when the stress is applied for long periods and/or at high temperatures, the behaviour is purely viscous. Between these two extremes, and this is the range of practical interest for most applications, the behaviour is intermediate or visco-elastic..
vi. The principal limitation of bitumen as a coating material is its vulnerability to heat; many will soften and creep on inclined surfaces if exposed to strong sunshine so are unsuitable for applying to pipes carrying hot liquids. They should also be used with caution in conjunction with oil paints, as for example, when bituminous coating might be applied on top of a red lead primer. The reason for this is that chemicals in the bitumen can have the effect of preventing hardening in oil-bound paints and the result may be a failure in adhesion of the combined coating. It should also be noted that bitumen is unlovely in appearance, which often restricts its use to buried metalwork and industrial protection systems in which aesthetic values are not a high priority.

One reason that is attributed to all these above characteristics is that bitumen is not a well-characterized chemical, despites its wide use. The material is a complex mixture of organic and inorganic compounds and their complexes [33 and 36].

Modification of bitumen to enhance its shortcomings in coat-protective applications

To mitigate temperature dependence and other shortcomings of bitumen, it is often formulated with additives to improve its service performance by changing such properties as its durability, resistance to ageing, elasticity and plasticity. The most important modifiers are polymers such as thermoplastics, thermo sets, and rubber. Because of cost consideration, polypropylene and styrene-butadiene-styrene (SBS) modifications find applications in paving and coating. Amorphous polypropylene (APP), a waste by-product in the manufacture of isotactic polypropylene (IPP), was initially used in Europe to modify asphalt for roofing membranes and other applications. The technology is now applied in many countries such as United States of America. Copolymer polypropylene containing 2-10% ethylene has been found to increase clarity, toughness, flexibility, and lower melting points of bitumen. Thermoplastic block copolymers with styrene end-blocks and rubber mid-blocks, for example, butadiene (SBS), isoprene (SIS), and their hydrogenated versions (SEB, SEPS) are common modifiers of asphalt [36]. Polymer modification of bitumen is achieved by poly-blending with rubber polymers, for example, SBS, SEBS, SIS, and ethylene/vinyl acetate/carbon monoxide (E/VA/Co) at 2-5% by weight polymer level in paving applications. For coatings, both rubber and polypropylene modifications are used but at a much higher polymer loading. Typically 11-15% by weight SBS rubber polymer (linear, radial, or combination) or 20-25% by weight polypropylene (APP/IPP or copolymer PP/FPP) based on bitumen is used for coating. Bitumen is also often coordinated with resins such as phenolics, alkyds, urea formaldehyde or polystyrene to increase the strength of bituminous finishes. Such finishes are used for treating the external surfaces of pipelines employed to carry water, gas or oil [36 and 41].

3.6 Health Question of Bitumen

Bitumen is usually handled and coat-applied at high temperatures, which can be above their flash points so this presents potential hazard from skin burns and inhalation of substances such as sulphur compounds from hot storage tanks. Skin burns can however be alleviated by plunging into cold water and once cooled; no further harm will be done as the bitumen provides a sterile covering until it becomes detached [35]. Bitumen contain compounds which are potentially carcinogenic but the concentrations of these compounds in the bitumen have been found to be negligibly very minute and thus do not necessarily constitute a health risk in practice, although appropriate precaution should always be taken [35 and 42].

The unmistakable odour of bitumen, which can be carried over great distances, may result in a variety of complaints ranging from slight discomfort to mild nausea or feeling ill. The pungency of the odour varies with a number of factors, including the source of bitumen (composition), temperature of the bitumen, ambient temperature, prevailing winds, and the type and condition of the melting equipment. The fumes emitted by bitumen tend to be concentrated at the locations where it is being heated, discharged into carriers, and applied. Unfortunately, current technology for heating bitumen, relying on external heating sources and exhausting fumes into the air, makes its aroma an unavoidable eternality that must be taken into consideration each time they are heated and applied. Complaints from individuals regarding the noxiousness of the fumes, particularly on such sensitive projects as schools and health care facilities, have, in some instances, led to costly interruptions, severe restriction to work schedules, and in extreme cases the complete cessation of the activities [42].

Odour emissions are one of the key concerns for manufacturers of asphalt and bitumen coating industries. The industry has implemented several measures for reducing odour output. Examples are the placement of higher stack, the implementation of fine dust filters, scrubbers, and the covering of storage areas. In some cases these measures are not sufficient and neighbours continue complaining about the odour emissions even after the initial odour removal measures. Due to reported complaints and high costs imposed by them on contractors involved in the use of bitumen, a research project was designed to investigate potential ways of mitigating adverse effects with respects to the odour produced while heating the material. The project consisted of laboratory testing and field trials of commercial fragrant compounds to determine their effectiveness in masking the odours associated with heated bitumen. The results of this research indicated that these compounds can be successfully employed to screen the aroma of hot bitumen and reduce the discomfort of individuals who find it offensive. The compounds include natural and synthetic oil or extract fragrances such as lemon oil, orange oil, peppermint, spearmint, cinnamon and bubble gum. Others are fragrances that consist of natural and synthetic materials having glycol ether, alcohols, esters, adehydes, ketones, etc [42].

IV. POSITION OF NIGERIAN BITUMEN

Nigeria's natural bitumen from various locations is yet to be developed, properly graded, supplied and exploited for economic and technological development. Yet, there is scarcity of comprehensive information on codes of practice with the Nigerian bitumen by standards organizations. Agbabu, a village of about 400 inhabitants with location coordinates of $E004^{O}48\text{-}49^{1}$ and $N06^{O}34\text{-}36^{1}$ is where bitumen was first spotted in Nigeria in 1910 and the first bitumen well NBC-7 was drilled. NBC-7 has remained open to the surface and

periodically flow heavy oil. The bitumen deposit within the region of the village is ranked as one of the first five major bitumen deposits in the world but is still equally undeveloped and unexploited [20, 21, 23 and 24]. Problems that impede natural bitumen development in Nigeria include policy inconsistency and lack of adequate legislation, high risk and health hazards in exploitation, weak regulation, lack of well equipped laboratories, unwholesome practices of stakeholders and inadequate number of trained personnel, lack of access to capital, lack of appropriate technology and machinery, and environmental degradation and pollution. Bitumen produced from crudes at KRPC is grossly inadequate for the needs of consumers even in Nigeria alone. At a news conference on Tuesday, July 22, 2014, in Kaduna, the Association of Bitumen Marketers and Distribution of Nigeria (ABIMD) reported that Nigeria loses about, 300 billion Naira on bitumen importation annually. The amount, the union said, could be used for other meaningful projects if the government had stopped importation of the product and encouraged its local production at KRPC. Fred Nyabam, the national vice chairman of the association described the massive importation of bitumen in the country as a serious threat to the economic development of the nation. He raised alarm over activities of some few individuals who he described as 'selfish individuals' and 'economic saboteurs', who he said had truncated all efforts made in the past to stop importation of bitumen in Nigeria and encourage local production. The brazen act of sabotage against the nation is that over 60% of all the bitumen imported into Nigeria was from a refinery in Iran whose bitumen production capacity is not bigger than that of KRPC; he stated [14, 43 and 44]. As earlier stated in this paper, it is contrary to engineering principles to harvest bitumen of unknown grade and characteristic performances from any source and coat a metal to any thickness or use it on the basis of general or average performances of bitumen for corrosion protection or other critical engineering applications. Proper engineering principles demands all necessary test evaluations of such bitumen to establish their grades, suitability levels, capability and handling properties before considering them for applications or further processing to meet the required service properties or standards [14 and 45]. Guma *et al* [2-7] contributed research efforts towards engineering coat-utilization of Nigeria's abundant bitumen resources for corrosion protection of steel works but a lot more still has to be done.

V. APPROACHES TOWARDS UTILIZATION OF NIGERIAN BITUMEN FOR CORROSION PROTECTION

For engineering utilization of Nigerian bitumen to optimally reduce the cost and effects of corrosion in her economy, the following approaches need to be followed among other things**.**

i. Problems that impede bitumen development in Nigeria such as lack of affordable optimal technology, adverse effects on the environment, and lack of the wherewithal should seriously be re-examined and addressed by all stakeholders especially the Nigerian engineering community and Government.

ii. Proper laboratory tests with coatings of various thicknesses of bitumen from the different resource locations in Nigeria on corrosion inhibition of important structural materials such as steel and concretes should be extensively conducted and cross-checked by field and service tests to optimize applicable data.

iii. An active research unit as part of Nigerian Bitumen Development Project or a different research centre equipped with laboratories and enough good facilities should be established and based in the Nigerian bitumen belt. The unit or centre should have on its employment, relevant professors, lecturers, higher degree holders, competent technical staff and management staff charged with the responsibility of conducting extensive and detailed applicable researches on specific engineering applications of Nigerian bitumen from several sources. All such researches should be properly collated, documented and made available to the public. All employers of the unit or centre should be on the salary scale of oil companies in Nigeria and paid higher than their counterparts on the same levels in Nigerian universities as incentive.

iv. Basic technical information on design coating-treatments; and by extension formulation of corrosion-resistant coatings such as paints, bituminous wrappings, admixtures in concrete encasements etc, of Nigerian bitumen for corrosion protection of structural steel works such as pipelines, surface and underground tanks in water, petroleum and other chemical industries should be properly conducted.

v. Researches on optimal modifications of bitumen from various Nigerian sources to mitigate poor characteristics that are associated with all bitumen such as temperature-dependence of properties should be conducted using affordable materials in Nigeria.

vi. The Standards Organization of Nigeria should collate and understudy all corrosion coat-inhibition research information on Nigerian bitumen in conjunction with existing standards worldwide on coating usage of bitumen and issue coating codes of practice with the country's bitumen.

V. CONCLUDING REMARK

Corrosion of carbon steel as prime structural material in relation to Nigerian economy, and coating use of bitumen in protective applications are reviewed. The review exposes corrosion as an outstanding material degrading mechanism that pose direct threat, cost and management challenges in the country's petroleum-dependent economy. Moreover, it exposes bitumen as an important widely used technological material that is available in a variety of grades that are not all good for specific engineering applications. For corrosion protection services; availability, hardness, consistency with respect to changes in temperature, adhesion and knowledge of minimum effective coating thickness are of paramount importance in choice and use of bitumen. Nigeria is blessed with vast sustainable reserves of natural bitumen; the second largest in the world whose compositional contents and quality vary from location to location. The potentials of exploiting the resources for the country's economic and technological developments are wide and great. In particular, the country's bitumen can be a source of sustainable coating material that can be more beneficially used to tackle her corrosion problems compared to imported materials if well planned, established, and laid down. Findings from the paper have however shown that, so far, Nigerian bitumen is generally undeveloped, uncharacterized and ungraded at various resource locations for proper exploitation due to a number of problems. For engineering coat-utilization of Nigerian bitumen for corrosion protection: impediments to development of her bitumen resources must be sincerely and radically addressed to make her bitumen readily available, extensive test-evaluation of relevant properties and performances as well as standard grading of the country's bitumen from various resource locations should be properly undertaken beforehand, and provision of documented overall applicable codes of practice with her bitumen is needful.

REFERENCES

[1] Pierre R. Roberge. *Handbook of corrosion engineering*. McGraw-Hill Publishers, 2015, 1-2

[2] T.N.Guma, P.B. Madakson, D.S. Yawas and S.Y. Aku. Assessment of physicochemical properties of some bitumen from Nigerian resources. *Nigerian journal of basic and applied science, Usmanu Danfodiyo University, Sokoto, Nigeria, 20(2),* 2012.

[3] T.N.Guma, P.B. Madakson, D.S. Yawas and S.Y. Aku. Effects of some bitumen coating treatments on the hardness corrosion of low carbon steel. *International research journal of engineering science and technology, 7(1),* 2010.

[4] T.N.Guma, P.B. Madakson, D.S. Yawas and S.Y. Aku. Assessment of capability levels of bitumen from some Nigerian sources to coat-inhibit tensile strength corrosion of low carbon steel. *International journal of engineering science, 3(1),* 2011.

[5] T.N.Guma, P.B. Madakson, D.S. Yawas and S.Y. Aku. Assessment of capability levels of bitumen from some Nigerian sources to coat-inhibit impact strength corrosion of low carbon steel. *International journal of mechanical engineering, 3(1),* 2011.

[6] T.N.Guma, P.B. Madakson, D.S. Yawas and S.Y. Aku. Effects of some bitumen coating treatments on the corrosion fatigue strength of low carbon steel. *Research Desk- International journal of science and technology, 2(1),* 2013.

[7] T.N.Guma, P.B. Madakson, D.S. Yawas and S.Y. Aku. X-ray diffraction analysis of the microscopies of some corrosion-protective bitumen coatings. *International journal of modern engineering research, 6(12),* 2013.

[8] Mars G. Fontana. *Corrosion engineering, 3rd edition.* McGraw-Hill Book Company, New York, 1987, 32-34.

[9] W.D. Callister. *Material science and engineering: an introduction, 5th edition.* John Wiley and Sons Inc. New York, 2004, 357-601.

[10] R.A.Higgins. *Engineering Metallurgy: applied physical metallurgy, 6th edition.* Arnold, Hodder Headline Group, London, 1993, 507-537.

[11] T.V. Rajan, C.P. Sharma and A. Sharma (1997). Heat treatment principles and techniques. Prentice-Hall of India Ltd, New Delhi, 1997, 236-390.

[12] Shreir, L. *Corrosion volume 2, principles of corrosion control*. Butterworth Publishers, London, 1979, 10.1-20.3

[13] Protection-Organiccoating:www.chemia.adlew.agh.edu.pl/.../corrosion/organic%20coatings.pdl Extracted on 14/05/2915

[14] Srivastava A and Van Roijen RC. Bitumen Performance in Hot and Arid Climates. A paper prepared for pavement seminar for the Middle East and North Africa region on *Innovative road rehabilitation and recycling technologies: new policies and practices in pavement design and executions*, Amman Jordan, 2000, October, 24-26.

[15] Bitumen Supplier Limited. Penetration Bitumen Suppliers Limited, 27 Hart Avenue Sandiacre Nottingham, NG 105FY United Kingdom, **www.bitumen** suppliers.com. Extracted on 12/07/2015

[16] Dixit, S. and Rastogi, D. Studies on the Improvement of Characteristics of bitumen with use of waste plastics. *International journal of emerging technology and advanced engineering 3(3*), 2013, 895-900.

[17] Wami, E. N. Investigation of underground corrosion of mild steel and high carbon steels. *Nigerian journal of technical education, 15(1),* 1988.

[18] Ali, J.A. Socio-economic costs of corrosion: the Nigerian situation and policy suggestions. *Journal of construction and material technology-Nigerian Building and Road Research Institute (NBBRI), 1(1),* 1998, 30-39.

[19] Oboh O.B, Ilori M.O, Akinyemi J.O and Adebusoye S.A. Hydrocarbon degrading potential of bacteria isolated from a Nigerian bitumen (tarsand) deposit. *Natural science, 4(3),* 2008, 51-58.

[20] Fagbote E.O and Olanipekun E.O. Levels of polycyclic aromatic hydrocarbons and polychlorinated biphenyls in sediment bitumen deposit impacted area. *International journal of environmental science and technology, 7(3),* 2010, 561-570.

[21] Adegoke O.S. Historical perspective of bitumen: tarsand development in south Western Nigeria. A paper Presented at 1st International Summit of Bitumen in Nigeria held in Akure, Nigeria, 2000, November, 14-16.

[22] Adegoke O.S, Omatsola M.E, Coker J.L. The geology of the Nigerian tarsand. in: heavy crude and tarsands hydrocarbons for 21st century. *Proceedings of 5th UNITAR International. Conference on heavy crude and tarsands,* 1991, 369-835.

[23] Adedemila AS. Bitumen Nigeria's other black gold? inaugural lecture series, University of Lagos, University of Lagos Press, Lagos, Nigeria, 2000, 1-45

[24] Olabemiwo O.M, Adelowo O.O, Tella A.O, and Bello I.A. Preliminary study on bio desulphurization of Nigerian natural bitumen. *International journal of basic and applied sciences- IJBAS 13(3),* 2013

[25] Bola O Oboh, Mathew O Ilori, Joseph O Akinyemi, and Sunday A Adebusoye. Hydrocarbon degrading potentials of bacteria isolated from a Nigerian bitumen (tarsand) deposit. *Nature and science 4(3),* 2006, 51-57.

[26] Olalere, A. *Asphalt/bitumen production from Nigerian crude, a research project*, Department of Chemical Engineering, Kaduna Polytechnic, Nigeria, HND, 1991.

[27] Laque, F.L. *Marine corrosion*. A Wiley-Interscience Publication, New York, 1975, 12-317.
[28] Barton, K. *Protection against atmospheric corrosion -theories and methods*. John Wiley and Sons Ltd, London, 1976, 11-182.
[29] Pludek, V.R. *Design and corrosion control.* The Macmillan Press Limited London, 1977, 1-35.
[30] Collins, J.A. *Failures of materials in mechanical design*. A Wiley-Interscience Publication, New York, 1981, 603-613.
[31] Uhlig, H.H. *Corrosion and corrosion control: an introduction to corrosion science and engineering*. John Wiley and Sons Inc, New York, 1971, 1-2.
[32] Diamant, R.M.E. *The prevention of corrosion*. Business books publishers, london, 1967, 24-166.
[33] Hall, C. *Polymer materials: an introduction for technologists and scientists*. Macmillan Limited, London, 1967, 181-188.
[34] Illston, J.M., Dinivoodie, J.M. and Smith, A.A. *Concrete, timber and metals: the nature and behaviour of structural materials.* Van Nostrand Reinhold Company Limited, London, 1979,. 569-615.
[35] Jackson, N. and Ravindra, K..D. *Civil Engineering materials.* Macmillan Press Limited, London, 1996, 53-64.
[36] Usmani, A.M. Polymer Network Formation in Asphalt Modification. In: A. M. Usmani (Ed), *Asphalt Science and Technology*, Marcel Dekker Inc, New York, 1997, 369-372.
[37] V Pipe coating.pdf (2014). http://www.truongnguyenvn.com/QTTC/pdf/V_Pipe%20Coating.pdf. Extracted on 20/7/2014
[38] Environmental and Health impact of Canada's Oil Sands Industry. Royal Society of Canada's Expert Panel, December, 2010. www.ianas.org/.../Environmental. Extracted on 12/10/2015.
[39] Painting and Decorating Contractors of America. *Painting and decoration craftsman's manual and textbook, 8th edition.* Published by Painting and Decorating Contractors of America Fairfax Va, 1995, 7 – 15.
[40] Arafat Suleiman Yero and Mohd Rosli Hainin. Influence of organic wax on bitumen characteristics. *American journal of. engineering and applied science 4(2)*, 2011, 265-269.
[41] Zielinski, J. Factors influencing compounding of constituents in bitumen-polymer compositions. In: A. M. Usmani (Ed), *Asphalt science and technology*, Marcel Dekker Inc, New York, 1997, 337-344.
[42] Kalinger, P., Booth, R.J. and Paroll, R.W. Reduction of ordour from hot asphalt. In: A.M. Usmani (Ed), *Asphalt science and technology*, Marcel Dekker Inc, New York, 1997, 135-148.
[43] Gyang J.D, Nanle N., and Chollom, S.G. An overview of mineral resources development in Nigeria: problems and prospects. *Continental journal of sustainable development,1,* 2010, 23-31
[44] Nigeria loses 300 billion annually to bitumen importation. Extracted from: leadership.ng/business/…/nigeria-loses-300bn-anually-bitumen-impotat... Extracted on (13/13/2014
[45] Johnson, S.M. *Deterioration, maintenance and repair of structures*. McGraw-Hill Book Company, New York, 1965, 20-57.

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Production and Characterization of Rice Husk Pellet

Japhet, J. A., Tokan, A., and Muhammad, M. H.
Department of Mechanical/Production Engineering
Abubakar Tafawa Balewa University, Bauchi, Nigeria

Abstract: *Production and characterization of rice husk pellet was investigated as an alternative source of energy. Pellets were produced from the rice husk using a mold and a small hydraulic press (fitted with pressure gauge) the pellets were produced without binder, at three (3) pressures of compaction of 28MPa, 31MPa and 34MPa and three (3) particles sizes of 212µm, 300µm and 425µm. The effects of compaction pressure on the properties of pellets were determined. The properties determined were moisture content, ash content, bulk density, porosity index, and the calorific value. The results showed that, the higher the compaction pressure the lower the porosity index and consequently the higher the bulk density. The fuel pellet's density affects its bulk thermal properties. This effect is seen, when 100g of each pellet sample were combusted. Increased burning time of pellets was observed as the bulk density increases. The result also showed that the maximum calorific value of 17.589MJ/kg was achieved with a compaction pressure of 34MPa and with particle size of 425µm. also the minimum calorific value of 15.129MJ/kg was achieved with a compaction pressure of 34MPa and with particle size of 212µm.*

Keywords: *Ash, Bulk density, Calorific value, Compaction pressure, Moisture, Porosity, Pellet*

I. INTRODUCTION

Rice husk is one of the largest readily available but most underutilized biomass resources. There are many reported uses of rice husk such as a fuel in brick kilns, in furnaces, in rice mills for parboiling process, in the raw material for the production of furfural, sodium silicate, Briquettes, molecular sieves [1]

Despite having so many well established uses of rice husk, little portion of rice husk produced is utilized in a meaningful way, the remaining part is allowed to burn in open piles or dumped as a solid waste or it is used as cattle feed. Many reasons associated with rice husk for not being utilized effectively as stated by [2] include: (1) lack of awareness of its potential, (2) insufficient information about proper use, (3) penetration of technology, (4) lack of environmental concerns etc.

With the global campaign to combat climate change, countries are now looking for alternative sources of energy to minimize green house gas (GHG) emissions. Aside from being carbon neutral, the use of biomass for energy reduces dependency on the consumption of fossil fuel; hence, contributing to energy security and climate change mitigation [3].

Agricultural wastes have been highly promoted to be used in various heating systems, during the past decades. Compared to fossil fuel, however, most of agricultural wastes have higher moisture content and lower density, thus making them technically unsuitable for direct use due to combustion and handling problems. Conversion of biomass wastes to briquettes (pellets) is a solution for such problems. It improves biomass handling characteristics, increases the volumetric calorific values, and reduces transportation, collection, and storage costs [4] and [5].

The densification of biomass into briquettes, logs, bales, chips, pellets, etc has become an important source of energy even in the rural communities. The main advantage of the Biofuel briquettes are its domestic origin, potential for reducing total dependence on oil and gas economy, jobs creation to the rural dwellers and help in the waste management by changing waste to wealth. Biofuels briquettes for utilization as energy source for domestic and industrial heating processes can significantly reduce emissions of air pollutants [6].

This work is aimed at producing rice husk pellet by varying the compaction pressure. Effect of compaction pressure of biomass materials on physical properties and combustion characteristics were also investigated.

II. MATERIALS AND METHODS

2.1. Raw Material Procurement

The rice husk was collected from a rice mill at Yelwa Tudu, it was grinded into a powdered form and sieve through screens to obtain three particle sizes of 212µm 300µm and 425µm.

2.2. Pellet Production

The Rice husk pellet was produced by compaction in a mold with the following dimensions 12mm diameter and 20mm length at three (3) pressures of 28MPa, 31MPa and 34MPa. [4] investigated the optimal compositions of coal, rice husk and palm oil sludge for energy derivation produced at various compression pressures in the range of 20 to 45Mpa. The rice husk powder was first mixed with a little water directly to moisten it before loading in the mold. Water acts as both a binding agent and a lubricant. Water helps develop Vander Waals' forces by increasing the area of contact between particles [5]. The production of the pellet was done using a manually operated hydraulic press fixed with a pressure gauge for varying the pressure and a simple mould. The setup is shown in fig. 1.

Figure 1: Manual hydraulic press fixed with a pressure gauge

Figure 2: The mould use for the production

Figure 3: Pellets produced

2.3 Determination of Bulk Density

Bulk density measurement was determined according to the method of [7] which states that for all densified products (cubes, pellets, or crumbles); use a cylindrical container with a height-diameter ratio within the range of 1.25–1.50. The diameter of the container must be at least ten times larger than the largest dimension of a single product. The bulk density was determined by calculating the ratio of the mass to the volume occupied. A cylindrical metal container with 100 mm diameter and 130 mm height was weighed. The bulk density measurement was repeated five times and the average value and range were reported. The bulk density was calculated from the relationship:

$$Bulk\ density\ (\boldsymbol{B}_d) = \frac{W_1 - W_0}{V_2} \qquad (1)$$

Where:

W_0 = Mass of the container

W_1 = Mass of the sample and the container

V_2 = Volume occupied by the pellet

2.5 Determination of Ash Content

Ash content was determined using the method of [8]. 3 pieces of each pellet samples were placed in a pre-weighted crucible and were weighed out. The samples were incinerated in a furnace at 760^0C until complete ashing was achieved. The crucibles were left over night to cool. The cooled samples were then weighed. The ash content was calculated by using equation (2):

$$Ash\ content\ (\%) = \frac{(W_5 - W_3) \times 100\%}{W_4 - W_3} \qquad (2)$$

Where:

W_3 = Weight of the crucible,

W_4 = Weight of the crucible + sample before incineration and

W_5 = Weight of the crucible + sample after incineration

2.6 Determination of Moisture Content

The moisture content of each pellet sample was determined by the oven drying method. This was carried out at temperature of 103 ± 2^0C in accordance with the method of [9]. The samples were dried in the oven for 1 hour. The moisture content was calculated by using equation (3):

$$Moisture\ content\ (\%) = \frac{[(W_7 - W_6) - (W_8 - W_6)] \times 100\%}{W_7 - W_6} \qquad (3)$$

Where:

W_6 = wt of empty container

W_7 = wt of container + sample before drying

W_8 = wt of container + sample after drying

2.7 Determination of Porosity Index

The porosity of each pellet sample was determined based on the amount of water two pieces of each pellet sample was able to absorb. Each pellet sample was immersed in water at room temperature for 30s. The porosity index was calculated as the ratio of the mass of water absorbed to the mass of the sample immersed in the water [10]. The test was replicated five times and the average value recorded.

$$Porosity\ index\ (P_i) = \frac{(W_{10} - W_9) \times 100}{W_9} \qquad (4)$$

Where:

W_9 = mass of sample

W_{10} = mass of sample immersed in water

$(W_{10} - W_9)$ = mass of water absorbed

2.8 Determination of Calorific Value

The net calorific values of the 12 samples were determined by using the relationship below of [11]

$$NCV = 18.7(1.0 - AC - MC) - (2.5MC) \quad (5)$$

Where

NCV = net (lower) calorific value
AC = ash content
MC = moisture content

2.9 Determination of Burning Rate

Burning rate is the ratio of the mass of the fuel burnt (in grams) to the total time taken (in minutes) [12].

$$Burning\ rate\ (B_R) = \frac{mass\ of\ fuel\ consumed\ (g)}{total\ time\ taken\ (\text{min})} \quad (6)$$

100g of each pellet samples were weighed using an electronic weighing machine. Each sample at the time of burning was put in a domestic stove. The combustion was initiated by the addition of a little kerosene and igniting with matches. The temperature of the burning samples was taken by means of thermocouple at every two minute intervals using a stop watch until it was completely burnt. The temperature was taking from a particular point on the stove for all the samples.

III RESULTS AND DISCUSSION

3.0 Results

The results of the experiments carried out on the properties of the rice husk pellet are presented on table 1 to

Table 1: The description of pellet samples

Samples	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
Particles size (µm)	425	425	425	300	300	300	212	212	212
Compaction pressure (MPa)	28	31	34	28	31	34	28	31	34

Table 2: The result of bulk density of pellet samples

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
Mass of container, W_0 (kg)	.0736	.0736	.0736	.0736	.0736	.0736	.0736	.0736	.0736
Mass of sample + container, W_1 (kg)	.5979	.6300	.6407	.8050	.8143	.8236	.8443	.8650	.8665
Range (kg)	.0029	.0033	.0028	.0026	.0022	.0021	.0044	.0026	.0022
Volume occupied, V_2 (m^3)	.001	.001	.001	.001	.001	.001	.001	.001	.001
Bulk density, B_d ($kg/m^{3)}$	524.3	556.4	567.1	731.4	740.7	750.0	770.7	791.4	792.9

Table 3: The result of ash content of pellet samples

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
Weight of crucible, W_3 (g)	61.9	51.2	63.8	62.4	96.6	110.2	66.3	90.3	114.9
Weight of crucible + before incineration W_4 (g)	67.8	56.9	69.2	69.8	102.6	115.9	72.3	96.7	120.2
Weight of crucible + after incineration W_5 (g)	62.4	51.5	64.0	63.0	97.4	110.8	67.2	91.2	115.6
Ash content (%)	8.5	6.0	3.7	10.5	13.3	10.5	15.0	14.0	13.2

Table 4: The results of moisture content of pellet and charcoal samples

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
wt of empty container W_6 (g)	24.1	24.0	23.9	24.0	23.7	24.7	24.1	23.8	24.0
wt of container + sample before drying W_7 (g)	34.3	34.1	33.8	35.7	34.2	34.2	34.5	34.5	33.6
wt of container + sample after drying W_8 (g)	33.8	33.8	33.6	35.4	33.9	33.9	34.2	34.1	33.1
Moisture content %	4.9	3.0	2.0	2.6	2.9	3.2	2.9	3.7	5.2

Table 5: The results of porosity index of pellet samples

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
Mass of sample W_9 (g)	4.7	4.7	4.8	5.1	4.3	4.2	4.8	5.1	4.9
Mass of sample immersed in water W_{10} (g)	9.3	9.2	9.3	7.3	5.8	5.6	5.5	5.8	5.5
Mass of water absorbed ($W_{10} - W_9$) (g)	4.6	4.5	4.5	2.2	1.5	1.4	0.7	0.7	0.6
Porosity Index %	97.9	95.6	93.8	43.1	34.9	33.3	14.6	13.7	12.2

Table 6: result of net calorific value of pellet samples

Sample	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
NCV unit	16.072 MJ/kg	16.942 MJ/kg	17.584 MJ/kg	16.185 MJ/kg	15.598 MJ/kg	16.058 MJ/kg	15.281 MJ/kg	15.292 MJ/kg	15.129 MJ/kg

Table 7: The result of proximate analyses for pellet samples

Sample	**Moisture content %**	**Ash content %**	**Bulkdensity kg/m^3**	**Porosity index %**	**Calorific value MJ/kg**	**Burning rate (g/min)**
P_1	4.9	8.5	524.3	97.9	16.072	2.38
P_2	3.0	6.0	556.4	95.6	16.942	2.27
P_3	2.0	3.7	567.1	93.8	17.584	2.27
P_4	2.6	10.5	731.4	43.1	16.185	1.79
P_5	2.9	13.3	740.7	34.9	15.598	1.47
P_6	3.2	10.5	750.0	33.3	16.058	2.17
P_7	2.9	15.0	770.7	14.6	15.281	2.17
P_8	3.7	14.0	791.4	13.7	15.292	2.00
P_9	5.2	13.2	792.9	12.2	15.129	1.85

Table 8: Results of time and temperature for burning 100g of fuel

Time (min)	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
0	26	26	26	26	26	26	26	26	26
2	44	47	52	54	32	38	38	31	30
4	95	91	161	84	46	68	60	57	39
6	128	108	180	89	54	94	83	90	66
8	160	115	189	78	59	132	106	97	95
10	147	123	217	80	67	145	108	101	103

12	129	124	167	79	77	136	122	112	112
14	112	107	130	73	94	118	148	119	131
16	97	97	100	73	104	104	154	122	136
18	88	89	81	76	97	92	148	113	122
20	77	82	76	83	72	90	126	104	102
22	73	77	69	100	54	79	113	90	85
24	68	71	59	101	46	74	103	73	72
26	62	66	57	89	42	70	92	67	63
28	56	58	49	78	44	60	82	60	59
30	50	56	49	71	46	54	69	54	54
32	46	51	47	60	50	49	63	48	54
34	43	47	39	51	50	46	44	46	55
36	38	42	39	48	48	39	42	44	50
38	35	37	35	45	48	38	38	39	47
40	33	35	33	46	51	36	36	38	44
42	31	33	32	42	51	34	34	36	38
44		32	31	51	50	32	32	35	37
46				37	50	31	30	34	35
48				37	43			32	34
50				36	42			31	34
52				35	43				33
54				33	42				32
56				32	38				
58					36				
60					37				
62					37				
64					36				
66					33				
68					32				
70									

Table 9: Result for burning rate of pellet samples

	P_1	**P_2**	**P_3**	**P_4**	**P_5**	**P_6**	**P_7**	**P_8**	**P_9**
Mass of fuel (g)	100	100	100	100	100	100	100	100	100
Total time taken (min)	42	44	44	56	68	46	46	50	54
Burning rate (g/min)	2.38	2.27	2.27	1.79	1.47	2.17	2.17	2.00	1.85

IV DISCUSSIONS

4.1 Bulk Density

It was observed from the results of tables 1 and 2 that the bulk density of the rice husk pellet was influence by the compaction pressure. As the compaction pressure increases from P_1 to P_3, P_4 to P_6 and P_7 to P_9, the bulk density also increase. The fuel pellet's density affects its bulk thermal properties. The lower the density, the less heat is required for a specific volume of fuel to reach the ignition temperature. This was in line with the observation of [13]. This was seen on the burning rate of the different samples, for instant pellet P_1, P_2 and P_3 recorded slightly higher temperatures within few minute of combustion, while P_6, P_7, P_8, and P_9 recorded slightly lower temperature within the same time range. And again, while pellet P_1, P_2 and P_3 maintained high temperatures for a relatively short period, P_6, P_7, P_8, and P_9 maintained high temperature for a relatively longer period as shown on Table 8. The deviation of pellet sample P_4 and P_5, may be attributed to prevailing atmospheric wind condition at the time of the combustion.

4.2 Porosity index

The porosity, which is the measure of the resistance to water penetration, is an important physical property in the determination of the quality of the pellet fuel: The lower the porosity, the higher the resistance to water penetration. In his finding, [14] observed that the higher the percentage resistance to water penetration of briquette, their best shatter and durability indices showed that they have good shock and impact resistance and are good for handling and transportation.

The investigations reveal from tables 1 and 5 that pellet porosities are influenced by compaction pressure. The less the compaction pressure the high porosity and the lesser the porosity the higher the bulk density. The lowest density was 524.3 kg/m^3 at a pressure of 28MPa, while the highest was 792.9 kg/m^3 at a pressure of 34MPa. The lower porosities will hinder mass transfer, such as drying, devolatilization and char burning processes, due to fewer free spaces for mass diffusion (e.g. water vapor, volatile matter, and carbon dioxide outflows and simultaneously oxygen infiltration). Consequently its combustion rates were lowered, given rise to longer period of combustion as observed by [15]. This condition was observed for pellet samples P_1 to P_3 and P_7 to P_9 as shown on Tables 8 and 9. For samples P_4 to P_6, the deviation show that there are other factors that may affect the combustion rate. Further investigation may be carried out to ascertain this.

4.3 Calorific value

Significant differences in heating values were found among pellet samples produced. From the result shown in Table 6 and table 1, the maximum calorific value of 17.589MJ/kg was achieved with a compaction pressure of 34MPa and with particle size of 425µm. also the minimum calorific value of 15.129MJ/kg was achieved with a compaction pressure of 34MPa and with particle size of 212µm. From the result of table 4, as the moisture content increases the heating value reduces. This was observed for instance P_1, P_2 and P_3, with moisture content 4.9%, 3%, and 2% and heating value 16.072MJ/kg, 16.942MJ/kg and 17.584MJ/kg respectively. Higher moisture content implies a lower calorific value as each unit mass of fuel contains less oven dry biomass – which is the part of the fuel that actually undergoes combustion to release heat (The Carbon Trust, 2008). The ash content also affects the heating value. From table 3, it was observed that P_5 and P_7 have the same moisture content of 2.9, ash content of 13.3% and 15% and calorific value of 15.598MJ/kg and 15.281MJ/kg respectively. This was in line with the observation of [13], the higher the fuel's ash content, the lower the calorific value. [16] and [17] also observed that the presence of high mineral matter components in wood is not desirable, because they are not degraded during carbonization and they remain in charcoal as ash, which also contributes to the reduction of charcoal heating value.

V CONCLUSION

Energy demand, most especially in the developing nations can be augmented by the use of waste biomass, a renewable energy source which is available in abundance. Ineffective utilization of the biomass residues constitutes environmental hazard and pollution and also emits strong irritating smell due to microbial decomposition activities at dump sites. This calls for production and characterization of rice husk for energy production. This study has shown that compaction pressure has influence on the physical and thermal properties of the fuel. Although the moisture and ash contents affects the calorific value of the fuel, the net calorific value for the pellet samples P_1 to P_9 are high to produce enough heat required for domestic household cooking and small-scale industrial cottage applications.

REFERENCES

[1]. Tejinder Singh (2000). The Tribune, Online Edition, Monday, November, 13, 2000, Chandigarh, India.

[2]. Gidde, M.R. and Jivani, A.P. (2007): Waste to Wealth- Potential of rice husk in India a literature Review: Proceedings of the International Conference on Cleaner Technologies and Environmental Management PEC, Pondicherry. India. January 4-6 2007, Pp 586-590.

[3]. United Nations Environmental Programme (UNEP), (2009): Converting Waste Agricultural Biomass into a Resource. *Compendium of Technologies.* Division of Technology, Industry and Economics International Environmental Technology Centre Osaka/Shiga, Japan. Pp. 6

[4]. Markson, I.E., Akpan, W.A. and Ufot, E., (2013): Determination of Combustion Characteristics of Compressed Pulverized Coal-Rice Husk Briquettes; *International Journal of Applied Science and Technology, Vol. 3 No. 2, Pp 61 - 64*

[5]. Grover P.D. and Mishra S.K. (1996): Biomass Briquetting Technology and Practice. Food and Agriculture Organization of the United Nations, Bangkok. Regional Wood Energy Development Program (RWEDP).

[6]. Fabian M. (2003): An introduction to anaerobic digestion of organic wastes. Scotland Remade.

[7]. ASABE Standards (2012) Densified products for bulk handling—definitions and method. ASABE S269.5. In: ASABE Standards 2012, American Society of Agricultural and Biological Engineers, St. Joseph, MI, p 1–8

[8]. American Society for Testing and Materials (ASTM) (1998): D2017 - 98 Standard Test Method of Accelerated Laboratory Test of Natural Decay Resistance of Woods , decay, evaluation, laboratory, natural, resistance and subjected to termite bioassay according to no-choice test procedure based upon AWPA E1-97 (AWPA, 1998) and ASTM D 3345-74 (ASTM, 1998c) standard: pp 111 – 175

[9]. American Society for Testing and Materials (ASTM) (1991): Standard Methods of Evaluating the Fibre and Panel Materials. ASTM D 1037 - 91. Annual book of ASTM Standards, 04.09 Wood, Philadelphia, PA. pp. 169 – 191. Properties of Wood-Based
[10]. Montgomery, W.F., (1978). Standard Laboratory Test Methods for Coal and Coke in Analytical Methods for Coal and Coal Products, Academic Press, New York, pp. 194-224.
[11]. Omoniyi, T.E. and Olorunnisola A.O., (2014): Experimental Characterisation of Bagasse Biomass Material for Energy Production; International Journal of Engineering and Technology Volume 4 No. 10, Pp 582 - 589
[12]. Onuegbu T.U., Ekpunobi U.E., Ogbu I.M., Ekeoma M.O. and Obumselu F.O. (2011): Comparative Studies Of Ignition Time And Water Boiling Test Of Coal And Biomass Briquettes Blend (www.arpapress.com) IJRRAS 7 (2)
[13]. Loo S. V. and Koppejan J., (2008): The Handbook of Biomass Combustion and Co-firing. Earth scan, London
[14]. Sengar S. H., Mohod A. G., Khandetod Y. P., Patil S. S. and Chandake A. D., (2012): Performance of Briquetting Machine for Briquette fuel; International Journal of Energy Engineering, 2 (1): 28 -34
[15]. Joseph O. A., Francis K., and Stephen J. M., (2012): "Physico-chemical characteristics and market Potential of sawdust charcoal briquette" Akowuah et al. International Journal of Energy and Environmental Engineering, 3:20
[16]. The Carbon Trust (2008): Biomass Heating**;** A Practical Guide for Potential Users www.carbontrust.co.uk
[17]. Tsoumis, G., (1991): Science and Technology of Wood: Structure, Properties, Utilization, *Van Nostr and Rein old, New York, NY, USA.*

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Application of Taguchi Method & Anova in turning of AISI 1045 to improve surface roughness by Optimize cutting factor

[1]Mohammed Irfaan, [2]Ahmed Dagne Temesgen, [3]Mekonnen Mesele Tsegay
[1]*Lecturer, Department Of Mechanical Engineering, Adigrat University, Ethiopia*
[2]*Lecturer, Department Of Mechanical Engineering, Adigrat University, Ethiopia*
3Lecturer, Department Of Mechanical Engineering, Adigrat University, Ethiopia

ABSTRACT: *The improvement of surface roughness in the turning of AISI 1045 was investigated by using parameters as cutting speed, feed rate, and depth of cut. Theseparameters are most responsible for surface roughness and their working range is set. Taguchi method is used to collect the experimental data.*
An orthogonal design L-9, signal to noise ratio and analysis of variance were employed to improve surface roughnessFeed rate exerted the higher effect on surface roughness, monitored by depth of cut.
The surface roughness increases with increasing feed rate, depth of cut and decrease with decreasing cutting speed.
Keywords- *MINITAB-17, TAGUCHI L-9 ORTHOGONAL ARRAY, AISI 1045 STEEL*

I. Introduction

Current days, increase productivity and quality of the cutting machine (in terms of piecework dimensional accuracy, and the completion of a good surface, and less wear of the blocks and metal tools high removal rate and the economy in machining, and the cost of each component and the performance of the product) are the main challenges for the manufacture of metal pieces during manufacturing operations different **[1]**
It can improve the design quality by improving quality and productivity. These include the activities concerned with the quality of product planning, product design and process design **[2]**
Taguchi method involves the reduction of variation in the process through powerful design of experiments. The overall objective of this method for the production of low cost high quality products to the manufacturer. Therefore, the quality is poor in the process affects not only the manufacturer but also the community. This is a way to design tests to check how different parameters affect the contrast medium and the process that you know how the process works well performance feature. Experimental design proposed by Taguchi involves the use of orthogonal arrays on the organization of the parameters that affect the process and the levels at which they should be varied. It allows for the collection of data needed to identify the factors that affect the product with the most minimal experimentation quality, thereby saving time and resources. Variation on the data collected from the design of experiments, Taguchi analysis can be used to determine a new parameter values to improve performance characteristic. **[3]**
Performance characteristics are affected by parameter such as cutting speed, feed rate and depth of cut. Various examiners calculated that the effect of cutting circumstances cutting speed, depth of cut and feed rate**[4], [5], [6]** the influence of work piece hardness, the tool geometry, cutting time, tool materials and effect of cutting lubrication fluid. **[7, 8]**

II. Experimental Details

2.1 Material

The work piece material selected for experiment was an AISI 1045 is a carbon steels a category of steels with 0.43 to 0.50% carbon content. AISI is a medium carbon steel designed to be able to function in areas requiring greater strength as well as rigidity. This steel retains admirable size precision, concentricity, and straightness which together enable to reduce wear in high speed solicitations. AISI 1045 formed into turned, ground and polished bars that can be machined unsymmetrically with limited distortion. Table 1 & 2 shows the chemical composition and mechanical properties of AISI 1045 steel respectively.

Table 01 *Chemical Composition of AISI 1045 steel*

Element	Content %
Carbon (C)	0.43-0.50
Manganese (Mn)	0.60-0.90
Sulphur (S)	0.05(max)
Phosphorous (P)	0.04 (max)
Iron, Fe	Balance

Table 02 *Mechanical Properties of AISI 1045 steel*

Properties	Metric
Tensile strength	585 MPa
Yield strength	450 MPa
Modulus of elasticity	200 GPa
Shear modulus (typical for steel)	80 GPa
Poisson's ratio	0.29
Hardness	163

2.2 Design of Experiment

Forthe effect ofcuttingparametersonsurface roughnessin the process ofturning of AISI 1045 larger numbers oftestsare needed. Butwiththreeparameter andthree levelsin theL9Taguchiorthogonalgroupprovidesnine setsofexperiments. Most of theimpacts of cutting parameters arecutting speed, feed rate and depth ofcut.
Table 3 and table 4 represent level of parameters and Taguchi orthogonal array respectively.

Table 3 Level of Parameters

Cutting Parameter	Level of Parameters		
	Low	Medium	High
Cutting speed (m/min)	58.908	86.3938	113.8827
Feed rate (mm/rev.)	0.1	0.2	0.3
Depth of cut (mm)	0.4	0.6	0.8

Table 4 Taguchi's L-09 Orthogonal Array

Exp. No.	Factorial combination		
	V	f	d
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	1
6	2	3	3
7	3	1	3
8	3	2	1
9	3	3	2

2.3 Application of Taguchi Method

One method presented in this study is the process of experimental design call design Taguchi method. Taguchi design is a set of methodologies that have been taken of the inherent variability of materials and manufacturing processes into account in the design phase. The application of this technique has become widespread in many American and European industries after the 1980s.
Taguchidesignis thatmultiple factorsconsideredat the same time.

Moreover, it seeksthe nominaldesignpointwhichis insensitiveto changes inproductionenvironmentsand easyto improve theyieldin manufacturing andreliabilityin theperformanceof the product.Therefore,factors thatcan be consideredcontrolledonly that,but the noisefactorsas well.Despite thesimilarityin the design ofexperiment(DOE), andthe design ofTaguchionlybeingbalanced(orthogonal) experimentalgroups, which makes thedesignmore effectiveTaguchioffractionalfactorialdesign. **[9]**

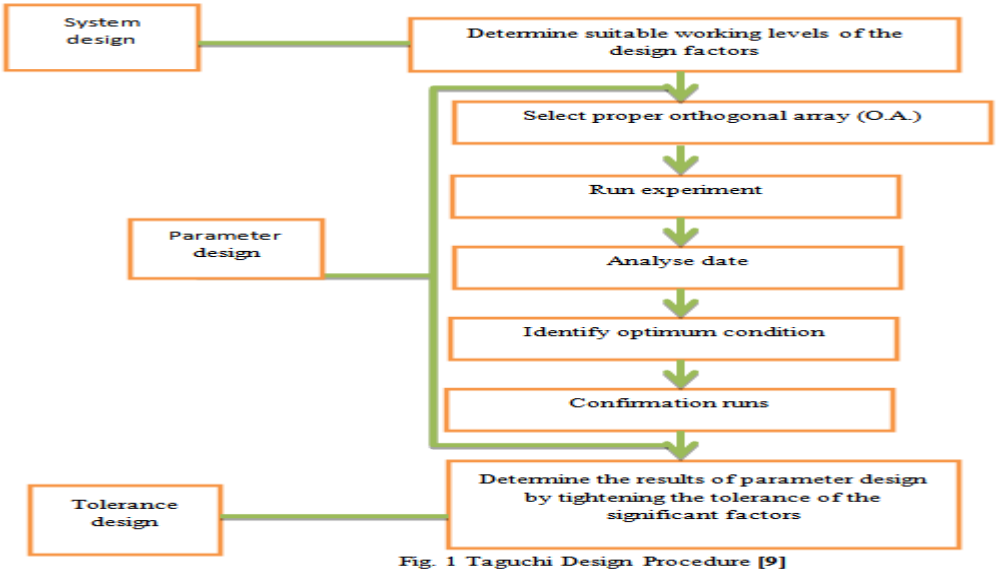


Fig. 1 Taguchi Design Procedure [9]

Classic parameter set by the Fischer complex design and not easy to use. In particular, a large number of experiments to be implemented when the number of parameters increases. To solve this task, Taguchi method special design of the space orthogonal arrays to study the whole parameter with a small number of experiments used only.

Then the definition of loss of function to calculate the deviation between the experimental value and the desired value. Taguchi recommends the use of job loss to measure the performance characteristic deviation from the desired value.

III. RESULTS AND DISCUSSION

3.1 Optimization and Analysis by Taguchi Technique:-

Table 05 Surface Roughness Based on Taguchi Technique

Exp. No.	Cutting parameters: Taguchi cutting parameters v	f	d	Actual value: Cutting speed(m/min)	Feed rate (mm/rev.)	Depth of cut (mm)	Surface roughness (μm)
1	1	1	1	58.9048	0.1	0.4	2.220
2	1	2	2	58.9048	0.2	0.6	2.423
3	1	3	3	58.9048	0.3	0.8	2.589
4	2	1	2	86.3938	0.1	0.6	2.949
5	2	2	1	86.3938	0.2	0.4	3.133
6	2	3	3	86.3938	0.3	0.8	3.173
7	3	1	3	113.8827	0.1	0.8	2.480
8	3	2	1	113.8827	0.2	0.4	2.530
9	3	3	2	113.8827	0.3	0.6	2.673

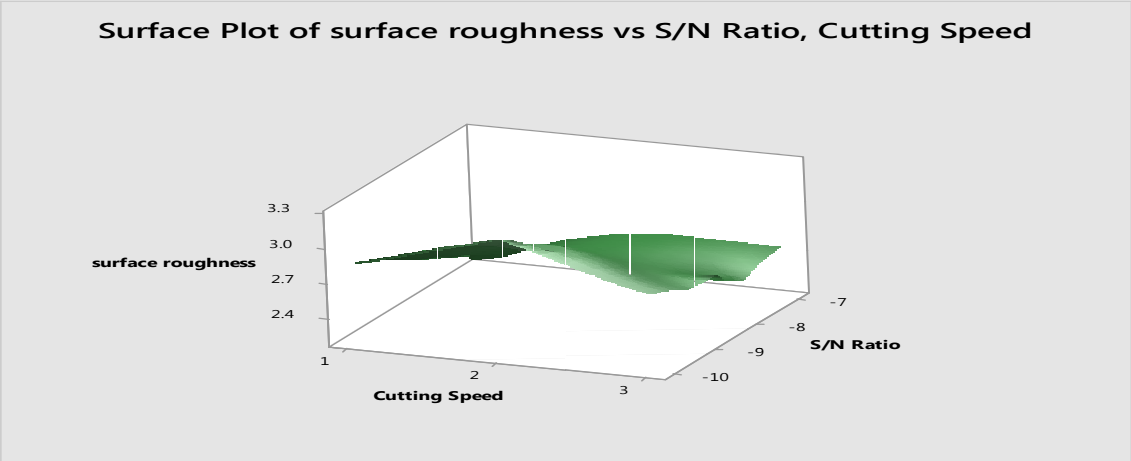
Table 06 S/N Ratio Table for Smaller is better

Exp. No.	Cutting parameters: Taguchi cutting parameters v	f	d	Actual value: Cutting speed(m/min)	Feed rate (mm/rev.)	Depth of cut (mm)	Surface roughness (μm)	S/N Ratio
1	1	1	1	58.9048	0.1	0.4	2.220	-6.9271
2	1	2	2	58.9048	0.2	0.6	2.423	-7.6871
3	1	3	3	58.9048	0.3	0.8	2.589	-8.2626
4	2	1	2	86.3938	0.1	0.6	2.949	-9.3935
5	2	2	1	86.3938	0.2	0.4	3.133	-9.9192
6	2	3	3	86.3938	0.3	0.8	3.173	-10.0294
7	3	1	3	113.8827	0.1	0.8	2.480	-7.8890
8	3	2	1	113.8827	0.2	0.4	2.530	-8.0624
9	3	3	2	113.8827	0.3	0.6	2.673	-8.5400

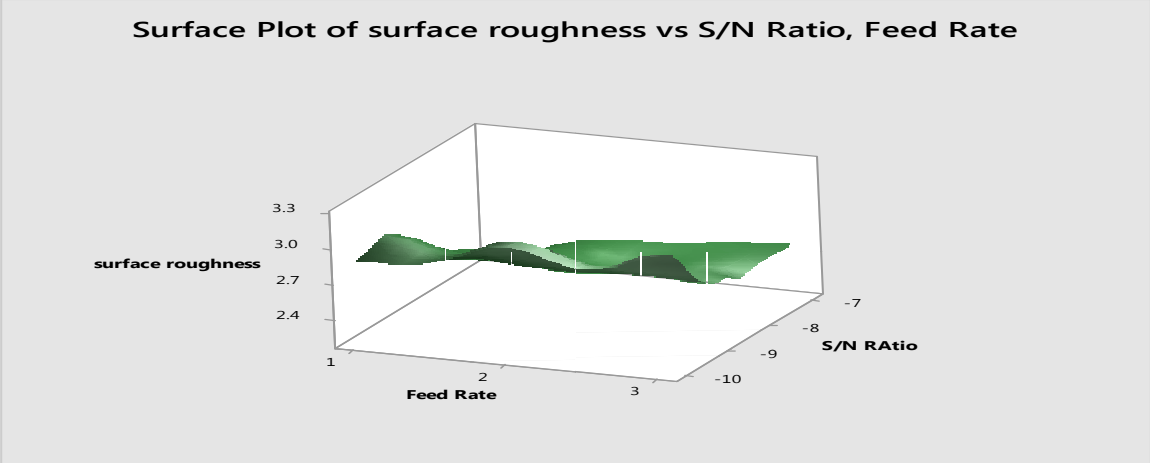
Table 07 Analysis of Variance for S/N Ratio

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Cutting speed	2	7.54853	3.77427	0.965	0.003
Feed rate	2	1.15105	0.57553	7.048	0.016
Depth of cut	2	0.18573	0.09286	2.176	0.093
Error	2	0.01903	0.00952	-	-
Total	8	8.90434	-	-	-

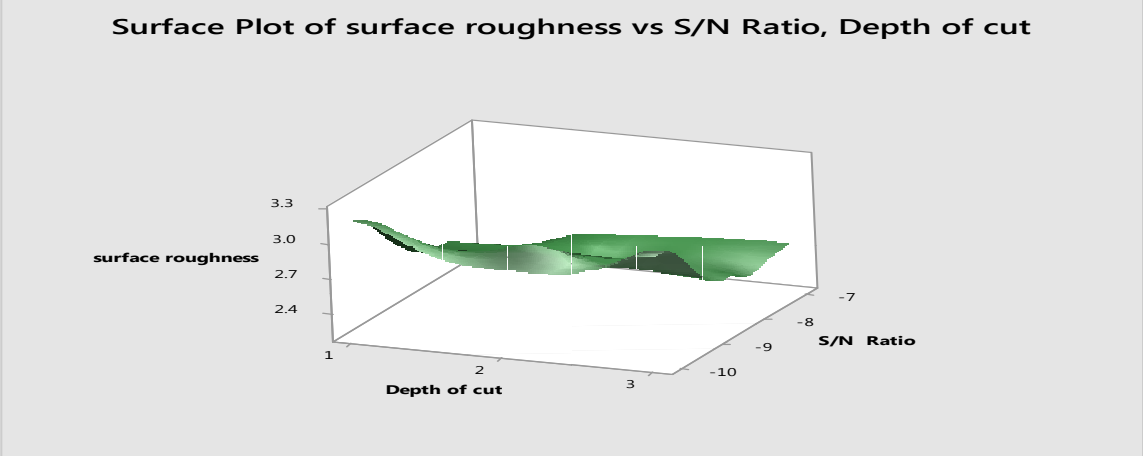
3.2 3-D Graph



(a) Effect of Cutting Speed on Surface Roughness and S/N Ratio

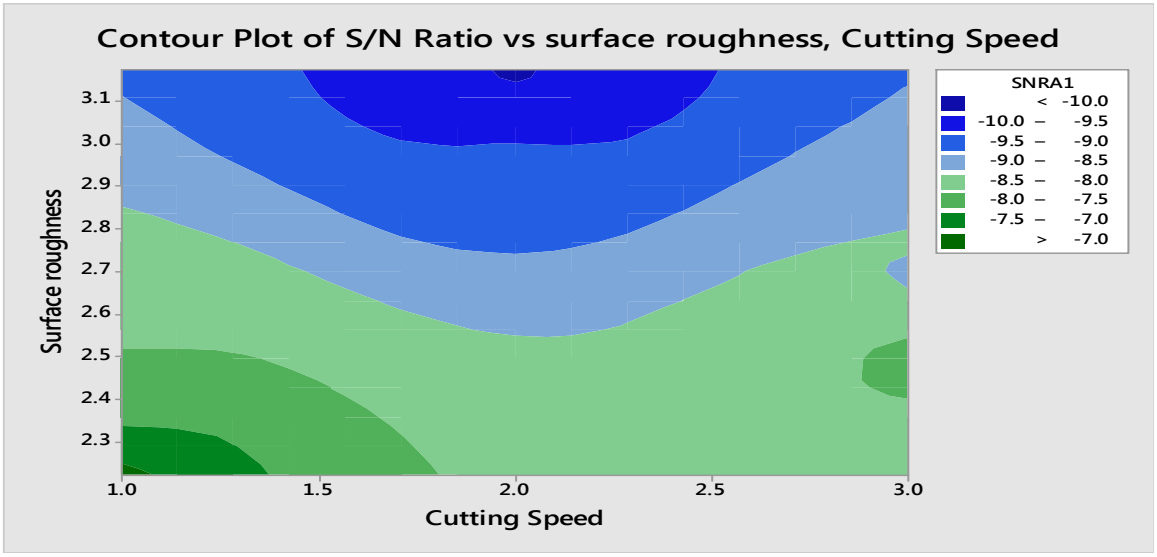


(b) Effect of Feed Rate on Surface Roughness and S/N Ratio

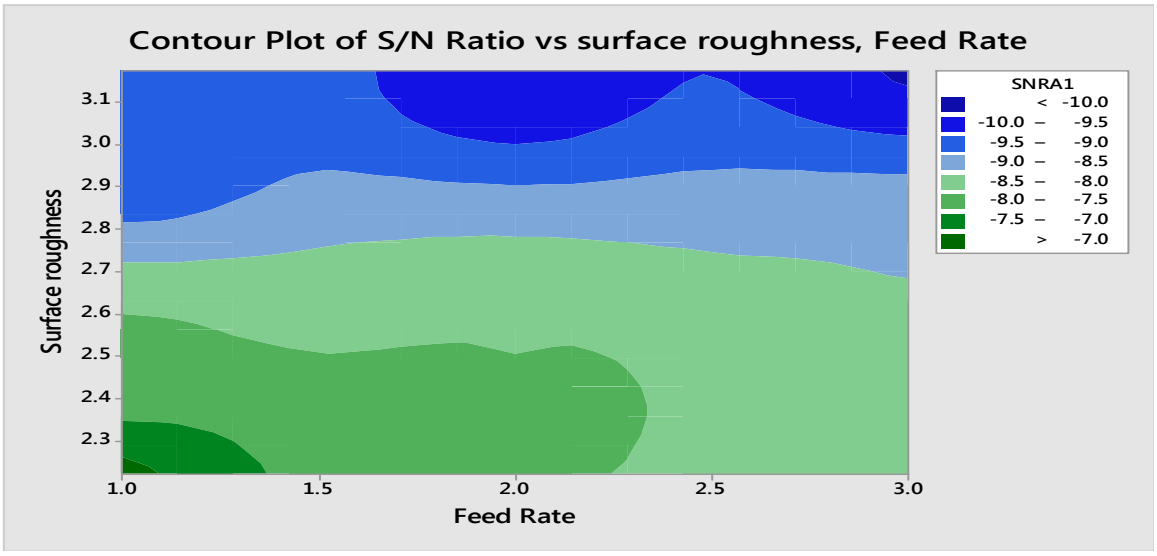


(c) Effect of Depth of Cut on Surface Roughness and S/N Ratio

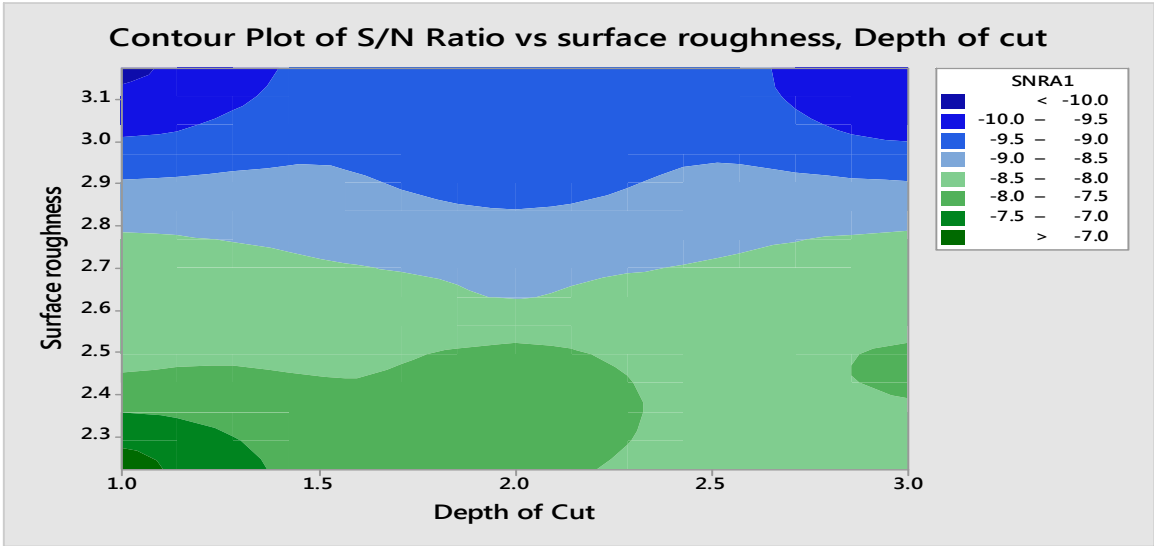
3.3 Contour Plot



(d) Effect of Cutting Speed on Surface Roughness and S/N Ratio



(e) Effect of Feed Rate on Surface Roughness and S/N Ratio



(f) Effect of Depth of Cut on Surface Roughness and S/N Ratio

IV. CONCLUSIONS

The following conclusion may be drawn from several cutting conditions in machining the AISI 1045.
Feed rate exerted the higher effect on surface roughness, monitored by depth of cut.
The surface roughness increases with increasing feed rate, depth of cut and decrease with decreasing cutting speed.

REFERENCES

[1] S.R. Das, R.P. Nayak and D. Dhupal, "Optimization of Cutting Parameters On Tool Wear, Work piece Surface Temperature and Material Removal Rate During Turning of AISI D2 Steel" International Journal Of Engineering and Technology, Vol.1,pp. 1-10, (2012)

[2] R. Roy, Design of Experiment Using the Taguchi Approach, John Wiley & Sons, New York, (2001)

[3] G. Taguchi, S. Chowdhury, Y. Wu, (2005), Taguchi's Quality Engineering Handbook, John Wiley & Sons, New Jersey.

[4] H. Singh, R. Khanna and M.P. Garg, "Effect of Cutting Parameters on MRR and Surface Roughness in Turning EN-8" international J. of current engineering and technology, vol. 1 pp. 100-104, (2011)

[5] H. Yanda, J.A. Ghani, M.A.M. Rodzi, K. Othman and C.H.C. Haron, "Optimization of Material Removal Rate, Surface Roughness and Tool Life on Conventional Dry Turning of FCD700" International Journal of Mechanical and Materials Engineering, Vol. 5, pp. 182-190, (2010)

[6] V.S. Sharma, S. Dhiman, R. Sehgal and S.K. Sharma, "Assessment and Optimization of Cutting Parameters While Turning AISI 52100 Steel" International Journal of Precision and Manufacturing, vol. 5, pp. 1-10, (2008).

[7] M.N. Islam and Brian Boswell, "An Investigation of Surface Finish In Dry Turning" proceedings of the world congress on engineering, London, pp. 1-6, (2011).

[8] T. Ozel, T.K. Hsu and E. Zeren, "Effects of cutting edge geometry, work piece hardness, feed rate and cutting speed on surface roughness and forces in finish turning of hardened AISI H13 steel", I. J. Adv. Manufacturing Technology, Vol. 25, pp. 262-269, (2005).

[9] Zhang, J.Z. Chenb, J.C., Kirby, E.D. (2007). "Surface Roughness Optimization in an End-Milling Operation Using the Taguchi Design Method" *Journal of MaterialsProcessing Technology*, vol. 184, p. 233- 239.

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Adaption of Fast Modified Frequent Pattern Growth approach for frequent item sets mining in Telecommunication Industry

Sanjib Kumar Routray[1] , Sasmita Mishra[2] ,Laxman Sahoo[3]
[1] *Research Scholar, Utkal University, Bhubaneswar, Odisha, India*
[2] *Asst. Professor, IGIT, Saranga, Dhenkanal,Odisha,India*
[3] *Professor, Computer Science &Engineering, KIIT, Bhubaneswar, Odisha, India*

ABSTRACT: *A Fast Modified Frequent Pattern Growth approach namely (F-MFPG) is presented to mine the frequent item sets through adaption of frequent growth method. From experimental analysis on CRM real datasets in special reference to Telecommunication Industry, this approach improved the mining efficiency of Association rule. In this paper modified FP-tree algorithm with reduced header table and Auxiliary tree and FFIM algorithm for association rule mining is proposed. The advantage of F-MFPG approach is finding association rules without candidate set as well as CP-tree generation, which saves the execution time.*

Keywords**:** *Association Rules, Customer Relationship Management, Frequent Item sets, Reduced Header Table, Main Modified FP-Tree, Auxiliary Tree*

I. INTRODUCTION

In recent years, handling of large database from several sources is quite difficult. In Telecommunication Industry, conversion of large amount of data into useful and interesting information through knowledge discovery process can be achieved by various data mining functionalities like Association, Correlation analysis, Classification, Cluster analysis[1]. Out of which rules of Association are one of the most important prime research methods. Customer relationship management is the active module of Telecommunication Industry, where Association rules may due to several reasons. (1)Market Basket Analysis : Process of observing customer buying habits (2)Competitive Market : Successfully tailoring the marketing strategy through understanding customer's personal & demographic characteristics (3)High Churn rate : Predicting whether customer will churn with reason (4)Big data collection : Predicting the customer behavior in future that helps the management for making effective decisions. Association rules mining is for finding strong association, which can be divided into two parts. (1)Determining frequent item sets by using two interesting measures, support and confidence (2) Generating Association rules from frequent item sets. An Association rule in the form X =>Y where X,Y are finite set of items x_1,x_2,x_3……..x_n and y_1,y_2,y_3…….y_n represents that if the set of items X in a transactions exists, then set of items Y occurs with high probability in same transactions[13]. In this regard Apriori heuristic (Agarwal & Srikant 1994) have two important drawbacks. First repetitive scanning, which needs lot of I/O head. Second it requires huge candidate sets[14]. For example, if any length 'a' pattern is not frequent, its length (a + 1), super pattern can never be frequent. Hence it is required to generate iteratively huge set of candidate patterns of length (a + 1) from the frequent pattern of length 'a'(for 'a' greater than equal to 1). For 10^4 frequent item sets, Apriori approach needs to generate $10^7 - 2$ candidates. Frequent pattern of size 100 (x_1,x_2…….x_{100}), it must generate $2^{100} - 2 = 10^{30}$ candidates(say), which is very costly[8]. In order to avoid those repeated scanning and checking of large candidates, a new novel research developed called frequent pattern growth mining. The advantage of FP-Growth algorithm is, scanning database two times, compressing database into frequent pattern tree to ensure the data structure compact and informative without using a candidate key and generates various Association rule. However in FP-Growth mining, there are again two drawbacks. First in FP-Tree, conditional FP-Tree and its traversal requires more time in recursive digging, that affects the efficiency of algorithm with respect to time and space. Second for this traditional algorithm, construction of huge FP-Tree is essential that consume long processing time for some amount of processing. For this problem, this paper proposes a novel version of efficient association mining techniques by using three data structure (1) Modified FP-Tree (2) Reduced Header Table (3) Auxiliary Tree to discover valuable knowledge model from large Telecommunication data sets for customer relationship management in a fast and efficient way. The outline of the remaining paper is as follows. Sec-II discusses the literature review. The main idea of theory and methodology in detail is discussed in Sec-III. Sec-IV illustrates the experimental results and implementation. Finally conclusion describes in Sec-V.

II. REVIEW OF LITERATURE

Data mining play a crucial role in Telecommunication Industry due to availability of huge data sets for Customer relationship management [1] and big data under Telecommunication Industry implemented frequent pattern mining by interpreting the relationships between characteristics of input data as proposed by [2]. On research it has shown by [3], that a good number of Telecommunication companies using data mining models for improving a CRM strategy for keeping customer happy. A general survey has been done by [4] on Association rule mining with different merits and demerits of different data mining methods like Apriori, FP-Growth with positive and negative association rules. The Association rule mining is to find all association rules above minimum user defined support threshold and confidence and it is done by two steps (1) Finding all frequent pattern (2) generating all association rules from frequent pattern. Every frequent pattern mining techniques is a unique as suggested by [5] and can be applied depending on input data in many applications of real life. For finding frequent pattern, Apriori algorithm uses prior knowledge of frequent item set properties but it suffers several drawbacks like generation of candidate sets and multiple scanning, which creates lot of memory and time complexities [6]. To avoid generating many candidate sets and multiple scanning, [7] proposes Rapid Association rule mining (RARM), which shows better performance. Finally [8] proposed a mining of complete set of frequent item sets without candidate generation on divide-and-conquer principle. First scanning the database once for deriving the list of frequent items in order of descending frequency and then compressing the database into FP-Tree for retaining item set association information. This frequent pattern mining has ample scope of data analysis with deep impact on pattern mining applications presently and in future for extracting the new information that helps for more guidance as per research study by [9] [10]. Also [11] suggested that for handling massive small files, an improved parallel FP-Growth algorithm required for frequent item sets mining, which increases good speed-up and higher mining efficiency. Similarly for achieving better performance on frequent item set mining, new algorithm proposed by [12] namely Header Table Recursion (HTR) , where no. of new FP-Tree generation decreases on each recursive call of classical FP-Growth algorithm. As traditional FP-Tree, generating many candidate sets and CP-Tree, its efficiency decreases. In order to avoid those drawbacks, an improved version of FP-Tree algorithm with a modified header table along with a spare table and mining frequent item sets algorithm can be developed as Improved FP-Growth techniques decreases space and time complexities by [13]. It is concluded that FP-Growth techniques further can be modified by using different novel data structure to solve the time and space problems.

III. THEORY AND METHODOLOGY

Traditional Apriori algorithm involves expensive candidate generation process for mining the complete set of frequent item set. Hence an interesting method attempted called frequent pattern growth approach or simply FP-Growth, where divide-and-conquer strategy adopted instead of generate-and-test of Apriori. In this method, first database will be compressed for representing frequent items into frequent pattern tree, which retains the item set association information. Second it divides the compressed database into conditional database, each associated with one pattern fragment that mines each database separately.

Advantages: (1) Faster execution time than Apriori. (2) Only two scanning over complete datasets. First scan involves collection and sorting the frequent items and second for constructing FP-Tree. (3) Compresses complete data sets. (4) Construction without candidate sets.

Disadvantages: (1) More expensive for building complete FP-Tree by using Telecommunication Data sets. (2) May not fit in memory space. (3) More time needs to build complete FP-Tree. (4) If user defined support threshold is high, time will be wasted unnecessarily. (5) Support of all individual items calculated once the entire data-set is added to FP-Tree. (6) Increasing of space and time complexity, as it involves recursive call for tree traversing.

3.1 Proposed Fast Modified FP-Growth Approach (F-MFPG)

3.1.1 Idea behind proposed method

Out of different methods of mining association rules, FP-Tree is the latest method, where entire transactional datasets converted into a compact prefix tree structure. The path/branch of a FP-Tree is the representation of individual transaction and FP-Tree removes various shortcomings of traditional association rule mining methods. But fast proposed modified FP-Tree is highly condensed, which removes all shortcomings of traditional FP-Tree (1) expensive multiple scanning (2) Unnecessarily traversal of complete tree, while checking the particular node in the tree.

3.1.2 Reduced Header Table

Proposed reduced header table only keeps the items with their corresponding frequencies, which are already present in the FP-Tree according to descending order of support. The main advantage of reduced header table is all the items in the transactional data sets may not present always in the header table, in comparison to traditional to traditional header table of FP-Tree.

3.1.3 Auxiliary Tree

Auxiliary Tree is the third type of data structure, where existence of node item name and their node count of same item in the proposed modified FP-Tree. Initially auxiliary tree will be constructed, where 2nd most frequent item will be the root node and other node, whose frequencies on descending order will be child node correspondingly. Starting from root node to end node, node-count will be initialized to zero initially. There are only two cases, when items in the individual transaction will be added to auxiliary tree.

(1) When the most frequent item is not present as first element of individual transaction, all transactional node item will be added in auxiliary tree as a result node-count will be incremented.
(2) When there is no direct link between the current root and item in consideration and also exist in the FP-Tree, then all the following items in the transaction will be added to auxiliary tree as a result node count will be incremented.

3.2 Proposed Main Modified FP-Tree Generation Algorithm

First transactional data sets are read initially for finding the frequency of each item. Then most frequent item is identified. Declare user defined minimum support threshold and remove items, which do not have minimum support threshold. Then arrange all transactions in descending order of frequency of items. Initially created Root node initialized to NULL. Let first item in each transaction be 'X' & remaining be 'Y'. First check whether 'X' is the most frequent item & child of root, if not create a node corresponding to 'X' as the child of root node. If exists increment the node-count in the reduced header table & root will be shifted. In the auxiliary tree, create a root node as 2nd most frequent item and other child items exists in order of descending support correspondingly and initialize node counts of all items to zero. If X is not the most frequent item, then all the items in that transactions are moved to auxiliary tree and node count of added items will be incremented. For each item Y in the transaction, check direct link between current root and node-item, if exists, then increment the count in the reduced header table and root will be moved. If not exists, then again check, whether the node corresponding to that item exists in the FP-Tree through reduced header table. If exists, then move the items to the auxiliary tree and node-count of auxiliary tree will be incremented. If not, node is not available in modified FP-Tree, then child current root create corresponding to that item and move to this node. If an item added to auxiliary tree, then irrespective of all conditions, all the following items in those transactions are also moved. Repeat the procedure until all transactional datasets are read.

INPUT: Transaction Database
OUTPUT: Main Modified FP-Tree, Reduced Header Table & Auxiliary Tree
STEP-1.List out all items in the transaction dataset & find its Support for each item.
STEP-2.Declare the minimum support threshold and remove the item from list, which do not have minimum threshold.
STEP-3.Identify the most frequent item in the transaction dataset & for each transaction in the dataset sort the individual transaction based on the support in a descending order.
STEP-4.Create a root node which is referred to as Original root of a main modified FP-Tree.
STEP-5.Set the original root as current root for each transaction of main-modified FP-Tree.
STEP-6.Create a root node as 2nd most frequent item from list of the items of Auxiliary Tree. Other child items exist in order of decreasing support correspondingly & initialize node counts of all items to zero.
Let the first item in each transaction be 'X' and remaining be 'Y'.
If
'X' is the most frequent item
If
'X' is not child of current root of main modified FP-Tree
Create 'X' as the child of current root
Make count of the first item in reduced header table as 1.
Make the newly created node as current root
Else
Make 'X's node as the current root
Increment the count of 'X' in reduced header table
For all frequent items 'Y' when 'X' is the most frequent item
If 'y' exists as a child of current node
Increment the count in the reduced header table
Move the current root to the child node
Else If 'Y' is not present in the reduced header table
Create a new node for 'Y' as the child of current root
Make the count of corresponding item in the reduced header table as 1.
Make the newly created node as current root

Else
Increment the node count of remaining item in Auxiliary tree
Else
Increment the node count of all the items in the Auxiliary tree.

3.3 Proposed Main Modified FP-Tree Generation Algorithm description with CRM-Dataset example

In the CRM master database, of one Telecommunication Company, following example transactional CRM-data set is considered for describing proposed main modified FP-Tree on which, 32 no. of attributes are present. Out of which 9 (nine) attributes are selected for forming a transactional data sets of 10 (Ten) transactions on 6 (six) various types of data items as per Table-I.

Table 1: Sample Transactional CRM-data set for main modified FP-Tree

Transactions	Items
100	a,b
200	b,c,d
300	a,c,d,e,f
400	a.d,e
500	a,b,c
600	a,b,c,d,f
700	a,f
800	a,b,e
900	a,b,d
1000	b,c,e

On scanning of above transactional data sets, we find the support for each item on descending order. User defined minimum threshold support assumed in this case is 4. Identify the most frequent item as 'a' as the frequency is 8. Identify the item which does not meet the minimum user defined threshold support as 4. Accordingly Item 'f' removed because its frequency is less than minimum support as per Table-II.

Table 2: Transactions Item and their Support

Item	Support
A	8
B	7
C	5
D	5
E	4

Identify the most frequent item in the transaction dataset & for each transaction in the dataset sort the individual transactions based on the support in a descending order and create a root node which is referred to as "original root" and initialize it to "NULL" in case of main modified FP-Tree. Create a root node as 2nd most frequent item from list of the items of auxiliary Tree. Other child items exist in order of decreasing support correspondingly & initialize node counts of all items to zero.

(1)Transaction 100: [a,b]

As [a], is the most frequent item and not the child of original root, new node will be created corresponding to [a] and child of original root will be made. Similarly [b] is not a child of [a] and [b] is not in the tree so node corresponding to [b] will be created and represented as child of node corresponding to [a]. There will be no change in auxiliary tree.(M-Tree stands for Main Modified FP-Tree and A-Tree stands for Auxiliary Tree for all figures)

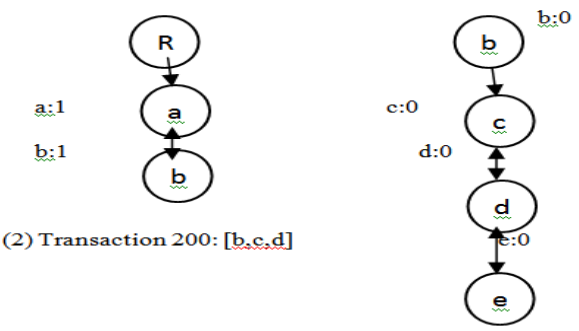

Fig. 1: M-Tree and A-Tree representation of Transaction [a,b]

Since [b] is not the most frequent items in this transaction, so all items present in the transaction are sent to auxiliary tree and node count of above transactional items in the auxiliary tree will be incremented.

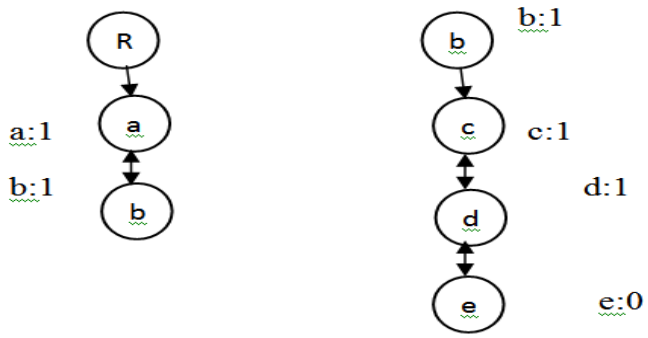

Fig. 2:M-Tree and A-Tree representation of Transaction [b,c,d]

(3) Transaction 300: [a,c,d,e,f]
[a] already exists in the main modified FP-Tree. Hence count of [a] will be incremented in the reduced header table. In this transaction as [a] is not direct link from [c], all remaining items including [c] are added to auxiliary tree. Node count of items in the auxiliary tree will be incremented accordingly. [f] is not considered because it is removed initially as its frequency is less than user defined minimum support threshold.

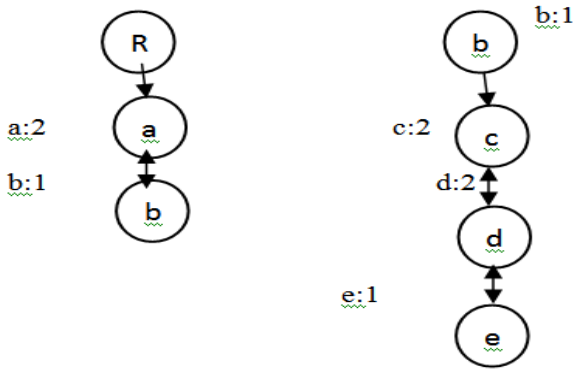

Fig. 3:M-Tree and A-Tree representation of Transaction [a,c,d,e,f]

(4) Transaction 400: [a,d,e]
[a] already exists. Hence count of [a] will be incremented in reduced header table. Since [d] is not a child of [a] and is not available in the main modified FP-Tree, a node corresponding to [d] will be created as a child node representing [a]. Similarly [e] will be created as a child node representing [d]. There will be no change in the auxiliary tree.

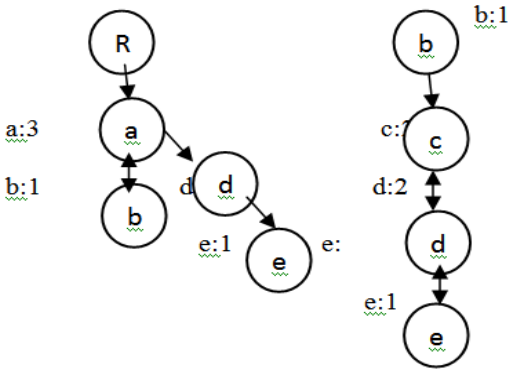

Fig.4:M-Tree and A-Tree representation of Transaction [a,d,e]

(5) Transaction 1000: [b,c,e]

Since [b] is not the most frequent items in this transaction, so all items present in the transaction are sent to auxiliary tree and node count of above transactional items in the auxiliary tree will be incremented.

The final main modified FP-Tree and auxiliary tree obtained as per figure-10.

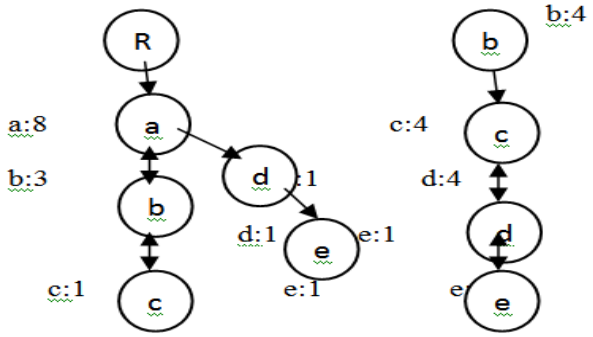

Fig.5:M-Tree and A-Tree representation of Transaction [b,c,e]

3.4 Fast Frequent Item sets Mining (FFIM) Algorithm

The proposed main modified FP-Tree along with the reduced header table and auxiliary tree are given as input to the FFIM algorithm that reduces the complexities of unnecessary generation of CP-Trees. In this algorithm, by traversing reduced header table FP-Tree items are accessed one by one as items in the modified FP-Tree are same as items in the reduced header table. First of all frequency of each item is compared with user defined minimum support threshold, if frequency is less than minimum support, all the items in the modified FP-Tree connected to that most frequent items are taken into account. If frequency is equal to user defined minimum support threshold, the item sets at lower index than the current item's index in reduced header table are taken into account as initially on descending order. Accordingly frequent item sets are generated by using these items with support is equal to sum of the frequency and auxiliary tree node-count. If frequency is more than user defined minimum support threshold, frequency is frequency of that item as present in reduced header table considered as above in same manner. FFIM Algorithm is as follows.

INPUT: Modified FP-Tree, Reduced Header Table, Auxiliary Tree

Output: Items set 'A' containing all frequent item set with their corresponding frequencies

Initially 'A' is empty

For all items in the reduced header Table

S=User declared minimum support threshold

F=Frequency of the item in reduced header table

Auxiliary Node count as AN Count = count in the node item of Auxiliary tree

If

F is not equal to S

If

F is greater than S

Frequency of frequent item set is FF = F

Else

Frequency of frequent item set is FF = F + AN Count

Generate all maximum possible combination of the current item and all the nodes up to most frequent item node in modified FP-tree and than to 'A' with their frequencies as FF

Else

Frequency of frequent item set is FF = F

Generate all possible combination of the current item and all the elements present at the lower index than the current item's index in the reduced header table

IV. EXPERIMENTAL RESULTS AND IMPLEMENTATION

The fast frequent item sets with their frequencies are generated by inputting main modified FP-Tree, reduced header table and auxiliary tree to the fast frequent item sets mining (FFIM) algorithm. Fast of all items will be accessed in the reduced header table in the evaluation as items are already stored in sorted manner. Initially we compare with user defined minimum support threshold with frequency of item in main modified FP-Tree. In above example 4 is the minimum support and frequency of first item [a] present in reduced header table is 8, which is greater. So frequency of frequent item sets generated using this item will be – 8. Hence by considering all possible combination of current item with all the nodes up to most frequent item node present in main

modified FP-Tree, frequent items generated. Frequent items will be {{ a : 8 }}. The second item in reduced header table is [b],whose frequency is 3, which is less than minimum support frequency. So the frequency of frequent items generated will be addition of main modified FP-Tree frequency (3) and auxiliary node count of that item [b]. Hence by considering all possible combination of items up to most frequent item node present in main modified FP-Tree, frequent items generated. Frequent item will be {{b : 7},{a,b : 7}}. Similarly for third item in the reduced header table is [c], frequent item will be {{c : 5},{a,c : 5},{b,c : 5},{a,b,c : 5}}.
Similarly frequent item sets will be generated for all the items.

4.1 Generating Association Rule

If we consider minimum confidence threshold is 50%, the frequent item set {{a,b,c : 5)) is taken to mine the association rules accordingly

1. a,b => c
   Frequency {{a,b,c}} = 2
   Frequency {{a,b,}} = 5
   Hence confidence is 2/5 = 0.4 = 40% (Not selected)
2. b,c => a
   Frequency {{a,b,c}} = 2
   Frequency {{b,c}} = 4
   Hence confidence is 2/4 = 0.5 = 50% **(Selected)**
3. a,c => b
   Frequency {{a,b,c}} = 2
   Frequency {{a,c}} = 3
   Hence confidence is 2/3 = 0.66 = 66% **(Selected)**
4. a => b,c
   Frequency {{a,b,c}} = 2
   Frequency {{a}} = 8
   Hence confidence is 2/8 = 0.25 = 25% (Not selected)
5. c => a,b
   Frequency {{a,b,c}} = 2
   Frequency {{c}} = 5
   Hence confidence is 2/5 = 0.4 = 40% (Not selected)
6. b => a,c
   Frequency {{a,b,c}} = 2
   Frequency {{b}} = 7
   Hence confidence is 2/7 = 0.28 = 28% (Not selected)

Accordingly we find the association rules by using all frequent item sets generated by FFIM algorithm.

4.2 Challenges

In the main modified FP-Tree, each item may appear at most once for making very condensed. Reduced header table contains pointer to each node in the main modified FP-Tree with their frequencies. As there is no recursive calls during tree traversal in FFIM algorithm, time complexity and space complexity increases. As no. of database scans is less than some traditional association rule mining, saving of execution times is the main challenging issue in this case. Further no conditional Pattern Tree and candidate set generation required for reducing complexities.

4.3 Implementation

Experimental analysis on CRM data sets of Telecommunication Industry containing 5000 transactions and 32 items between the traditional FP-Tree and proposed Fast modified FP-Tree. The implementation of both the algorithms was done in matlab 7.12(2011A) version in windows platform. The analysis of simulation result shows that the proposed algorithm has a better detection as well as the faster rate of execution as compared to the existing one. The used data sets in the analysis were obtained from one CRM-Master database of one Telecommunication Industry. During experimental analysis on implementation phase, it is observed that, proposed algorithm takes less time to find association rules in comparison to Traditional FP-Tree algorithm.

V. CONCLUSION & SCOPE FOR FUTURE WORK

5.1 Conclusion

The proposed fast modified FP-Growth approach (F-MFPG) can be represented in condensed form of large CRM-data sets in Telecommunication Industry. As reduced header table avoided many recursive calls during tree traversal of main modified FP-Tree during implementation phase, time complexity is optimized and saving of execution time.

5.2 Scope for future work

Using F-MFPG pattern, Telecommunication Industry may find various association rules of billing & network modules.

As time consumption & requirement of space is very less, proposed approach may apply on other data mining techniques like classification for finding effective decision in Telecommunication Industry.

REFERENCES

[1] Marwah,Ranju.: *"Data mining techniques and applications in Telecommunication Industry". IJARCSE, Vol 4 issue9 :* pp.430-433, 2014

[2] Akioka ,Sayaka.: *"Data performance characterization of frequent pattern mining algorithms", IJDKP ,Vol 5 issue 1 :* pp.51-70, 2015

[3] Camilovic,D.: *"Data mining and CRM in Telecommunication, Serbian Journal of Management" ,Vol 3 issue1 :*pp.61-72, 2008

[4] Jain, J K., Tiwari, N., Ramaiya, M.*:" A survey on Association Rule mining", IJERA,Vol 3 issue 1 :* pp.2065-2069, 2013

[5] Patil, V S., Deshpande, N A.*:" Pattern mining techniques of data mining", IJETAE,Vol 4 issue3* :pp. 523-529, 2014

[6] Das, N., Ghosh, A., Das, P.:" Mining Association Rules to evaluate consumer perception": A new FP-Tree Approach, *Proc 5th Int Conf Centre for Quality:* pp. 855-872, 2011

[7] Vijayarani, S., Sathya, P.: *"An efficient algorithm for mining frequent items in data stream" ,IJIRCC , Vol 1 issue3 :*pp. 742-747, 2013

[8] Han, J., Pei, J., Yin, Y., Mao, R.: *"Mining frequent patterns without candidate generation:A FP Tree Approach". Proc Int Conf on Management of Data (SIGMODOO), Dalton, TX:* PP. 1-12, 2000

[9] Jiawei , H., Hong, C., Dong, X., Xifeng, Y.: *"Data mining knowledge description", Springer Science, Business Media:* pp. 55-86, 2007

[10] Abdullah, Saad Almalaise Alghamdi. *:"Efficient implementation of FP-Growth algorithm : Data mining on Medical data", IJCSNS,Vol 11 issue 12* :pp. 7-15, 2011

[11] Dawen, X., Yanhui, Z., Zhuobo, R., Zili, Z.: *"An improved parallel FP-Growth algorithm for frequent item set mining", Proc 59th ISI World Statistics Congress:* pp. 25-30, 2013

[12] Tianjun, Lu., Tian,Si., Wang, Shal.*:" Header table recursion algorithm for mining frequent patterns", AISS Vol 5 issue 2 :*pp. 769-775, 2013

[13] Agarwal , V., Kushal, M., Kumar, P.*: "An improvised frequent pattern tree based Association Rule mining technique with mining frequent item sets algorithm and a modified header table", IJDKP , Vol 5 issue (2)* :pp. 39-51, 2015

[14] Zhou, Lijuan., Wang, X.: *"Research of FP Growth Algorithm based on Cloud Environments", Journal of Software, Vol-9 issue(3)*:pp .676-683, 2014

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Deconvolution and Interpretation of Well Test Data 'Masked' By Wellbore Storage in A Build Up Test

[1]Akintola A. S, [2]Oriji. A. B and [3]Duru K.M
Department of Petroleum and Gas Engineering University of Port Harcourt, Nigeria.

ABSTRACT: When a well test contains a series of different flow rates, or a continuously varying flow rate, the combination of the pressure transients due to varying flow rate is called convolution. while deconvolution means removing a distorting effect upon the variable of interest. This paper is on the study of an analytical technique that can be used to explicitly deconvolve wellbore storage distorted well test data using pressure data and the flow rate. Then to determine the reservoir properties from this deconvolved well test data by using the conventional well test interpretation methods. Also the comparison of the material balance deconvolution method results with the β-deconvlolution method result were carried out and then used to determine which method was a better deconvolution tool**.** The results showed that the material balance deconvolution technique performed very well with minor discrepancies and gave better estimation of the reservoir parameters.

Keywords: Buildup Test, β-deconvlolution, Wellbore Storage Effect, Material Balance deconvolution,

I. INTRODUCTION

Well testing can be said to be the only technique that examines a significant portion of the reservoir under dynamic conditions in order to determine its production capability and reservoir properties. It has long been recognized that wellbore storage (after flow) can impede pressure transient test analysis thus several methods have been suggested for determining the effects of afterflow when well known semi-logarithmic techniques cannot be used for transient test analysis. Often times, during well testing, the test may not be carried out for a very long time so as to acquire sufficient information that can be used to interpret the result in the usual conventional method available in literatures, hence, the need to make use of the early time region (ETR) data, for the interpretation. In such situation, we then have to try to make the data as reliable as possible by eliminating wellbore storage effect from the data.

Ramey H.T(1970) concluded that annulus unloading and wellbore storage are important physical effect that often controls the behavior of early pressure data taken during a well test. Van Everdingen and Hurst.. (1953) reported that wellbore storage effects include a "skin effect" or a region of altered permeability adjacent to the wellbore and that in many cases the production flow rate can be approximated using equation. Kuchuk F.J, (1985) applied "β deconvolution" for the analysis of wellbore storage distorted pressure transient data and formulated the β-deconvolution equation that helps to computes the undistorted pressure drop function directly from the wellbore storage affected data. Bourdet et al (1989) showed that the most recently documented pressure derivative approach has combined the most powerful aspects of the two previously distinct methods into a single stage interpretative plot Roumboustsos and Stewart (1985) developed convolution and deconvolution methods based on the ideas proposed by kuchuk. Kuchuk presented a generalized rate-convolution and deconvolution methods. He obtained deconvolved pressure values from the Riemann sum and from exponential wellbore flow-rate case. Igbokoyi, A.O (2007) used the deconvolution approach and the resulting Duhamels integral formulation to develop a model that successfully interpreted short-time pressure data distorted by wellbore storage and skin in a buildup test.

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II. MATERIAL BALANCE DECONVOLUTION

Material balance deconvolution is a practical approach for the analysis of pressure transient data distorted by wellbore storage effects, The general form of material balance deconvolution provide for the pressure drawdown case in terms of the material balance time function and the rate normalized pressure drop function. The material balance time function and the rate-normalized pressure drop function is given by the equations 1and 2

$$t_{mb} = \frac{N_p}{q} \quad \text{(1)}$$

$$\frac{\Delta p}{q} = \frac{(p_i - p_{wf})}{q} \quad \text{(2)}$$

From the first principle, applying material balance to a well with wellbore storage, the following equations are stated,

$$q_{sf} = q + \frac{24C_s}{B}\frac{dP_w}{dt} \quad \text{(3)}$$

For buildup, the flow rate at the surface q = 0,
so we have:

$$q_{sf} = \frac{24C_s}{B}\frac{dP_w}{dt} \quad \text{(4)}$$

Then for a normalization of the sandface flow rate, q_{ref}

$$\frac{q_{sf}}{q_{ref}} = \frac{24C_s}{q_{ref}B}\frac{dP_w}{dt} \quad \text{(5)}$$

But for this case, we can say that $\frac{q_{sf}}{q_{ref}} = q_{wbs}$. (6)

Then the equation 5 becomes:

$$\frac{dP_w}{dt} = q_{wbs} * \frac{q_{ref}B}{24C_s} \quad \text{(7)}$$

But $C_s = C_{wb} * V_{wb}$ (7a)

From equation (7),

A plot of $\frac{dP_w}{dt}$ against q_{wbs} gives the slope m_{wbs} ,

which can be express as:

$$m_{wbs} = \frac{qB}{24C_s} \quad \text{(8)}$$

Substituting equation (8) into equation (6)

$$q_{wbs} = \frac{1}{m_{wbs}}\frac{d}{d\Delta t}(\Delta p_{ws}) \quad \text{(9)}$$

For a buildup test, the pressure drop is measured against pressure at time t =0,
thus the pressure drop is given as:

$$\Delta P_{ws} = p_{ws} - p_{wf}(\Delta t = 0) \quad \text{(10)}$$

NOTE:

$$\left(\frac{d(\Delta P_{ws})}{d(\Delta t)}\right)_n = \frac{(\Delta P_{ws})_{\Delta t_{n+1}} - (\Delta P_{ws})_{\Delta t_{n-1}}}{\Delta t_{n+1} - \Delta t_{n-1}} \quad \text{(11)}$$

Integrating the equation :

$$N_p = \int q_{sf}\, dt = \frac{24C_s}{B}\int \frac{dp_w}{dt}dt \quad \text{_____(12)}$$

$$N_p = \frac{24C_s}{B} * P_w \quad \text{_____(13)}$$

Now, to normalize the above equation, we divide all through by reference rate q_{ref}.

$$\frac{N_p}{q_{ref}} = \frac{24C_s}{q_{ref}B} * P_w \quad \text{_____(14)}$$

$$N = \frac{1}{m_{wbs}} * P_w \quad \text{_____(15)}$$

Applying the above equation for the case of a buildup test we have:

$$N = \frac{1}{m_{wbs}} * \Delta P_{ws} \quad \text{_____(16)}$$

Applying material balance to the time:

$$\Delta t = \Delta t_{wbs} + N \quad \text{_____(17)}$$

$$\Delta t_{wbs} = \Delta t - \frac{1}{m_{wbs}}\Delta p_{wbs} \quad \text{_____(18)}$$

Also, the rate due to wellbore storage in a buildup test is given as:

$$q_{ref} = q_{BU} + q_{sf} \quad \text{_____(19)}$$

$$q^* = 1 - \frac{q_{sf}}{q_{ref}} \quad \text{_____(20)}$$

$$q^* = 1 - q_{wbs} \quad \text{_____(21)}$$

The wellbore storage-based, material balance time function is expressed as:

$$\Delta t_{mb} = \frac{N}{1 - q_{wbs}} \quad \text{_____(22)}$$

Substituting equation (11) and (16) into (22)

Then the wellbore storage based rate-normalized pressure drop function becomes

$$\Delta p_s = \frac{1}{1 - \frac{1}{m_{wbs}}\frac{d}{d\Delta t}(\Delta p_{wbs})}(\Delta p_{wbs}) \quad \text{…_____ (23)}$$

Plot of rate-normalized pressure function versus the material balance time function shows that the material balance time function does correct the erroneous shift in the semi log straight-line obtained by rate normalization.

β- DECONVOLUTION FORMULATION

Van Everdingen and Hurst (1953) introduced an exponential model for the sandface rate during the wellbore storage distortion period of a pressure transient test. The exponential formulation of the flowrate function is given as:

$$q_D(t_D) = 1 - e^{-\beta t_D} \quad \text{…_____(24)}$$

Equation (23) is based on the empirical observations made by Van Everdingen and Hurst.

Recalling the Duhamel's convolution principle equation:

$$P_{WD} = \int_0^{t_D} q'_D(\tau)\, p_{SD}(t_D - \tau)\, d\tau \quad \text{(25)}$$

Laplace transform of integration function is given as follows: If

$$g(t) = \int_o^t f(\tau)\, d\tau \quad \text{(26)}$$

Then $$L(g)(z) = \frac{1}{Z} L(f)(z) \quad \text{(27)}$$

Where z is the Laplace space function.
Therefore, applying Laplace transformation to equation (24):

$$\bar{P}_{WD}(Z) = Z' \bar{q}_D(Z) \bar{P}_{SD}(Z) \quad \text{(28)}$$

NOTE: $z' = \frac{1}{z}$

Rearranging for the equivalent constant rate pressure drop function, $\bar{P}_{SD}$ we obtain The Laplace transform of the rate profile, equation (15) is: Substituting equation (19) into equation (18), we obtain:

$$\bar{P}_{SD}(Z) = \bar{P}_{WD}(Z)(1 + \frac{Z}{\beta}) \quad \text{(29)}$$

Taking the inverse Laplace transformation of this result yields the "beta" deconvolution formula:

$$\beta = \frac{1}{P(t_D) - P_{WD}} \frac{dp_{WD}(t_D)}{dt_D} \quad \text{(30)}$$

To alleviate the issue of the exponential sandface flowrate, equation (18) to solve for the β-term.
Solving equation (18) for the β-term, we have:

Multiplying through by the C_D – term, we have:

$$\beta C_D = \frac{1}{P_{sD}(t_D) - P_{wD}(t_D)} C_D \frac{dP_{wD}(t_D)}{dt_D} \ldots \quad (31)$$

Recalling the definition of the wellbore storage model, we have:

$$q_D(t_D) = 1 - C_D \frac{dp_{wD}(t_D)}{dt_D} \ldots \quad (32)$$

Assuming wellbore storage domination (i.e $q_D \approx 0$) at early times then equation (32) becomes:

$$C_D \frac{dp_{wD}(t_D)}{dt_D} \approx 1 \quad \text{(Early time)} \quad (33)$$

Integrating by separating the variables in equation (23) above, we have:

$$P_{wD} \approx \frac{t_D}{C_D} \quad \text{(Early time).} \quad (34)$$

Substituting Equation (33) and (34) into equation (31); we obtain:

(Early time)…… (35)

$$\beta C_D = \frac{1}{P_{sD}(t_D) - \frac{t_D}{C_D}}$$

Equation (35) has shown that one can "correlate" the βC_D-product with $\frac{t_D}{C_D}$-this observation becomes the basis for the use of these plotting functions to compare the β-deconvolution relations. The "master" plot of the β-deconvolution function for the case of a single well in an infinite-acting homogenous reservoir is derived using equation (20).

III. DERIVATION OF THE COEFFICIENT FOR β-DECONVOLUTION

From Van Everdingen and Hurst exponential rate model, we have:

$$q_D = 1 - e^{-\beta(t_D)t_D} \quad \text{(36)}$$

Taking the time derivative of equation (36), we have

$$q'_D = \frac{dq_D}{dt_D} = b(t_D)e^{-\beta(t_D)t_D} \quad \text{(37)}$$

Where the $b(t_D)$ -term is defined as:

$$b(t_D) = \beta(t_D) + \beta'(t_D)t_D \quad \text{(28)}$$

taking the time derivative, $q'_D(t_D) = \frac{dq_D}{dt_D} = -C_D \frac{d^2 p_{wD}}{dt^2} = -C_D\, p''_{wD} \cdots$ (39)

Equating equations (27) and (28) gives:

$$C_D p''_{wD}(t_D) = C_D \frac{d^2 p_{wD}}{dt_D^2} = -b(t_D)e^{-\beta(t_D)t_D} \cdots \quad \text{(40)}$$

Equating equation (21) and (25), we have:

$$e^{-\beta(t_D)t_D} = C_D \frac{dp_{wD}}{dt_D} = C_D p'_{wD}(t_D) \quad \text{(41)}$$

Combining equation (28) and (29) and solving for $b(t_D)$

$$b(t_D) = -\frac{1}{t_D}\frac{p''_{wD}}{p'_{wD}} = \beta(t_D) + \beta'(t_D)t_D \quad \text{(42)}$$

Where the p''_{wD} and p'_{wD} terms are defined as:

$$P_{wDd} = t_D \frac{dp_{wD}}{dt_D} \quad \text{(43)}$$

$$P_{wDdd} = t^2_D \frac{d^2 p_{wD}}{dt^2_D} \quad \text{(44)}$$

Equation (41) can be used to determine $\beta(t_D)$ and $\beta'(t_D)$ — a graphical representation of the equation, where the intercept and slope values are $\beta(t_D)$ and $\beta'(t_D)$ respectively.

The value of $\beta(t_D)$ and $\beta'(t_D)$ can be approximated by numerical methods such as least square — which is the functional approach adopted here

IV. DISCUSSION AND RESULT:

A single-phase and single-rate pressure buildup test was conducted on a case study oil well- Xl. using the following reservoir parameters: B_O = 1.224 rb/stb, h = 55ft, ϕ = 0.06, r_w = 0.21ft, C_t =17.5 x 10^{-6} Psi^{-1}, μ_o = 0.65 cp, ρ_o =53.5 lbm/ft^3, q_f = 250stb/day, t_p=13,630 hours.

The material balance deconvolution technique performs extremely well, with minor discrepancies at the start of the data set. At the beginning of the data set deconvolved, the material balance shows an abnormal curve or deviation from the normal trend, thus, not a better tool for deconvolving during this time period. However, after the very early time period, the material balance deconvolution method performs very well like every other deconvolution method and gives a better estimation of the reservoir parameters than any other deconvolution technique. The 'beta' deconvolution method was also a good deconvolution method as shown in Figure 3 It has an advantage over the material balance during the very early time period and after which it is not a better deconvolution method than the material balance method as shown in Figure 4. However it gives an estimate of the reservoir parameters during the periods dominated by the wellbore storage effects, though not as accurate as the material balance method. Nevertheless, both can yield reservoir parameters at any time, provided the production rate varies exponentially during the shut-in period.

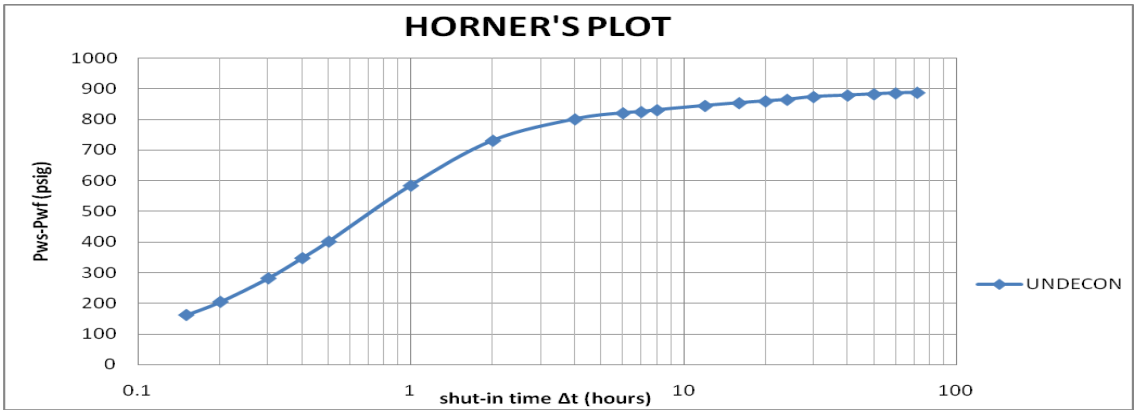

Figure 1: Horner's plot for the case study well-XI.

Table1 : Pressure buildup data from the case study well-XI

S/N	Δt	P_{ws}
1	0	3519
2	0.15	3680
3	0.2	3723
4	0.3	3800
5	0.4	3866
6	0.5	3920
7	1	4103
8	2	4250
9	4	4320
10	6	4340
11	7	4344
12	8	4350
13	12	4364
14	16	4373
15	20	4379
16	24	4384
17	30	4393
18	40	4398
19	50	4402
20	60	4405
21	72	4407

Table 2: Shut-in time and undeconvolved Pressure data

S/N	Δt	P_{ws}	ΔP_{ws}
1.	0	3519	0
2	0.15	3680	161
3	0.2	3723	204
4	0.3	3800	281
5	0.4	3866	347
6	0.5	3920	401
7	1	4103	584
8	2	4250	731
9	4	4320	801
10	6	4340	821
11	7	4344	825
12	8	4350	831
13	12	4364	845

14	16	4373	854
15	20	4379	860
16	24	4384	865
17	30	4393	874
18	40	4398	879
19	50	4402	883
20	60	4405	886
21	72	4407	888

Table 3: Material data deconvolution data

S/N	$P_{ws}(psig)$	$P_{ws}(psia)$	$\Delta t(hours)$	Δp_{ws}	$\frac{1}{m_{wbs}}\Delta p_{ws}$	$\Delta t-\frac{1}{m_{wbs}}\Delta p_{ws}$	$\frac{d}{d\Delta t}[\Delta p_{ws}]$	$\frac{1}{m_{wbs}}\frac{d}{d\Delta t}[\Delta p_{ws}]$	$1-\frac{1}{m_{wbs}}\frac{d}{d\Delta t}[\Delta p_{ws}]$	t_{mbs}	p_{mbs}
1	3519	3534	0	0	0	0	0	0	1	0	0
2	3680	3695	0.15	161	0.1607	-0.0107	509.250	0.509	0.491	-0.022	327.458
3	3723	3738	0.2	204	0.2037	-0.0037	400.000	0.400	0.600	-0.006	339.500
4	3800	3815	0.3	281	0.2807	0.0193	357.500	0.358	0.643	0.030	436.887
5	3866	3881	0.4	347	0.3467	0.0533	300.000	0.300	0.700	0.076	495.286
6	3920	3935	0.5	401	0.4007	0.0993	197.500	0.198	0.803	0.124	499.315
7	4103	4118	1	584	0.5837	0.4163	110.000	0.110	0.890	0.468	655.843
8	4250	4265	2	731	0.7307	1.2693	36.167	0.036	0.964	1.317	758.119
9	4320	4335	4	801	0.8007	3.1993	11.250	0.011	0.989	3.236	809.810
10	4340	4355	6	821	0.8207	5.1793	4.000	0.004	0.996	5.200	823.996
11	4344	4359	7	825	0.8247	6.1753	2.500	0.003	0.998	6.191	826.767
12	4350	4365	8	831	0.8307	7.1693	2.000	0.002	0.998	7.184	832.365
13	4364	4379	12	845	0.8447	11.1553	1.438	0.001	0.999	11.171	845.916
14	4373	4388	16	854	0.8537	15.1463	0.938	0.001	0.999	15.161	854.501
15	4379	4394	20	860	0.8597	19.1403	0.688	0.001	0.999	19.153	860.291
16	4384	4399	24	865	0.8647	23.1353	0.700	0.001	0.999	23.152	865.306
17	4393	4408	30	874	0.8737	29.1263	0.438	0.000	1.000	29.139	874.082
18	4398	4413	40	879	0.8787	39.1213	0.225	0.000	1.000	39.130	878.898
19	4402	4417	50	883	0.8827	49.1173	0.175	0.000	1.000	49.126	882.854
20	4405	4420	60	886	0.8857	59.1143	0.114	0.000	1.000	59.121	885.801
21	4407	4422	72	888	0.8877	71.1123	7.381	0.007	0.993	71.641	894.301

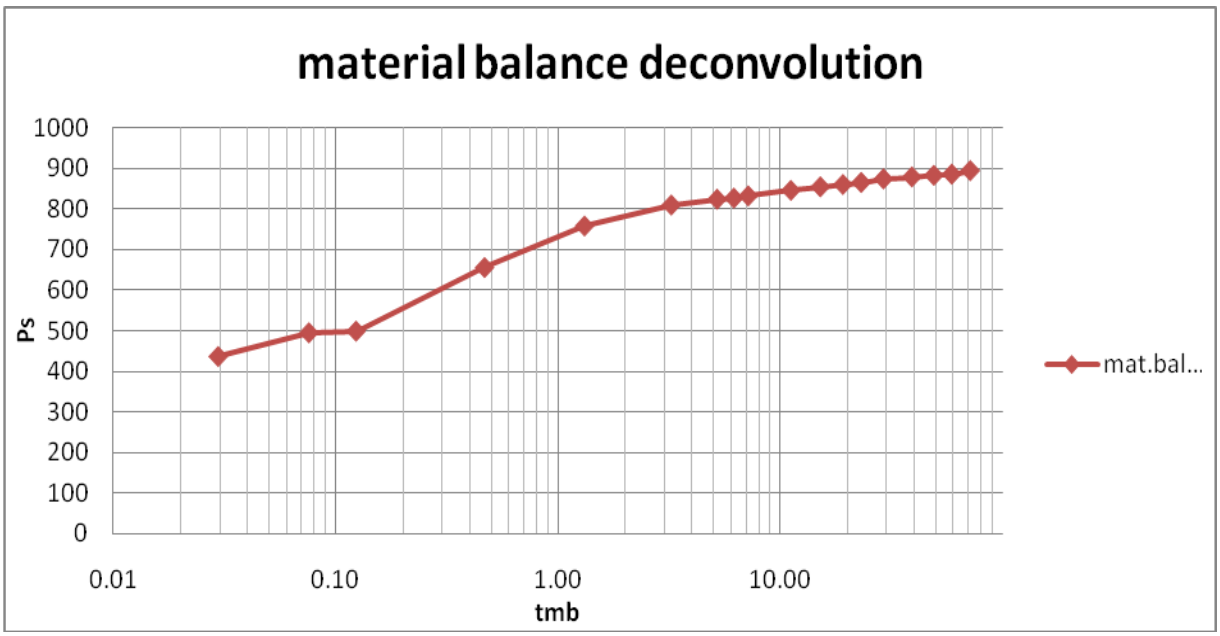

Figure 2: Material balance deconvolved data

Table 4: Beta deconvolution data

S/N	Δt	P_{ws}	ΔP_{ws}	P_D	t_D	$\frac{\partial P_D}{\partial t_D}$	$\frac{1}{\beta}\frac{\partial P_D}{\partial t_D}$	P_{SD}
1	0	3519	0	0	0	0		0
2	0.15	3680	161	2.605118	0.110518	11.2003	0.00053	338.7342
3	0.2	3723	204	3.300895	0.147357	8.78455	0.000554	429.1883
4	0.3	3800	281	4.54682	0.221036	7.851191	0.000742	591.1832
5	0.4	3866	347	5.614757	0.294715	6.588412	0.000831	730.0264
6	0.5	3920	401	6.488523	0.368394	4.337371	0.000684	843.5969
7	1	4103	584	9.44962	0.736787	2.415751	0.000761	1134.046
8	2	4250	731	11.82821	1.473574	0.79427	0.000501	1419.445
9	4	4320	801	12.96087	2.947148	0.247065	0.000311	1555.341
10	6	4340	821	13.28448	4.420722	0.087845	0.000166	1594.158
11	7	4344	825	13.34921	5.157509	0.054903	0.000121	1601.919
12	8	4350	831	13.44629	5.894296	0.043923	0.000111	1613.568
13	12	4364	845	13.67282	8.841444	0.031569	0.000119	1640.753
14	16	4373	854	13.81845	11.78859	0.020589	0.000104	1658.227
15	20	4379	860	13.91554	14.73574	0.015098	9.52E-05	1669.876
16	24	4384	865	13.99644	17.68289	0.015373	0.000116	1679.587
17	30	4393	874	14.14207	22.10361	0.009608	9.09E-05	1697.059
18	40	4398	879	14.22297	29.47148	0.004941	6.23E-05	1706.764
19	50	4402	883	14.2877	36.83935	0.003843	6.06E-05	1714.531
20	60	4405	886	14.33624	44.20722	0.002496	4.72E-05	1720.354
21	72	4407	888	14.3686	53.04867	0.162148	0.00368	1724.674

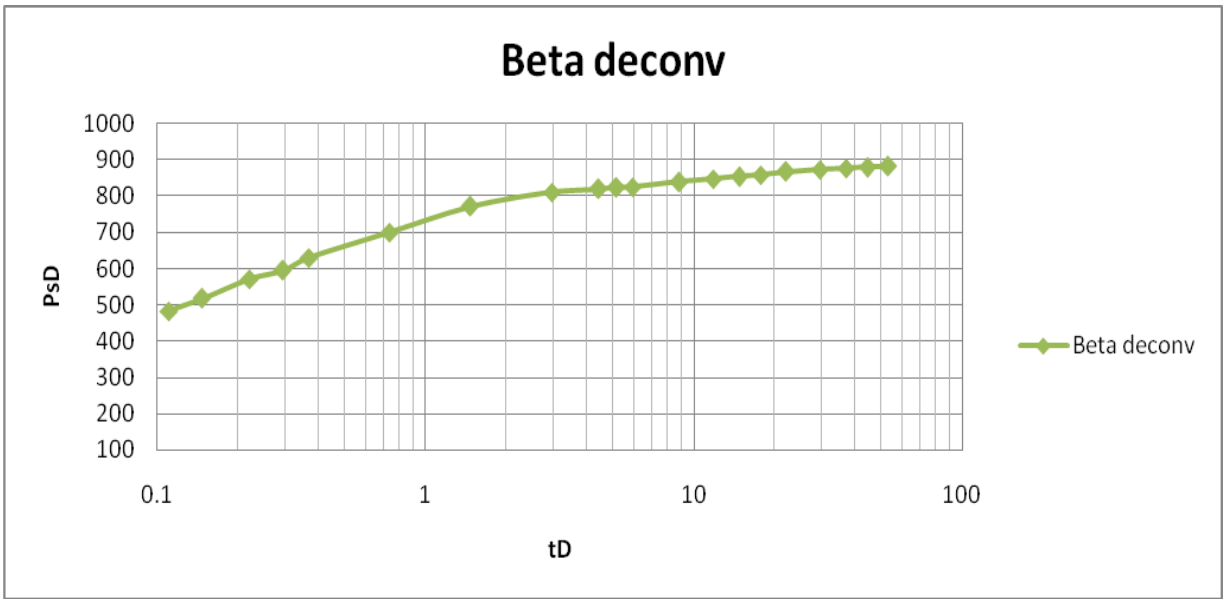

Figure 3: β-deconvolved data

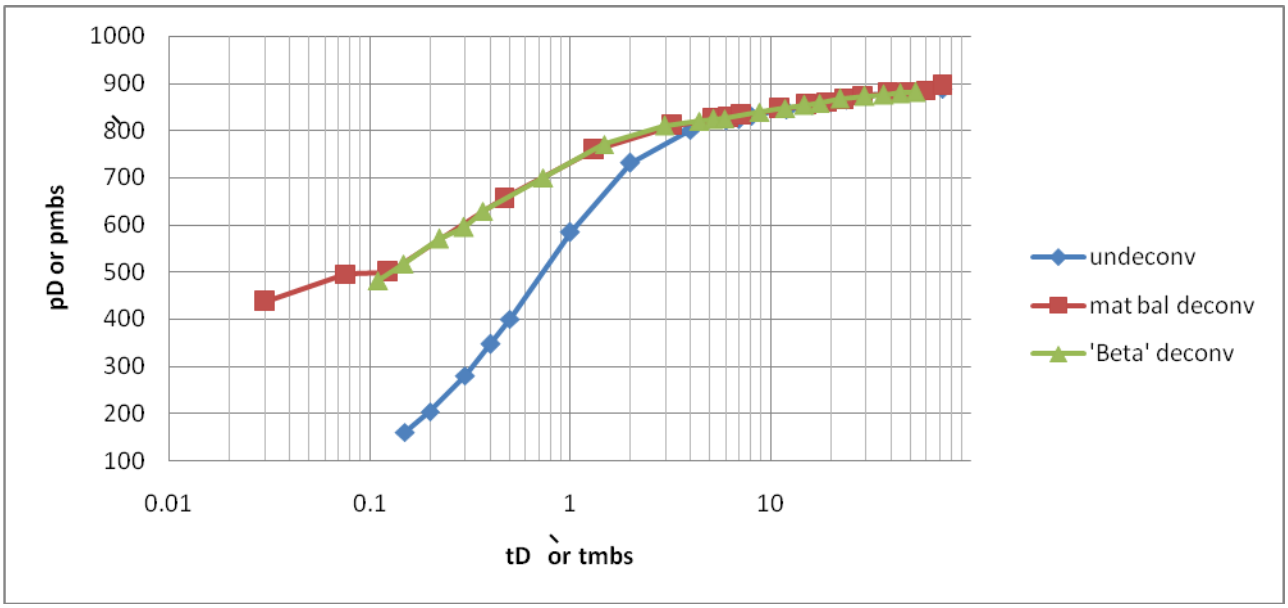

Figure 4: Comparison of the deconvolved and undeconvolved data

Table 5. Comparing the Undeconvolution and Deconvoluted Results

PARAMETER	UNDECONVOLUTED	DECONVOLUTED	
	(MTR)	MATERIAL BAL	BETA'
m(psi/cycle)	70	110	200
K(mD)	8.4	5.4	3.9
S	5.87	4.2	2.7

REFERENCES

[1] Bassey, E.E: (1997) "Deconvolution of Pressure Buildup Data Distorted by Wellbore Storage and Skin in Horizontal Wells" M.sc Thesis, University of Ibadan, Nigeria

[2] Bourdet D, Ayoub, J.A and Pirard, Y.M(1998): "Use of pressure derivation in well test interpretation" SPEFE 293-302.

[3] Horner, D.R(1951):"Pressure Build-up in Wells". Proc.Third World Pet. Cong, E.J. Brill, leiden , 503-521.

[4] Igbokoyi, A.O(2007):" Deconvolution of pressure buildup data distorted by wellbore storage" An M.sc Thesis in Petroleum Engineering University of Ibadan, Nigeria.

[5] kuchuk, F. J(1985):"well testing in low transmissivity oil reservoir" paper SPE 13666 .SPE California Regional Meeting, Bakersfield, March 27-29

[6] Lee W. J:(1982)" Well Testing" New York and Dallas: Society of Petroleum Engineers of AIME

[7] Mathew C.S and Russel, D.G(1967) 'Pressure Build-up and flow tests in wells'' Monograph Series, Society of Petroleum Engineers of AIME, Dallas .

[8] Oyewole, A.A(1995) :" Deconvolution of a two rate drawdown test distorted by wellbore storage and skin" M.sc Thesis, University of Ibadan, Nigeria.

[9] Ramey H.J Jr(1970):"Short-time Well Test Data interpretation in the presence of skin effect and wellbore storage" J. Pet Tech. 97-104

[10] Sulaimon A(1997):" Deconvolution of A Two-Rate Drawdown test distorted by wellbore storage and skin" M.sc Thesis, University of Ibadan, Nigeria .

[11] Van Everdingen, A.F. and Hurst, W(1953).: "The Application of the Laplace transformation to flow problems. Trans. AIME Vol. 186, 305-324

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Waste Management of Building Materials for Sustainable Development

Anwar Hussain
Assistant Professor, Architecture Section, University Polytechnic, Faculty of Engineering and Technology, AMU, Aligarh, India

ABSTRACT : *The building materials are an essential component in the building industry but unfortunately improper planning is associated with them. This paper aims to bring forward and highlight the important considerations of the factors associated with materials. The proper waste management of building materials on construction sites can save various environmental hazards and cost also. The paper will discuss the definition, important waste materials, and the benefits of waste minimization and finally bring forward certain recommendations for waste minimization based on site studies.*

Keywords–*Waste, C&D waste, Waste minimization, Sustainability*

I. INTRODUCTION

With the rapid urbanization, many factors associated with construction industry came into light. The increase in global warming has brought into light many factors associated with construction industry, which are contributing towards environmental hazards. The Indian construction industry is also facing major challenges, which are multi-dimensional, and construction waste is one such area of concern.The role of building materials play a very significant role in making the construction process sustainable altogether. With the aggression of sustainability the concept of Green Buildings, Green building material and zero waste came to light. As the usage of building materials increased rapidly, so did the generation of waste. The waste materials generated during the process are of great environmental hazard. During the construction process, there are many factors that negatively affect the performance and generate different types of waste. It is important to concentrate on the waste of important building materials, to have sustainable development.

II. NEED OF STUDY

The construction and demolition waste has very serious negative impact on environment. This leads to all types of pollution and GHG emissions. Apart from this, these have an impact on the economy also. In India, construction industry is the second largest economic activity after agriculture. The construction and demolition waste generation is very high in other countries also. Many countries in the world have taken initiatives in this field. U.K, USA and Germany have successfully developed technologies to recycle 80-90% of C & D waste[1]. India also needs to work in this direction and focus on minimization of waste.

III. DEFINITION OF WASTE

Waste has many definitions in construction industry. Waste can be understood as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of a building. Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product. Waste is “that which can be eliminated without reducing customer value” [2].

The waste generated in construction industry mainly consists of inert and bio-degradable materials like concrete, plaster, wood metal, masonry etc. Apart from these, wastes are generated at pre-building phase and post building phase also. Wastes are identified as of seven types-over production, waiting time, transportation, processing itself, having unnecessary stock on hand, using unnecessary motion and producing defective goods.[3]

IV. CONSTRUCTION AND DEMOLITION (C&D) WASTE

The waste generated in construction, maintenance and disposal phases of a building is called construction and demolition(C & D) waste.Globally, cities generate around 1.5 billion tons of solid waste/year and expected waste generation is 2.2 billion tons by 2025. Building materials account 50% of the solid waste generation worldwide.

In India, there is no systematic database on C&D waste available to the Government(MoEF). But as a thumb rule, TIFAC (Technology Information, Forecasting and Assessment Council) on the basis of studies, suggests that a new construction generates, 40-60 kg of C&D waste per sq. mt.[4]

If C &D waste is quantified, it will be more than all the other types of solid waste put together. So the question is, "How to utilize this huge amount of resources associated with C&D waste?

Table 1.A distribution of C&D waste generated from various sectors

Non-Residential demolition	33%
Residential demolition	15%
Non –Residential renovation	21%
Residential renovation	23%
Non –Residential new construction	3%
Residential new construction	5%

Source [5]

V. TYPES OF CONSTRUCTION WASTE

Construction material waste is defined as any material apart from earth materials, which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process [6].

C &D waste can be categorized in four types at source level[7].

1. **Design** – lack of proper thinking, selection of proper materials, lack of market survey etc.
2. **Operational**- lack of knowledge,negligence,improper communication etc.
3. **Material handling**- transportation, packing, unfriendly attitude etc.
4. **Procurement**-ordering errors, specifications mismatch etc.

VI. IMPORTANT BUILDING MATERIALS AND THEIR WASTAGE

The total quantum of waste from construction industry is estimated to be 12 to 14.7 million tons per annum. Quantity of different constituents of waste that arise from Construction Industry in India are estimated as follows:[8]

Table2. TonesofC&DWASTE[8]

Constituent	**Million tonnes/year**
Soil,Sand and gravel	4.20 to 5.14
Bricks and masonry	3.6 to 4.40
Concrete	2.4 to 3.67
Metals	0.6 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

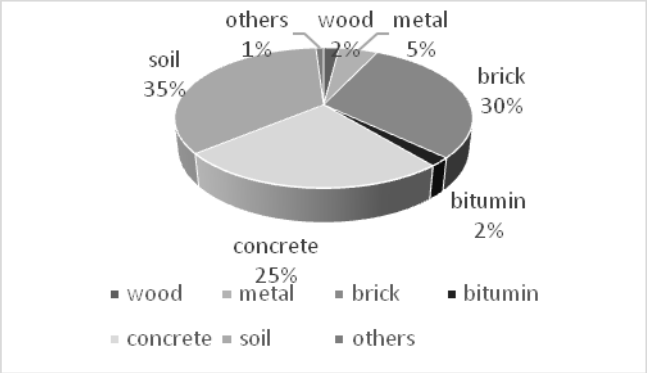

Figure1. VariousconstitutesofconstructionWASTE[8,9]

A lot of building materials are wasted at different levels on construction sites. Some major ones include steel reinforcement, concrete, formwork, blocks, cement, mortar, tiles, pipes, aggregate.

- Wastage of steel as a result of cutting, damages during storage and rusting. The reasons of likely waste of steel reinforcement are damage to mesh and bars, loss in mud and excess use of tying wire [9].
- Wastage in concrete mainly results from the mismatch between the quantity of concrete ordered and that required because of imperfect planning, leading to over-ordering. Concrete wastes also result from project delays and unnecessary waste handling processes [9].
- Timber wastage is mainly due to natural deterioration and cutting waste.
- Wastage of cement in multiple applications likebrick work, plastering, and floor screed because of poor handling, weather conditions etc.
- Mortarwastage in delivery operations.
- Bricks and blocks wastage in cutting, improper dimensioning etc.
- Electrical pipes, electrical wires, and hydraulic and sewage pipes wastages are difficult to manage during installation.

As the construction industry involves a number of consultants, the chance of waste generation at each level increases. There are a number of possible reasons for waste generation, those which can be checked, if taken care offat the right time.

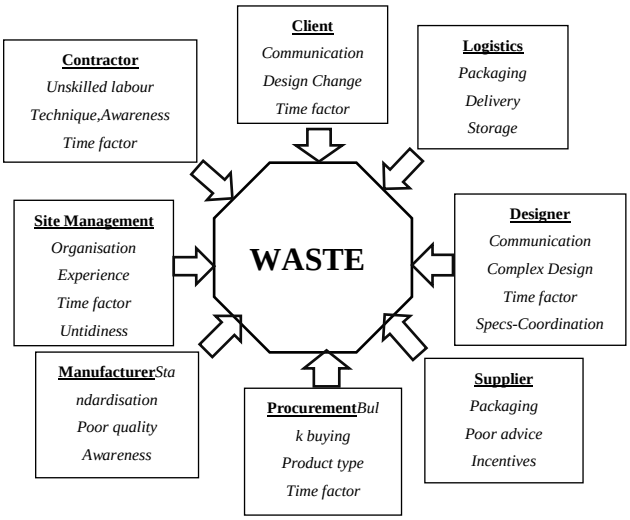

Figure2. WasteGeneration from different stakeholders [10]

VII. CONSTRUCTION WASTE MANAGEMENT

Haghi (2010) defined waste management as "the collection, transport, processing, recycling or disposal, and monitoring of waste material" [11]. Management software can help in keeping a check on the amount of material used in the project but generally the companies are not employing these methods and checking the waste manually on site, which leads to time wastage. Waste management has not gained importance in Indian construction industry. Based on severity, certain causes of waste have been identified [12].

The highly severe causes are:

- Improper planning
- Poor management
- Improper quality control
- Lack of individual responsibility
- Overall negligence

The moderately severe causes are:

- Improper designs
- Improper specifications
- Improper labour and supervision to faulty systems

The low severity causes are:

- Lack of technological know-how
- Unavailability of resources
- Unhygienic working environment
- Lack of standardization

VIII. CONSTRUCTION WASTE MINIMIZATION

The concept of construction waste minimization is based on 3R's, namely reduce, reuse and recycle.

- Reduceor source reduction, means preventing the creation of the waste in the first place
- Re-use is a form of waste reduction that: (1) extends resource supplies; (2) keeps high-quality-matter resources from being reduced to low-matter-quality waste; and (3) reduces energy and pollution even more than recycling
- Recycling is commonly defined as a process of separating recyclable materials from non-recyclable materials and supplying them to a hauler or business so they can be processed to make new products

Following is the waste management hierarchy suggested by Kibert &Chini,2000[13]

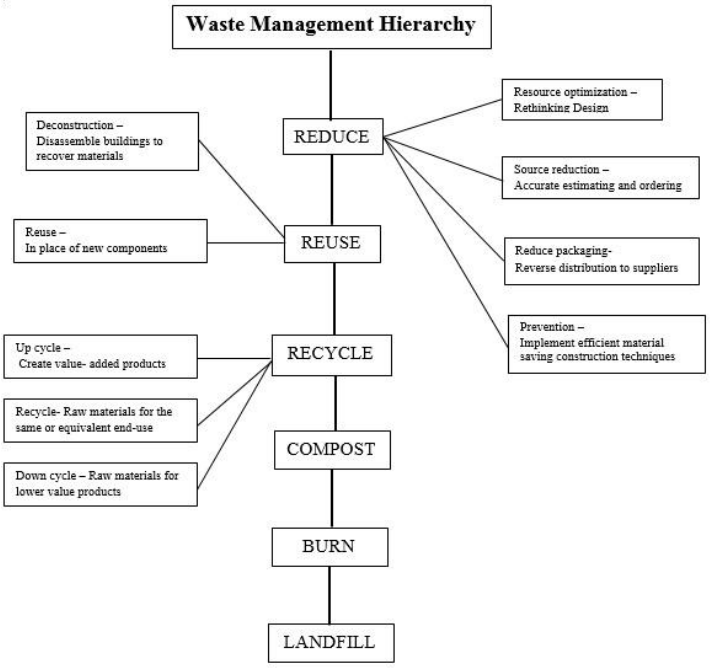

Figure3. Hierarchies for construction and demolition [13]

IX. BENEFITS OF CONSTRUCTION WASTE MINIMIZATION

In construction industry, all the stakeholders share equal responsibility for C & D waste minimization as the C & D waste constitute a significant cost to the business. The consideration of waste minimization can generate advantages such as financial and environmental benefits:

Financial benefits include:

- Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.

- Reduced disposal costs of waste materials.
- Reduced purchase quantity and price of raw materials by waste minimization.
- Reduced purchase price of new materials when considering reuse and recycling (depending on materials).
- Increased returns can be achieved by selling waste materials to be reused and recycled.

Environmental benefits include:

- Reduced quantity of waste generated.
- Efficient use of waste generated.
- Reduced environmental effects as a result of disposal, e.g. noise, pollution.
- Reduced transportation of waste to be disposed of (less noise, vehicle emission pollution, and energy used).

X. SUSTAINABILITY

Building materials play an important role towards sustainable construction. A number of organisations (Govt. and non-Govt.) are working in these areas and have developed strategies to overcome the environmental concerns. The properties and attributes of building materials should be checked at *pre building phase, construction/maintenance phase, and post building phase* to achieve sustainability.

For sustainable development,it is important to note, that there must be a balance between levels of development and the stock of natural resourcesi.e. development must be at a level that can be sustained without prejudice to the natural environment or to future generations [13].

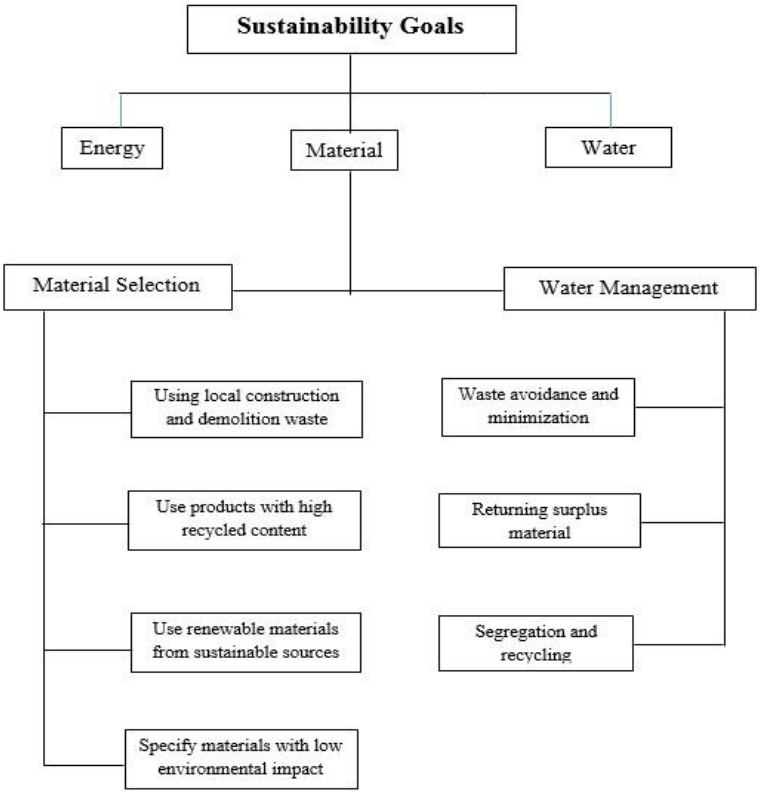

Figure4. Materials resource as a part of sustainable construction [14], WRAP (b) 2009

XI. RECOMMENDATIONS

On the basis of site studies, certain recommendations are worked out for different building materials on site, which can be listed as follows:

- ✓ Shifting of materials should be avoided to reduce the waste and maintain the quality.
- ✓ Minor accidents like scratches, fall of materials should be avoided by using proper safety measures.
- ✓ Appropriate tools and equipment should be used for handling of materials.
- ✓ Material loss should be avoided, which occur because of over stacking and improper storage.

- ✓ RMC can be employed for saving wastage on site.
- ✓ Daily check and maintenance of the tools, equipment, plants and machinery before the start of the day's work and after the end of the day's work.
- ✓ Material loss can take place because of huge buffer of materials. Pressure from the client to complete the project in time force the contractor to increase the buffer stock. Proper inventory and timely supply is necessary.
- ✓ Proper scheduling of construction project should be done.
- ✓ Proper storage spaces, like yards, should be created for placing the fresh building materials.
- ✓ Misuse of scrap material can result in quality deprivation, financial losses and the major constraint of the project. Proper storage for scrap is essential.
- ✓ Proper layout of the site is important to improve the proper flow of materials. The materials should be stacked near the actual area of operation.
- ✓ Circulation pattern for movement of material and labour should be planned beforehand. This will help manage the inflow and outflow of the building materials.
- ✓ Proper stacking of waste material should also be planned, so that the scrap can be reused or recycled.

XII. CONCLUSION

The importance of building materials as source of waste generation is highlighted in this paper. Various definitions of waste, C & D waste and Waste management have been discussed. Important building materials and their wastage proportions have been highlighted. The concept or 3 R's i.e. Reduce, Reuse and Recycle is elaborated with respect to building materials. The environmental and financial benefits of waste minimization are worked out. Finally recommendation are derived on the base of site studies, which can be employed for waste minimization. The paper brings a clear profile of C&D waste and its management practices in India.

REFERENCES

[1] Resource Venture (2005) *"Construction Waste Management Guide", Retrieved from resourceventure.org/free-resources/get-started/.../CWM%20Guide.pdf*

[2] Polat,G & Ballard,G.,(2004),*Waste in Turkish Construction-Need for Construction Technique, Proceedings IGLC, Aug, Denmark, 488- 501*

[3] Forbes & Ahmad (2004), *Adapting lean Construction methods for developing nations,LACCEI'2004,Miami,Florida,U.S.*

[4] Construction &Demolition Waste, CSE, *www.cseindia.org*

[5] USEPA, 530-R-98-010, June1998

[6] Ekanayake,L.L. & Ofori,G.(2000),*Building waste assessment score-design based tool,Building & Environment,Vol-39.No7,pp851-61*

[7] Agyekum.K,(2012)*PhD. thesishttp://ir.knust.edu.gh/bitstream/123456789/3992/1/Final.pdf*

[8] TIFAC, E. (2000).*Utilization of waste from Construction Industry. New Delhi: Department of Science & Technology.*

[9] Shen et al. (2002).*Material wastage in Construction Activities-A Hong Kong Survey*

[10] Mansi Jain (2012).*Economic aspects of construction waste materials in terms of cost saving – A case study of Indian Construction Industry. Rajasthan, India.*

[11] Haghi,A.K.(2010)*Waste Management: Research Advances to Convert Waste to Wealth Waste and Waste Management* (Nova Science Publishers,2010)

[12] Khan, S. (2015) "An Overview of Constructability: A Management Tool for Architects",*JOURNAL OFARCHITECTURE RESEARCH, Scientific & Academic Publishing (SAP), USA, Vol. 5 No. 5, 2015, pp. 125-139(available at http://article.sapub.org/10.5923.j.arch.20150505.01.html)*

[13] Adewole, A. Taiwo (2009)"Waste management towards sustainable development in Nigeria: A case study of Lagos state"*International NGO Journal Vol. 4 (4), pp. 173-179, April 2009 Available online at http:// www.academicjournals.org/INGOJ ISSN 1993–8225 © 2009 Academic Journals*

[14] Armanda Couto and João Pedro Couto"Guidelines to Improve Construction and Demolition Waste Management in Portugal", , University of Minho Portugal, *http://cdn.intechopen.com/pdfs-wm/9673.pdf*

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Modeling of traffic congestion on urban road network using fuzzy inference system

Surendra R. Kukadapwar[1], Dr. D. K. Parbat[2]
[1, 2](Department of Civil Engineering, Government Polytechnic, Nagpur, India.)

ABSTRACT : *Traffic congestion is a complex issue which most of metro cities are experiencing. The degree of congestion on urban links is not always measured & treated uniformly as it is not well defined phenomenon. The traditionalapproaches are unable to represent realistic& true traffic condition and leads to deviation in congestion measurement because of various factors such as imprecision of the measurement, the traveller's perception of acceptability, variation in sample data, and the analyst's uncertainty about causal relations. To overcome this, fuzzy inference approach is proposed in which, three input parameter i.e. speed reduction rate, proportion of time traveling at very low speed (below 5 kmph) compared with total travel time and traffic volume to roadway capacity ratio are combined to get single output in term of congestion index. The proposed model is demonstrated by considering real time traffic data on major road network of Nagpur city, India. This study allows the process to combine different measures and also to incorporate the uncertainty in the individual measures so that the composite picture of congestion can be reproduced with greater accuracy & low error margin.*

Keywords: *traffic congestion; fuzzy inference system, speed reduction rate, low speed rate, v/c ratio*

I. INTRODUCTION

The tremendous rise in number of vehicles is variably accompanied by ever increasing volume of traffic and intense traffic congestion on roads. Almost every city in India is facing acute traffic problem in regards to delay, congestion, pollution, accidents, parking etc. These problems contribute not only loss of precious manpower but also results in additional fuel consumption, development of mental stress and overall feel bad environment for the driver. Since traffic congestion has been one of the major issues that most of the metropolises are facing, a system for measuring the severity of traffic congestion is needed.Such a measure provides the foundation for traffic engineers and policy makers to identify problems and determines the effectiveness of mitigation strategies. In addition, a consistent and uniform measure will allow comparison of traffic conditions at different locations, so that priorities for improvementscan be developed, which helps the public to understand the trafficconditions objectively.

The roadway traffic congestion is one of the most confusing tasks, as it is very difficult to conceive of single value that will describe all of traveller's concern about congestion.Several measures of traffic congestion are suggested by various researchers in their studies which can be broadly categorized into four groups: (i) basic measures, (ii) ratio measures, (iii) level of service and (iv) indices. Each measure has individual advantages & limitations and isunable to define traffic congestion uniformly. It is found necessary to develop a process which will combine various independent traffic congestion measurement methodsand measure it into single index form. Thus a new approach is proposed to estimate the road traffic congestion using fuzzy techniques. In this paper the fuzzy inference system is used to measure the degree of congestion on major arterial road network by using the traffic flow information such as speed reduction rate, proportion of delay time within total travel time, traffic volume and roadway capacity information. The fuzzy logic is well known to be suitable for handling problems that are nonlinear in nature such as human feelings. Road congestion is a subjective quantity, because it comes from the feelings of vehicle driver and decision makers which may be different for different drivers or decision makers. In the same road conditions, some may feel that the road is heavily congested, while some others may feel that the road is only slightly congested. This is the problem of mismatching data interpretation due to different user's perception. With the help of fuzzy sets, the vagueness and uncertainties of the real world is handled in smooth manner.

The research paper is organized as follows; second section describes the state of art literature. The third section describes the proposed method to measure congestion based on fuzzy inference system. Section fourdeals with information about study area and field work adopted to collect relevant data. Thesection

fivedescribes the application and features of proposed fuzzy model. In section six, demonstration of model on real-world problem and their consequent results are discussed. Last the conclusion and outlook towards future research work is presented in section eight.

II. LITERATURE REVIEW

Though congestion is the fundamental concern in dealing with any transportation problem, the degree of congestion on urban arterial roadways is not always measured and treated uniformly, mainly because congestion is not a very well-defined phenomenon.Amudapuram Mohan Rao&KalagaRamchachandraRao [1] and MdAftabuzzaman [2] have carried out systematic and detailed review of traffic congestion in their paper covering the existing practises in different countries, the contributions by individuals and prevailing methodologies for measurement of the congestion along with critical review of the methods. Many definitions have been proposed to describe traffic congestion on roadways in urban areas. However, there is no universally accepted definition of traffic congestion. As perRothenberg [3], congestion is a condition in which number of vehicles attempting to use a roadway at any time exceeds the ability of the roadway to carry the load at generally acceptable service levels. While Downs [4] definesthe congestion as the situation when traffic is moving at speeds below the designed capacity of a roadway, Bovy and Salomon [5] found Congestion as state of traffic flow on a transportation facility characterized by high densities and low speeds, relative to some chosen reference state. Weisbrodet al. [6] described traffic congestion is a condition of traffic delay (when the flow of traffic is slowed below reasonable speeds) because the number of vehicles trying to use the road exceeds the traffic network capacity to handle those. Lomax et al. [7] defined traffic congestion is travel time or delay in excess of that normally incurred under light or free-flow travel conditions.

KhaledHamad&Shiya Kikuchi [8] has developed new approach to measure congestion on arterial roadways using fuzzy inference method by usingtwo independently treated measures i.e. average travel speed and the proportion of time travelling at very low speed rate within the total travel time as input for fuzzy inference to have single congestion index as outcome.NilanchalPatel&AlokBhushanMukherjee [9] in their study conducted at Ranchi, India demonstrated that application of the fuzzy concept and knowledge-based congestion weights can provide better realistic status of the congestion in the field as compared to traditionally used congestion index value of the influencing parameters. R.Narayanan et al.[10] conducted study for quantifying congestion using fuzzy logic, in which measurable quantities such as Speed and Inter Vehicular Distance were consider as two input parameters for fuzzy model and result found to be more appropriate compared to present system of defining congestion using v/c ratio.Hari Shankar et al. [11] evaluated the road traffic congestion of Dehradun city in India from traffic flow information using fuzzy techniques. Three different approaches namely Sugeno, Mamdani models which are manually tuned techniques, and an Adaptive Neuro-Fuzzy Inference System (ANFIS) which an automated model decides the ranges and parameters of the membership functions using grid partition technique, based on fuzzy logic. PanitaPongapaibooletal.[12] evaluated level of road traffic congestion using manually tuned fuzzy logic and adaptive neuro-fuzzy technique and compared measuring accuracy of output obtained by both the methods.

III. MEASURE OF CONGESTION BASED ON FUZZY INFERENCE SYSTEM

The various congestion measures used in practice have individual advantages and limitations. Since the congestion is a phenomenon which is caused by many factors and perceived in different ways the efforts are needed to incorporate more than one measure. Similarly while measuring the traffic congestion, one of the important element of the process i.e. traveller's perception of what is acceptable and unacceptable is required to be incorporated. As this boundary is not well defined and differs among each traveller and travel circumstances. Considering the facts and limitation of present congestion measurement methods, a process is proposed that uses fuzzy inference system which allows the vague boundary of a set and identify solution for problem involving ambiguity and uncertainty. The procedure consists of computing the values of the input parameters, classifying the input values into different groups, defining different states of congestion, and finally determining the congestion index.

3.1 Input Parameters

The proposed procedure considers three measures of congestion that are observed and then combines them into a single measure using fuzzy inference. The three measures are speed reductionrate, proportion of time traveling at very low speed (below 5 kmph) compared with total travel time and traffic volume to roadway capacity ratio. Initially all these three measures are computedseparately on the basis of field data collected and then, they are combined according to a set of fuzzy inference rules. The three inputs as a composite represent the traffic condition, making use of average speed, variation of speed within travel and volume to capacity ratio represents the traveller's sense of frustration and irritation.

Speed reduction rate is the rate of reduction in speed of vehicle caused by congestion. It provides a way to compare the amount of congestion on different routes for non-peak and peak condition.

$$\text{Speed reduction rate} = \frac{(NonPeakFlowSpeed - PeakFlowSpeed)}{NonPeakFlowSpeed} \quad \textbf{(1)}$$

This value is between 0 and 1, 0 being the best condition, when the Peak flow speed is larger than or equal to the Non-Peak flow speed, and 1 being the worst condition, when Peak flow speed is near to 0.

The very-low-speed rate is computed on the basis of the proportion of time traveling at very low speed compared with the total travel time.

$$\text{Very-low-speed rate} = \frac{Timespentindelay}{Totaltraveltime} \quad \textbf{(2)}$$

This value is between 0 and 1, 0 being the best condition (least congestion), with no delay, and 1 being the worst condition, with most of the travel time spent in delayed conditions. Delay is defined as the total travel time at a speed less than 5kmph.

The volume to capacity ratio of each traffic link during peak flow condition is computed. The volume is calculated in terms of Passenger car unit/hour, while capacity of roadway is considered as per IRC 106:1990 recommendation [13].

$$\text{V/C Ratio} = \frac{Volume\ of\ vehicles in peak\ hour}{Capacity of roadway} \quad \textbf{(3)}$$

This value is between 0 and 3, a value near 0 being the best condition, when v/c ratiois minimum and 3 being the worst condition when very large volume of vehicles are moving on road compared to its capacity.

3.2Classification of Observed Values

After computing three mentioned input parameters from real-world data, each value is fuzzified. Fuzzification means mapping the value to a class of conditions defined by a natural language to which the traveller can relate, such as "high congestion." Each of the natural-language classes is considered as a fuzzy set, which has vague boundaries.

For speed reduction rate, the calculated value is translated into one of six natural-language-based classes from very good (near 0) to very bad (near 1). The six categories are designated A to F, for ease of designation: A is the best, and F, the worst. The correspondence between the values and the fuzzy sets is based on the HCM 2000 [14] definition of LOS for urban and suburban arterials. The membership functions corresponding to each of these classes are shown in Figure 1, in where a value of speed reduction rate is given, the degree to which this value is compatible with a class is given in the membership function. It is possible that one value could correspond to more than one class.

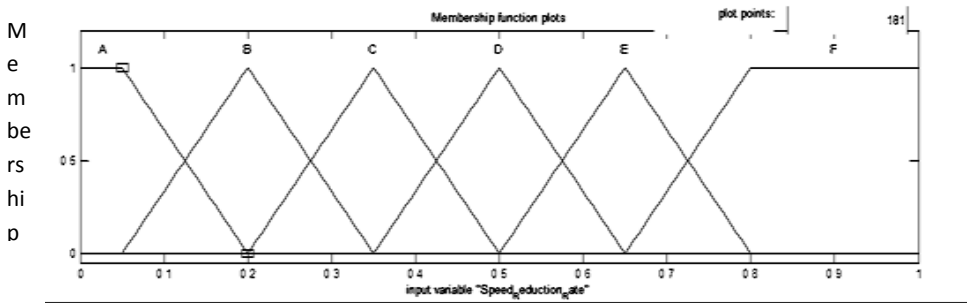

Figure 1: Membership Function for Speed Reduction Rate

Similarly, the values of very-low-speed rate are categorized into three groups that are identifiable to travellers: "low," "moderate," and "high," where "low" indicates that the proportion of travel time at very low speeds (less than 5 kmph) is minir ` ıd thus the condition is very good. The membership functions of the three classes are shown in Figure 2.

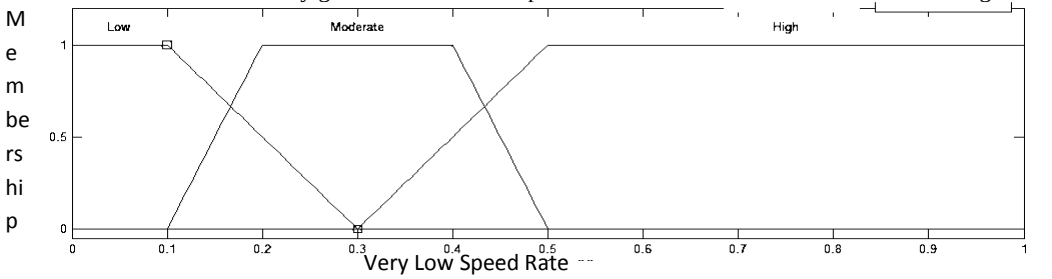

Figure 2: Membership Function for Very Low Speed Rate

For v/c ratio, the values classified into three groups that can be realize by travellers: “low,” “medium,” and “high,” where “low” indicates that the ratio of vehicles travelling on road to standard roadway capacity is minimal and thus the condition is very good. The membership functions of the three classes are shown in Fig.3.

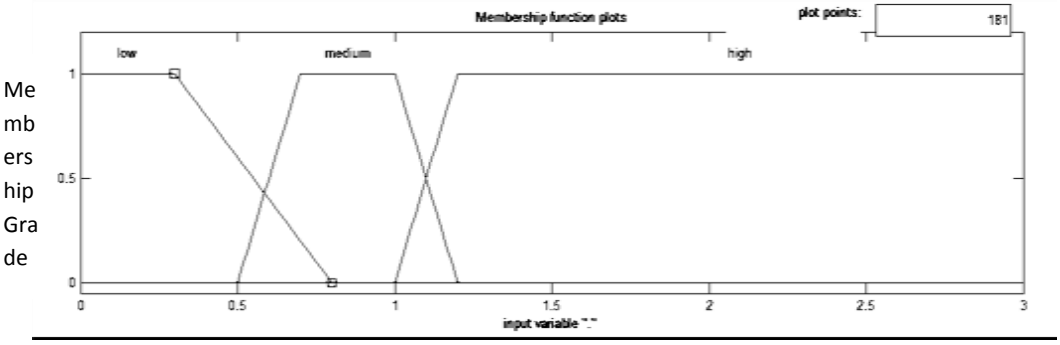

Figure 3: Membership Function for V/C Ratio

3.3 Output Parameter

The quantification of congestion in terms of “congestion index” is the output of the process, is categorized into four classes: “low,” “moderate,” “high,” and “very high.” Their membership functions are shown in Figure4, in which the x-axis is a scale between 0 and 1, where 0, is very good, and 1 is very bad. The four classes of congestion condition are defined on the basis of this scale. The boundaries of the classes are rather vague, and hence each class is designated with a natural-language term, which is useful in expressing the prevailing situation.

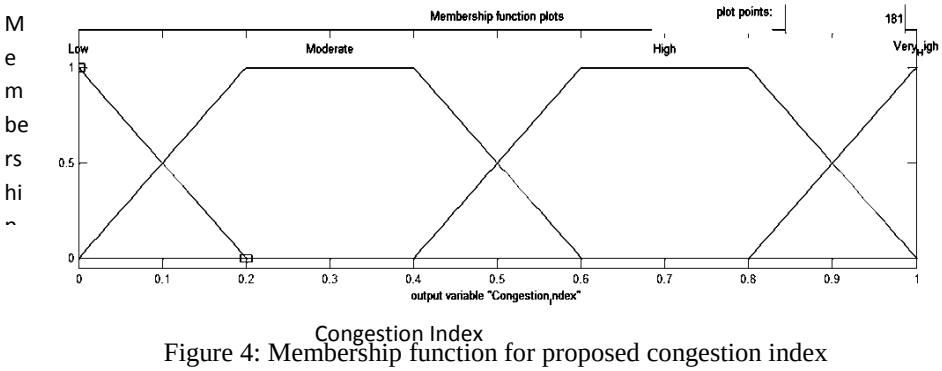

Figure 4: Membership function for proposed congestion index

3.4 Rules

The task of combining three inputs (i.e. Speed reduction rate, very-low-speed rate and v/c ratio) and deriving a natural-language-based congestion measure is performed using a fuzzy rule which are manually designed are of the following type:

Rule: IF (speed reduction rate is P) AND (the very-low-speed rate is Q) AND (v/c ratio is R), THEN (Congestion is S)

WhereP,Q,R and S each represent the degree of congestion as defined in Figures 1, 2, 3, and 4. The part of the rule following IF is called the antecedent, and the part following THEN is called the consequent. The two rules corresponding to the extreme conditions are as follows:

IF speed reduction rate is “high” AND the very-low-speed rate is “high” AND v/c ratio is “high”, THEN congestion is “very high.”

IF speed reduction rate is “low” AND the very-low-speed rate is “low” AND v/c ratio is “low”, THEN congestion is “low.”

As much as 54 no. of rules between these three extremes are possible using combinations of different classes in the speed reduction rate, very-low-speed rate and v/c ratio. Out of these, 38 no. of possible rules areexecuted in this process to get desired output.

IV. SELECTION OF THE STUDY AREA AND FIELD WORK FOR DATA COLLECTION

Nagpur is the fast growing multimodal centre of India and second capital of Maharashtra state with population exceeding 25 lacks situated almost in the centre of country. The city has coordinal point’s 21^0 09’ north latitude and 79^0 05’ east longitudes with altitude over 312.42 m above mean sea level. The city is spreaded over the metropolitan area of 217.56 km^2. In recent years, many major projects such as Multi-Modal International Cargo

Hub and Airport at Nagpur (MIHAN), IT Industries, and Premier educational institutes like IIM, IIIT and AIIMS are introduced in the city, which will lead heavy flow of people from all over the country. It is estimated that population of city will be about 40 lakhs by 2021. As far as the link flow is considered, most of the routes are congested because traffic volume is much higher than the capacity of the road. Nagpur is experiencing the several traffic problems as most of cities of India are facing such as non-uniformity of roadway features, encroachment on roads, abutting land-use pattern and resulting pedestrian activities, poor lane discipline, improper bus stop location, uncontrolled on-street parking, heterogeneity of traffic etc. resulting into traffic congestion on major road network of the city. The severity of this congestion reaches to highest level during morning and evening peak hours.

The field work is carried out invariably under perfect weather condition on normal working day in the month of January-February 2014. Field work is carried out in two parts: (a) travel time study and (b) traffic volume count.For conducting travel time study, the test car technique is adopted. Test car was run on traffic links in peak hours and non- peak hours. The average speed, travel time and distance between intersections, and total time traveling at speed less than or equal to 5kmph. was observed and tabulated. The timing of field work was from 9.30 am to 11.30 am during morning peak hour and 5.30 pm to 7.30 pm during evening peak hours. Test car was made to run on road network between 7 am to 9 am and 12 noon to 5 pm to record travel time in non-peak hours. During the study, the test car was run at speed which in the opinion of driver is the representative of average speed of all the vehicles in stream of flow at the time of run.

The traffic volume data is collected manually by team of experts during the peak hours of the day. Number of vehicles passing over the links was noted and all vehicles moving on street are converted into common unit termed as “Passenger Car Unit” (PCU). Considering equivalent PCU of different vehicle, the volume of traffic during peak hour is calculated in PCU/Hour. The capacity of each link is considered as referred by IRC 106:1990. [13]

V. Application of Fuzzy Inference System for Computing Congestion Index

The manually tuned Mamdani-type fuzzy inference system is used to compute the traffic congestion. MamdaniFIS is the most used in the developing fuzzy models.Mamdaniarchitecture used in this paper for estimation of road traffic congestion is designed with three inputs, one output parameter and thirty eight fuzzy rules. The manner in which the fuzzy rules are executed is as follows. The specific values of speed reduction rate, very-low-speed rate and v/c ratio are the inputs to the rules. For a given rule, a match between the input values and the antecedent of the rule is calculated using Figures 1, 2, & 3. Then the minimum value of the membership degrees among the two is taken as the truth of the antecedent. Thus, this value controls the truth of the consequent of the rule. When the given values of speed reduction rate, very-low-speed rate& v/c ratio correspond to more than one class, all applicable rules can be used (or “fired”). Consequents for different rules are aggregated to form the conclusion. Figure 5illustrates the process of computation.

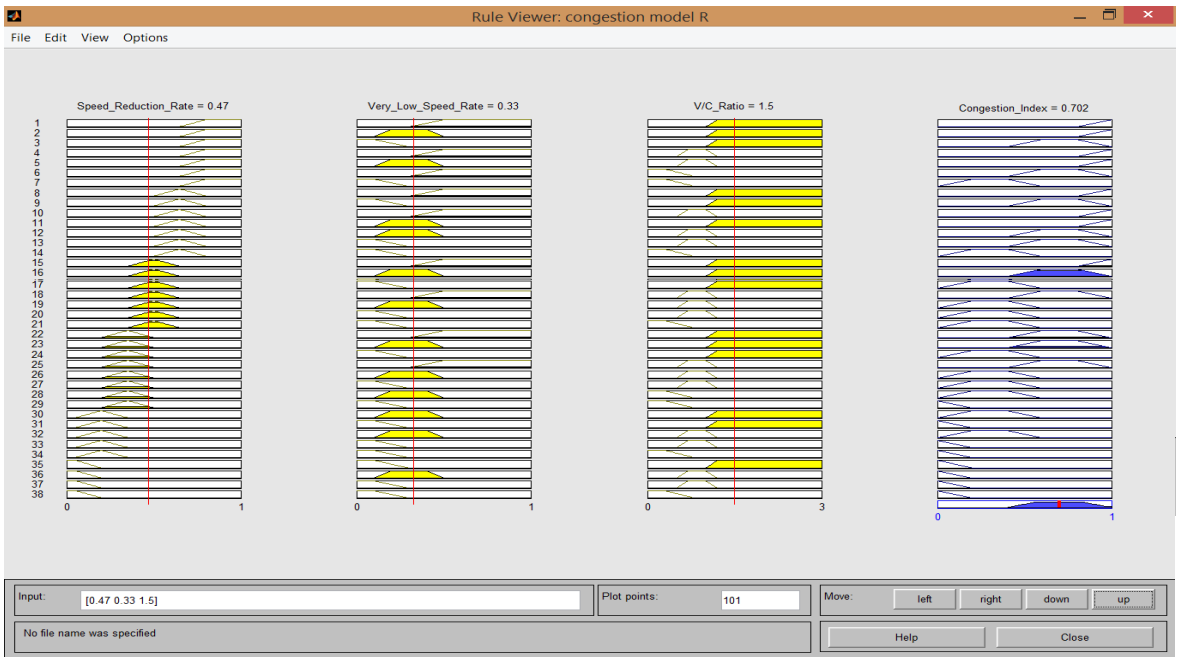

Figure 5: Proposed Fuzzy Model

The conclusion derived is a number between 0 and 1. This value carries the information about the current situation in terms of congestion index. It is a continuous measure. For different combinations of speed reduction rate, very-low-speed rate& v/c ratio, Figure 5 shows the corresponding congestion measure according to the rules framed. While demonstrating model, it is observed that when all the three input parameters are near 0, the congestion index is close to 0, indicating a very good condition. Furthermore, when these input parametersare close to 1, the congestion index is close to 1, indicating a very bad condition.

VI. RESULT & DISCUSSION

The proposed congestion model is applied to a real-world road network of study area. The relevant traffic data i.e. distance between consecutive intersections, travel time, delay time& traffic volume required for computing input parameter are collected on all major traffic links of study area. The values of input parameters i.e. speed reduction rate; very-low-speed rate and v/c ratio for each link are calculated as per equation 1, 2& 3. The resulting congestion index is obtained in last column showing the congestion status of each link. The proposed model is demonstrated on Central Avenue road; which is one of the busiest road of Nagpur is as shown in Table No.1.

Table 1: Input Data & Result

Road-way Link		Distance (km)	Travel Time (sec)		Time Spent In Delay (sec)	Traffic Volume (pcu/hr)	Non-Peak Flow Speed (km/hr)	Peak Flow Speed (km/hr)	Speed Reduction Rate	Very-Low Speed Rate	V/C Ratio	Congestion Index
From	To		Non-Peak Flow	Peak Flow								
Variety Square	Old Morris College Square	0.4	45	60	22	2073.15	32.00	24.00	0.25	0.37	1.15	0.44
Old Morris College Square	Zero Mile Square	0.25	25	34	8	4025.5	36.00	26.47	0.26	0.24	2.24	0.454
Zero Mile Square	RBI Square	0.4	32	48	12	3313.3	45.00	30.00	0.33	0.25	1.84	0.596
RBI Square	BHEL Office Square	0.3	32	60	20	2707.8	33.75	18.00	0.47	0.33	1.50	0.702
BHEL Office Square	JaistambhaChowk	0.3	45	68	33	3978.4	24.00	15.88	0.34	0.49	2.21	0.668
JaistambhaChowk	PoddareshwarChowk	0.3	40	55	21	3750.10	27.00	19.64	0.27	0.38	2.08	0.488
PoddareshwarChowk	Mayo Hospital	0.18	28	38	8	2211.85	23.14	17.05	0.26	0.21	1.23	0.443
Mayo Hospital	DosariBhawan Square	0.21	28	35	5	1939.25	27.00	21.60	0.20	0.14	1.08	0.258
DosariBhawan Square	Gitanjali Talkies	0.23	30	38	8	2385	27.60	21.79	0.21	0.21	1.33	0.316
Gitanjali Talkies	Agrasen Square	0.4	55	85	27	2426	26.18	16.94	0.35	0.32	1.35	0.7
Agrasen Square	Bhawsar Square	0.3	36	55	18	2229.9	30.00	19.64	0.35	0.33	1.24	0.7
Bhawsar Square	M.G. Square	0.25	34	52	15	2431.9	26.47	17.31	0.35	0.29	1.35	0.676
M.G. Square	Darodkar Square	0.24	30	40	9	2507.75	28.80	21.60	0.25	0.225	1.39	0.425
Darodkar Square	Azad Hind Square	0.2	25	35	8	2727.35	28.80	20.57	0.29	0.23	1.52	0.52
Azad Hind Square	Telephone Exchange	0.5	48	60	18	2107.2	37.50	30.00	0.20	0.30	1.17	0.3
Telephone Exchange	Chapru Nagar Square	0.4	42	54	14	3149.6	34.29	26.67	0.22	0.26	1.75	0.357
Chapru Nagar Square	Ambedkar Square	0.3	38	53	12	2065.4	28.42	20.38	0.28	0.23	1.15	0.497
Ambedkar Square	Wardhaman Nagar Square	0.55	48	59	8	1870	41.25	33.56	0.19	0.14	1.04	0.247
Wardhaman Nagar Square	Vaishnavi Devi Square	0.4	30	42	5	2135.5	48.00	34.29	0.29	0.12	1.19	0.387
Vaishnavi Devi Square	HB Town Square	0.8	68	90	0	1776.3	42.35	32.00	0.24	0	0.99	0.228

From above table, it may be observed that, using either one of the input parameter cannot give real picture of traffic congestion. The combination of all three parameters captures the real status of condition. It is observed that if one of the input parameter is much higher and remaining two parameters are on lower side as in case of Old Morris College Square to Zero Mile Square link, the congestion effect is moderate. However on traffic link between RBI Square to BHEL Office Square, all three parameters are of noticeable amount resulting higher congestion effect. Similarly the links subjected to lower values of speed reduction rate, very low speed rate and v/c ratio resulting lower congestion index. The proposed model gives more realistic and detailed congestion picture compared to that obtained in traditional methods by considering single parameter.

VII. CONCLUSIONS

In this paper, we proposed fuzzy inference method to evaluate congestion status on links of real road network.In proposed congestion model, three traditionally used congestion measures i.e. speed reduction rate, very low speed rate & v/c ratio are combinedinto a single composite measure of congestion. Each one of thesemeasures can individually indicate characteristic of traffic flow qualitywith the help of sharp boundaries where possible error in measurementmay misleadwith actual traffic condition similarly each individual method have their own limitations.To overcome this, fuzzyinferenceapproach is proposedwhich consider every small variation in each of input parameterand their composite effect gives true and realistic image of traffic condition. Since the proposed model is based on natural-language rules, which are consistent with the general feelings of the travellers therefore it is possible to use such fuzzy model with greater accuracy & low error margin.

The proposed model is simple to use and follows commonsenselogic. Itcan be applied to represent the traffic conditionsover roadway segments, corridors, or a highway network. Future research, however, is needed to determinehow the model can be expanded to include other factors influencing traffic congestion suchas encroachments on road, on-street parking, roadway condition etc. Further researchis also needed to fine-tune the shapes of the membershipfunctions and defining rules more precisely.

REFERENCES

[1] Amudapuram Mohan Rao and KalagaRamchachandraRao (2012).Measuring Urban Traffic Congestion – A Review. International Journal for Traffic and Transport Engineering, 2(4): pp.286-305.

[2] Aftabuzzaman,M(2007). Measuring Traffic Congestion - A Critical Review. In Proceedings of the 30th Australasian Transport Research Forum. 16p.

[3] Rothenberg, M.J.(1985) Urban congestion in the United States-what does the future hold, ITE Journal, 55(7), pp. 22-39.

[4] Downs, A. (2004). Still stuck in traffic: coping with peak hour traffic congestion. Washington,D.C.:TheBrookingsInstitution. 455 p.

[5] Bovy, P.H.L.;Salomon,I.(2002). Congestion in Europe: measurements, patterns and policies. In Monograph Travel Behaviour: spatial patterns, congestion and modelling. Pp.143-179.

[6] Weisbrod, G.; Vary, D.; Treyz, G. (2001). Economic Implications of congestion, NCHRP Report 463. Washington, D.C.: Transportation Research Board. 47 p

[7] Lomax,T.; Turner,S.; Shunk,G.; Levinson, H.S.; Pratt., R.H.; Bay,P.N. and Douglas, G.B. (1997). Quantifying congestion, Volume 1, NCHRP Final Report 398. Washington,D.C.:Transportation Research Board. 108 p

[8] Hamad, K. and Kikuchi, S. (2002) Developing a measure of traffic time congestion: fuzzy inference approach, Transportation Research Record: Journal of the Transportation Research Board, No. 1802, pp. 77-85.

[9] Patel N. and Mukherjee A. B. (2014). Categorization of urban traffic congestion based on the fuzzification of congestion indexvalue and influencing parameters ,Theoretical and Empirical Researches in Urban Management Volume 9 Issue 4 / November 2014.pp. 36-51

[10] Narayanan, R., Udayakumar, R., Kumar, K., &Subbaraj, L. (2003).Quantification of congestion using Fuzzy Logic and Network Analysis using GIS. Map India Conference.

[11] Hari Shankar, P. L. N. Raju, K. Ram Mohan Rao (2012). Multi Model Criteria for the Estimation of Road Traffic Congestion from Traffic Flow Information Based on Fuzzy Logic Journal of Transportation Technologies, 2012, 2, pp.50-62

[12] PanitaPongpaibool, PojTangamchit&KanokchaiNoodwong (2007). Evaluation of Road Traffic Congestion Using Fuzzy Techniques

[13] IRC: 106-1990, Guidelines for Capacity of Urban Roads in Plain Areas.

[14] HCM 1985. Highway Capacity Manual. Washington, D.C.: TRB, National Research Council.

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Comparative Analysis of Electric Power Generation and Demand Forecast in Nigeria

Obi, P.I.[1] and Iloh, J.P.I[2]
[1]Department of Electrical/Electronic Engineering, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria
[2]Department of Electrical/Electronic Engineering, Chukwemeka Odumegwu Ojukwu University, Uli,Anambra State, Nigeria

ABSTRACT : *This paper analyzes the statistics of power generation and power transmitted in Nigeria over the period spanning from 23rd February to 8th June 2015. The data used for the analysis were collected from the periodic update of power statistics on the official website of the Federal Ministry of Power in Nigeria. The results showed that the highest peak generation occurred on the 16th of March when the value stood at 4,115.10 MW. The maximum average power generated and average power sent out over the same period occurred on the 23rd of February when the values were 3,699.23 MWH/H and 3,623.11 MWH/H respectively. Although the average efficiency of transmission system over the period under review was 97.76%, the best efficiency figure recorded for the system was 97.94 % which occurred on the 23rd February. The overall averages for the peak generation, energy generated and energy sent out were 3,639.82 MW, 3254.52 MWH/H and 3181.83 MWH/H respectively. These results also show that an average of about 72.69 MWH/H of energy was being lost between the generation and transmission subsystems. These figures clearly show that power generation in the country is still a far outcry from the peak demand forecast for the country which is 12,800 MW as projected by the Federal Ministry of Power.*

Keywords - *peak generation, energy generated, energy sent out, efficiency*

I. INTRODUCTION

The inadequate generation of power, poor transmission and distribution infrastructure among other problems have remained a recurring decimal in the Nigeria's power sector resulting in huge adverse economic consequences [1]. Although in recent past, the Federal Government of Nigeria has taken several measures in order to tackle these teething problems and ensure that sufficient power is made available to drive the economy of the nation. However, the results these efforts particularly the huge investments to the tune of billions of US dollars so far gulped by the power sector are yet to be fully harnessed by the majority of Nigerians. In acknowledging the fact that adequate and reliable energy supply has become the bedrock of economic development and enhanced productivity anywhere in the world, it is obvious that Nigeria's power supply as at June 2015 is grossly inadequate having only a meager peak generation of about 3,691MW for a population of about 180 million people (see Table I).

In its bid to address the problem of low power generation in the country, the Federal Government in 2004 initiated the National Integrated Power Projects (NIPP). The major aim of this project (NIPP) was to boost the generation capacity of the nation and at the same time end the environmental challenge of gas flaring in the Niger delta region of the country [2, 3]. It must be noted however that while substantial progress have been recorded in terms of building power plants under NIPP, issues of gas supply and disruption of supply still greatly affect the overall generation and distribution of power in the country [3].

II. RECENT TREND INPOWER GENERATION IN NIGERIA

Having noted the inadequacy in power generation in Nigeria, it is necessary also to capture the recent developments in the power sector with respect to the tangible efforts being made the federal government to increase the generation capacity in the country. Table I shows the Completed Generation Projects spanning the period from January 2011 to December 2012 [4]. The table shows that the incremental additions to the generation capacity resulted in a cumulative increase in generation of 1687.5 MW. This obviously impacted positively on the power system as reflected in the peak generation of 4517.60 MW recorded in December 2012 [5]. Incidentally this figure was the highest peak generation value recorded between December 2012 and June 2015.

Table I: Completed Generation Projects from January 2011 to December 2012

S/No	Power Station	Date	MW	Cumulative MW
1	Olorunsogo	Jan-11	112.5	112.5
2	Olorunsogo	Feb-11	112.5	225.0
3	Olorunsogo	May-11	112.5	337.5
4	Sapele	Aug-11	112.5	450.0
5	Olorunsogo	Nov-11	112.5	562.5
6	Sapele	Feb-12	112.5	675.0
7	Alaoji	Apr-12	112.5	787.5
8	Omotosho	Apr-12	112.5	900.0
9	Olorunsogo	Jul-12	112.5	1,012.5
10	Sapele	Aug-12	112.5	1,125.0
11	Omotosho	Aug-12	112.5	1,237.5
12	Alaoji	Sep-12	112.5	1,350.0
13	Omotosho	Oct-12	112.5	1,462.5
14	Sapele	Oct-12	112.5	1,575.0
15	**Omotosho**	**Dec-12**	**112.5**	1,687.5

Source: Federal Ministry of Power

It is therefore obvious that this significant progress achieved was not sustained by the managers of the power sector. If the same amount of generation capacity was continually added to the power system over the period from January 2013 to October 2014, the overall generation capacity would have maintained a steady increase and would likely hit close to 8000 MW by the end of 2016.

III. ANALYSIS OF CURRENT NIGERIA POWER STATISTICS

The summary of the data collected over the period under review is depicted in table II.

Table II: Summary of Nigeria's Power Statistics for the Period under Review (Feb – June 2015)

POWER STATISTICS									
Date	Peak Generation (MW)	Energy Generated (MW H/H)	Energy Sent Out (MW H/H)	Power Lost (MW H/H)	% loss	Efficiency %	Difference b/w peak generation and energy generated (MW)	Peak Demand Forecast (MW)	Highest Peak Generated since Dec 2012 (MW)
23/02/15	3,866.80	3,699.23	3,623.11	76.12	2.06	97.94	167.57	12,800.00	4,517.60
25/02/15	3,224.80	3,131.08	3,063.23	67.85	2.17	97.83	93.72	12,800.00	4,517.60
03/03/15	3,730.10	3,479.55	3,406.00	73.55	2.11	97.89	250.55	12,800.00	4,517.60
08/03/15	3,941.10	3,575.85	3,505.00	70.85	1.98	98.02	365.25	12,800.00	4,517.60
11/03/15	3,770.30	2,747.45	2,676.54	70.91	2.58	97.42	1,022.85	12,800.00	4,517.60
15/03/15	4,016.80	3,556.91	3,477.65	79.26	2.23	97.77	459.89	12,800.00	4,517.60
16/03/15	4,115.10	3,680.63	3,602.08	78.55	2.13	97.87	434.47	12,800.00	4,517.60
31/03/15	4,011.40	3,540.42	3,465.36	75.06	2.12	97.88	470.98	12,800.00	4,517.60
05/04/15	3,885.60	3,550.21	3,467.32	82.89	2.33	97.67	335.39	12,800.00	4,517.60
12/04/15	3,263.60	3,060.37	2,988.72	71.65	2.34	97.66	203.23	12,800.00	4,517.60
26/04/15	3,267.10	2,896.91	2,834.30	62.61	2.16	97.84	370.19	12,800.00	4,517.60
05/05/15	3,114.60	2,880.72	2,817.05	63.67	2.21	97.79	233.88	12,800.00	4,517.60
11/05/15	3,413.10	2,585.80	2,524.37	61.43	2.38	97.62	827.30	12,800.00	4,517.60
31/05/15	3,388.50	3,163.41	3,085.77	77.64	2.45	97.55	225.09	12,800.00	4,517.60
02/06/15	3,537.20	3,164.61	3,091.00	73.61	2.33	97.67	372.59	12,800.00	4,517.60
08/06/15	3691.00	3359.24	3281.84	77.40	2.30	97.70	331.76	12,800.00	4,517.60
Average	3,639.82	3,254.52	3,181.83	72.69	2.24	97.76	385.29	12,800.00	4,517.60

The data in Table II were used to generate several plots which were used to evaluate the performance of the Nigerian power sector in terms of how much power was generated and how much was distributed to the consumers.

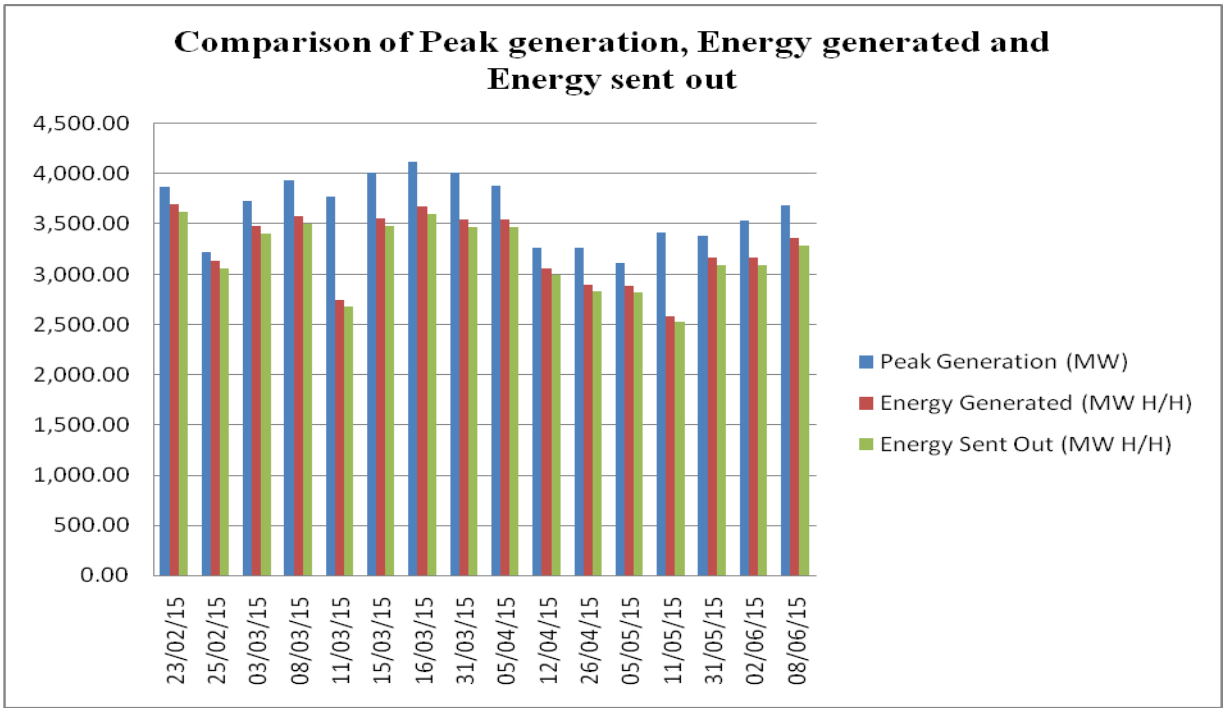

Figure 1: Comparison of Peak generation, Energy generation and Energy sent out

Fig. 1 is a chart showing the peak generation, energy generated and energy sent out over the period under review. This chart clearly shows that throughout the period under consideration, there is always a significant shortfall between the peak generation and average energy generated (energy generated) and also between average energy generated and average energy transmitted (energy sent out) to consumers. The implication of this result is that although the total generation is grossly insufficient to supply the customers, the power system cannot maintain the peak energy generation for a long period of time. Also the consistent shortfall between energy generated and energy sent out throughout the period also shows that the transmission network is always not able to evacuate all the power generated at any point in time. From the chart, it can be seen that the best performance of the system was recorded on 25th February 2015 when the difference between the peak generation and the energy generated was the least recorded with a shortfall of 93.72MW.

Fig. 2 shows the variation of peak generation, energy generated and energy sent out over the period under review. These plots clearly show that throughout the period, the power system continued to experience fluctuations in the amount of energy generated and transmitted. For example between 25th of February and 16th of March fairly significant increase in peak generation was recorded. However, the values started falling immediately after 16th of March and eventually got to its lowest over the period on the 5th of May

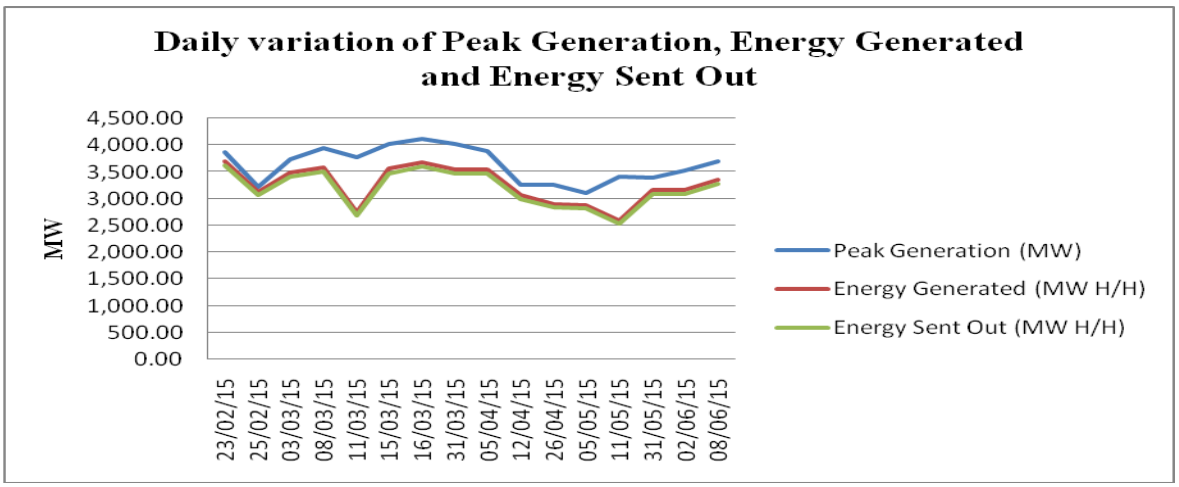

Figure 2: Variation of power generation and transmission from 23rd Feb to 8th June 2015

Another noticeable fact from the graphs in Fig. 2 is the persistent gap between the peak generation and the average generation for each date throughout the period. This information is better illustrated in Fig. 3 which shows a chart of the daily difference between the peak generation and the energy generated.

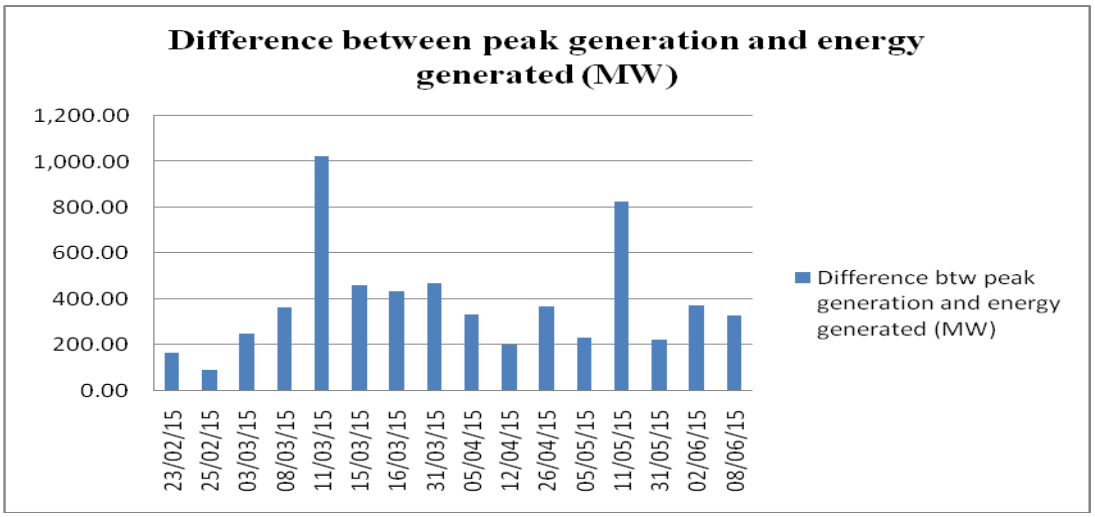

Figure 3: Difference between peak generation and energy generated

This chart clearly shows that the Nigerian power system so far cannot boast of maintaining its daily average energy generation very close to the peak generation. The closest difference was recorded on 25th February (93.72 MW) while the largest difference was recorded on 11th March (1022.85 MW). The average difference for the entire period was found to be 385.29 MW. The implication is that if the system was able to maintain daily power generation very close to its peak value for the day, an additional 376.66 MW of power per day would have been available over the period under review with 97.76% average efficiency.

A chart of the daily power lost between generation and transmission is shown in Fig. 4. The chart shows that between 61.43 MW and 82.89 MW of power were usually lost on daily basis throughout the period. The average value over the period was found to be 72.69 MW. Although the calculated average efficiency of the system (i.e. 97.76%) sounds good enough, the 2.24% lost which amounted to 72.69MW is quite significant suggesting that there is still need to improve the transmission network of the system.

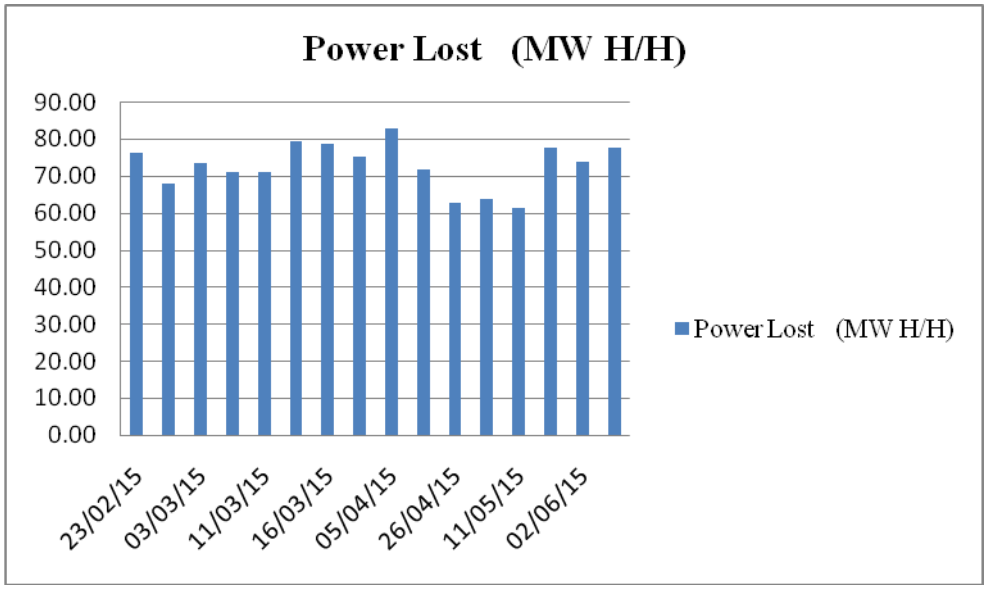

Figure 4: Power lost between generation and transmission

According to the Federal Ministry of Power, the highest peak ever generated since the year 2012 was 4517.60 MW while demand forecast till date stands at 12800MW [3]. A comparison of the peak generation over

the period under review with the quoted figure for highest peak and demand forecast is presented in Fig. 5. From the graph, it can be seen that after about two and half years of reaching highest peak of 4517.60 MW, the closest the peak generation could get to this figure was 4115.10MW (a difference of 402.5MW) which occurred on 16th March 2015. Considering the calculated average of peak generation (3639.82MW) over the period under review, it is obvious that no significant progress was made in terms of the overall amount of power available to the consumers over the past two and half years.

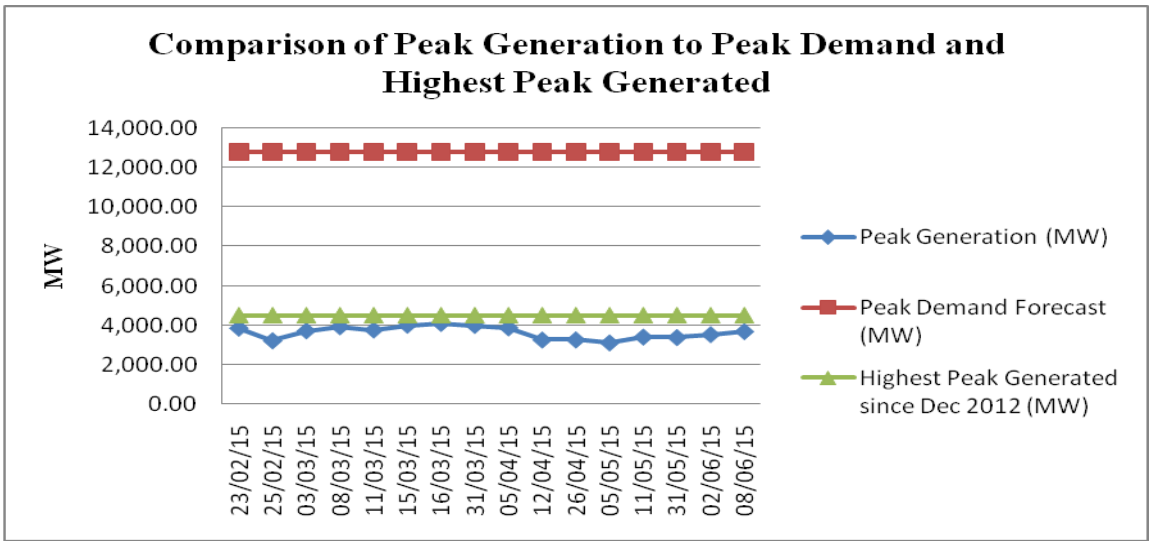

Figure 5: Comparison of the Peak Generation to Peak Demand Forecast

Going forward, in order to achieve the projected demand forecast in the nearest future, the average peak generation during the period under review must be increased by about 9160.18 MW. This figure certainly is a huge challenge to overcome.

IV. CONCLUSION

An analysis of the Nigeria's power statistics for the period spanning through 23rd February to 8th June 2015 was presented in this work. Major observations made based on the analysis show that there is persistent fluctuating trend in peak generation, energy generated and energy sent out for most part of the period under review. The study carried out also shows that there is need to improve the transmission network in order to ensure that the bulk of energy generated is completely evacuated to the consumers. Therefore, for the demand forecast to be met, Government should for once develop the political will to fully and religiously implement the National Integrated Power Projects [6]. It is obvious and understandable that lack of political will and policy inconsistency by several successive governments and power generating companies are responsible for the non-attainment of the set demand forecast.

REFERENCES

[1] Nigeria Electricity Privatisation (PHCN) (2013): "Overview of the Nigerian Electricity Industry (Roles, Responsibilities, Structure, Expectation)", Nigerian Power Sector Investment Forum, available @ www.nigeriaelectricityprivatisation.com/wp-content/plugins/download-monitor/download.php?id=26

[2] KPMG Nigeria (2013): A guide to the Nigerian power sector, www.kpmg.com/Africa/en/IssuesAndInsights/Articles-Publications/Documents/Guide%20to%20the%20Nigerian%20Power%20Sector.pdf, 2013, 7.

[3] T. Kio-Lawson, Emerging issues in Nigeria's energy sector, www.businessdayonline.com, August 6, 2014.

[4] Federal Ministry Power, Overview of Nigeria's power sector, www.power.gov.ng/index.php/conferences/finance-conference, 2013, 7.

[5] Federal Ministry of Power, Power statistics, www.power.gov.ng, 2015.

[6] P.I Obi., K.J. Offor and G.C. Chidolue, Reliable and efficient power supply in Nigeria through national integrated power projects and independent power projects: a case study of Onitsha Metropolis, International Journal of Advancement in Research & Technology (IJORAT), 2(5), 2013, 421–427

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Evaluation of heavy metal pollution in soils of Dana Steel limited dumpsite, Katsina State, Nigeria using Pollution load and degree of contamination indices.

S. Bello[1], Y.I Zakari[2], I.G.E Ibeanu[3] and B.G Muhammad[1]
[1]*Department of Physics,Umaru Musa Yaradua University Katsina. Katsina state, Nigeria*
[2]*Department of Physics,Ahmadu Bello University Zaria. Kaduna State, Nigeria.*
[3] *Center for energy research and training, Ahmadu Bello University Zaria. Kaduna State, Nigeria.*

***ABSTRACT**: Evaluation of heavy metals pollution level of the soils of Dana steel limited dumpsite located in latitude 12º 57¹ 43¹¹N to 12º 58¹ 7¹¹N, Longitude 7º 37¹11¹¹E to 7º 37¹ 16¹¹E and altitude 522.5m to 616.6m in Katsina state of Nigeria was carried out using contamination factor(CF), Pollution load index (PLI) and degree of contamination (DC) index. Soil samples were collected from the dumpsite and control site at depths ranges 0-<20cm,20- <40cm,40-<60cm and 60-<80cm.Flame Atomic Absorption spectroscopy (FAAS) was used to obtain the composition and concentration of the eight studied heavy metals (Zn, Cu, Cd, Co, Ni, Cr, Pb and As).The mean concentration (mg/kg) of the heavy metals in the dumpsite were 646.228, 175.278, 85.844, 15.022, 62.361, 1096.296, 0.564 and 202.100 for Zn, Cu, Ni, Cd, Co, Cr, As and Pb respectively. Statistical significant difference was observed between the mean of toxic metal concentration in the dumpsite and control area which suggested effect of anthropogenic inputs. The contamination factors, pollution load and degree of contamination indices were computed. the pollution load index revealed that the dumpsite was polluted with all the observed toxic metals(average PLI=2.113) and the degree of contamination index indicated that the dumpsite was in very high degree of contamination category (mean DC=30.624) which suggested that the dumpsite was seriously contaminated with all the observed heavy metals and the need for immediate implementation of remediation measures by the relevant authority to avert the consequences that it can pose on public health and environment.*
***KEY WORDS**: heavy metals, Pollution, PLI, DC, CF and FAAS*

I. INTRODUCTION

Pollution of the natural environment by the heavy metals is a universal problem because these metals are indestructible and most of them have toxic effects on living organisms when permissible concentration levels are exceeded (Mmolawa et al,2011).major environmental concern in the iron and steel industry in Nigeria is associated with the management of the industrial wastes generated in their different processes since it is becoming increasingly difficult for safe disposal of these volumes (Akinbinu,2010).human activity create wastes and it is the way this wastes are collected, handled, stored and disposed off that constitute risk to the public health and environment. the dumping of large amount of waste materials in sites without adequate soil protection measures results in soil surface and ground water pollution as well as degradation of abiotic and biotic components of the ecological systems (Namasivayam et al, 2001, Avwiri et al, 2011).the process of industrialization and continuous exploitation of earth resources for sustainable growth has depleted the non-renewable resources of the earth there by adversely affecting the environment. An integrated steel plant unit exhausts several harmful dusts, Fumes and substances that are quite injurious to human health, vegetation, crops, animals etc. such discharges contaminate and damage inland waters, environment, soil, food, human settlements and even plants and animals. therefore, these wastes cannot be left uncared for and that is why threshold limits for such harmful substances have been fixed and industries are required to adhere to these norms. Heavy metals through anthropogenic activities have been reported by various researchers (Onianwa and Fakayode, 2000; Martley et al, 2004; Kachenko and Singh, 2006; ngoc et al, 2009).the dumpsite studied is shown in plate1, the concentration of heavy metals in this dumpsite may be enhanced by bioaccumulation due to the presence of painted metals scraps and large volume of slags that were ubiquitous in the site.

The objective of the present work was to use Flame atomic absorption spectrophotometry to: (i) assess heavy metals concentration and contamination of environment by Zn, Cu, Cd, Cr, Pb, Co, As and Ni) using control soils obtained 3Km away from the dumpsite. (ii) Assess soil contamination of the dumpsite using contamination factor, pollution load index and degree of contamination index.

Plate 1: Dumpsite Studied showing the discarded waste generated by the steel rolling activity

II. MATERIALS AND METHODS

2.1 Study Area: (Description and sampling techniques)

Dana steel limited dumpsite is located in latitude 12^o 57^1 43^{11}N to 12^o 58^1 7^{11}N, Longitude 7^o 37^{1}11^{11}E to 7^o 37^1 16^{11}E and altitude 522.5m to 616.6m in Katsina state of Nigeria. The dumpsite was partitioned into nine (9) grid points labeled A-I. Soil samples were collected from each grid according to depth using hand auger. The depths were designated 1, 2, 3 and 4 which stands for 0- <20cm, 20- <40cm, 40-<60cm and 60-<80cm respectively. Nine (9) soil samples were collected from each depth making a total of 36 samples. Samples 1-9, 10-18, 19-27 and 28-36 were collected from depths 1, 2, 3 and 4 respectively. Control samples were collected at a distance 3Km away from the dumpsite. After removal of stones and some metal scraps, each soil sample was packed into its own secure water tight polythene bag to prevent cross contamination and was carried to laboratory for analysis.

2.2 Sample preparation and analysis

All soil samples were air-dried at ambient laboratory temperature. Soil samples were grounded using mortar and pestle and sieved to pass through 2 mm sieve and stored for chemical analysis. With the aid of spatula and weighing bottle, 0.5g of each soil sample was obtained. This was placed in a Teflon beaker and transferred to a fume-cupboard for digestion. The digestion was carried out using concentrated nitric (10mL) and concentrated perchloric (5 mL) acids in the ratio of 2:1 and the oven was maintained at 200 ^oC. After one hour, the mixture was allowed to cool before leaching the residue with 5 cm3 of 20% HNO3. Digested samples were then filtered and made up to 100 mL with deionized water. A blank determination was treated in the Atomic Absorption Spectrometer but without sample. Solution of samples were then taken and aspirated into Atomic Adsorption Spectrophotometer (Unicam Solar A.A.S 969 model) for analyzing metals. Blank determination was also carried out as in a similar way as described above except for the omission of the sample. A calibration graph was plotted for each element using measured absorbance and the corresponding concentration. The calibration curve was used to determine the concentration of the metal.

2.3 Assessment of heavy metal contamination

2.3.1 Contamination factor (CF)

Contamination factor (CF) is also called single pollution index (PI).Contamination factor is the quotient obtained by dividing the concentration of metals related to the target area by reference area. Their results are mostly associated with single pollution load, while their n-root was used for integrated pollution load index. The contamination factor can be calculated through the following formula as suggested by Harikumar et al. (2009).

$$CF = C_n/B_n \quad ....(1)$$

In the above equation, C_n is the concentration of metals in the target area, and B_n is the metals concentration of the reference area. CF is categorized as tabulated in table1

Table 1: Classification of contamination factor. Source: Hakanson, 1980

Contamination factor	Classification
CF<1	Low
1≤CF<3	Moderate
3≤CF<6	Considerable
CF≥6	Very high

2.3.2 Pollution load index

Pollution load index (PLI) is simple statistical technique used to determine elemental contents in soil beyond the reference concentration and provide comprehensive information about the metals toxicity in respective samples (Tomlinson et al. 1996; Yang et al.2011). Pollution load index can be determined through the following formula:

$$PLI = \sqrt[n]{CF_1 * CF_2 * CF_3 * \dots\dots\dots CF_n} \dots\dots\dots\dots\dots\dots (2)$$

Where PLI represents the pollution load index, CF is the contamination factor, and n is the number of elements. The PLI >1 indicates polluted, while PLI<1 indicates no pollution

2.3.3 Degree of contamination index

The degree of contamination (DC) of one determined area is the sum of all Contamination factors of the studied metals:

$$DC = \sum CF \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

The area is classified according to DC values as follows:

Table 2: Classification of degree of contamination. Source: Hakanson,1980

Degree of Contamination	Classification
DC<1	Low
1≤DC<3	Moderate
3≤DC<6	Considerable
DC≥6	Very high

III. RESULTS AND DISCUSSION

3.1 Heavy metals concentration in soils

Fig 1(a-h) presented the concentrations in (mg/kg) of the toxic metals analyzed (Zn, Cu, Ni, Cd, Co, As, Pb, Cr) in the dumpsite soil samples. Toxic metals were detected at varying concentrations in the samples except for Pb and Cr which were not detected in some samples due to the detection limit of the machine used. The mean and standard deviations of the concentrations(mg/kg) of Zn, Cu, Ni, Cd, Co, Cr, As and Pb in the dumpsite soil samples were 646.228±340.562, 175.278±206.622, 85.844±77.450, 15.022±7.314, 62.361±18.590, 1096.296±912.090, 0.564±0.081, 202.100±208.116 respectively. The Highest concentration corresponds to Cr and the lowest corresponds to As. The increasing trend was in the order: As <Cd <Co <Ni <Co <Pb <Zn <Cr. The mean concentrations of the toxic metals in the reference areas were 91.1±30.320, 11.9±3.994, 27.45±8.628, 12.6±1.657, 80.15±5.1, 800±0, 0.61±0.018 and N/d respectively. The concentrations of all the elements in the target area were found to be higher than that obtained in the control area with greater variation in relative abundance of most of the metals.

The obtained Average concentrations in the target and reference areas were compared with the results obtained by other researchers on the Industrial Sites .Ahmad et al, 2014 Analyzed heavy metals in spinach grown in waste water agricultural soil of Sargodha Pakistan. Rahib et al (2015) Analyzed heavy metal contents in soils of gadoon Amazai industrial Estate, Pakistan. Olayiwola, 2013 Analyzed heavy metal contents in steel rolling industrial Area of Ikirun, Osun State Nigeria while Boadu, 2014 studied heavy metals contaminations of soil and water at scrap market in Accra. Their results were presented in Table3. From the table we can see that the obtained average concentration (mg/kg) in this work corroborates with the results of those researchers. The High Cr and Co Concentration observed in this study corroborates with that obtained by Olayiwola, 2013.The Observed Concentration of Cd was in Line with that obtained by Rahib et al, 2015.The observed high concentration of Pb and Ni Corroborates with the result of Olayiwola,2013.Ahmad et al, 2014.Rahib et al, 2015. Cu and Zn concentrations were also in line with the results reported by Ahmad et al, 2014 and Rahib et al, 2015.

Table3:Comparison of present Study concentrations (mg/kg) with other national and international studies.

Cr	Cd	Pb	Ni	Cu	Zn	Co	As	References
1674	-	1387	495	-	-	267	-	Olayiwola,2013
475.5	1.0	205	46	185.7	555	-	-	Ahmad et al,2014
301.6	8.8	152	58	144.8	359.4	32.5	-	Rahib et al,2015
9.57-57.73	3.47-13.80	127.83-1392.67	6.47-62.53	226.80-6291.33	173.60-899.90	17.03-64.43	-	Boadu,2014
1096.296	15.022	202.100	85.844	175.278	646.228	62.361	0.564	This work(target area)
800	12.6	N/d	27.45	11.9	91.1	80.15	0.61	This Work(Control Area)

3.2 Contamination Factor, Degree of Contamination and Pollution Load Index

Table 5 presented the calculated contamination factors of the analyzed samples. the contamination factor was used to assess the level of contamination of each element in the studied soils, base on the categories discussed in chapter2, the elemental concentrations could be categorized as follows (i) As and Co in the low contamination category (ii) Cd in the moderate contamination category (iii) Ni in the considerable contamination category (iv)Zn and Cu in the very high contamination factor category.

Figure 2 and 3 presented the degree of contamination and pollution load index values plotted in a scatter plot. These indices were used to assess the overall pollution level of the site resulting from the observed metals. The pollution load index results indicated that the target area was contaminated with all the observed toxic metals (mean PLI=2.113) .The Results of the Degree of contamination index indicated that the target area is in very high degree of contamination category (Mean DC=30.624 which is greater than 4m (m=6)) base on the categories described in chapter2.

3.3 T-test

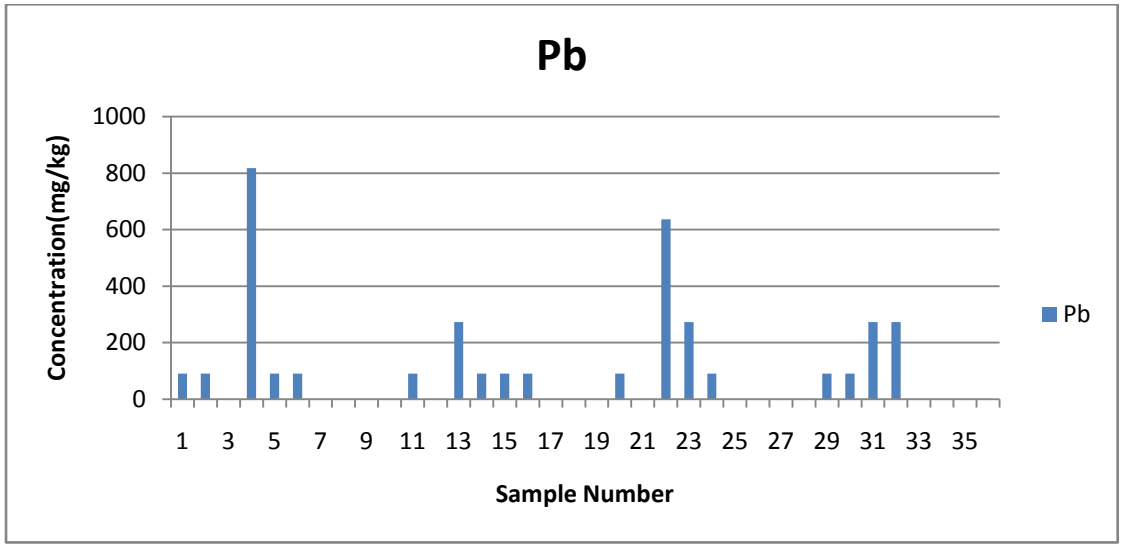
In order to understand the level of difference between the means at each depth of the observed toxic metals concentrations in the target and control area to ascertain the cause of the variation, the mean concentration(mg/kg) of each metal in the target and control area were analyzed using Microsoft excel 2007 T-test (Pair two samples for means) at $P<0.05$ significance (one-tail).the result of the test was displayed in table 4.The Results showed significant difference in the means of Zn, Cu, Ni, Co, As and Insignificant difference in respect of Cd. This suggested that all the significant toxic metals concentrations can be attributed to the industrial activity.

Table4: T-tests (Pair two sample for means) between toxic metals concentration in dumpsite soil and control site ($P<0.05$) one tail.

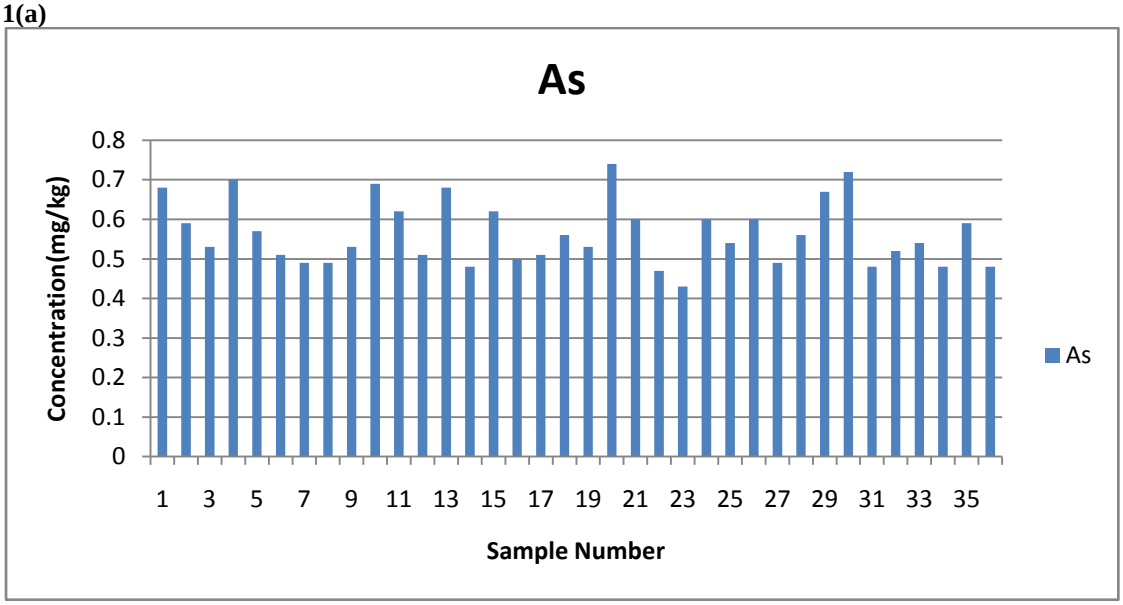
Toxic Met al	t-stat	P value	Level
Zn	-9.041	0.001	Significant
Cu	-10.657	0.0009	Significant
Ni	-6.951	0.003	Significant
Cd	-1.734	0.091	Not Significant
Co	5.995	0.005	Significant
As	-4.631	0.009	Significant

IV. CONCLUSION

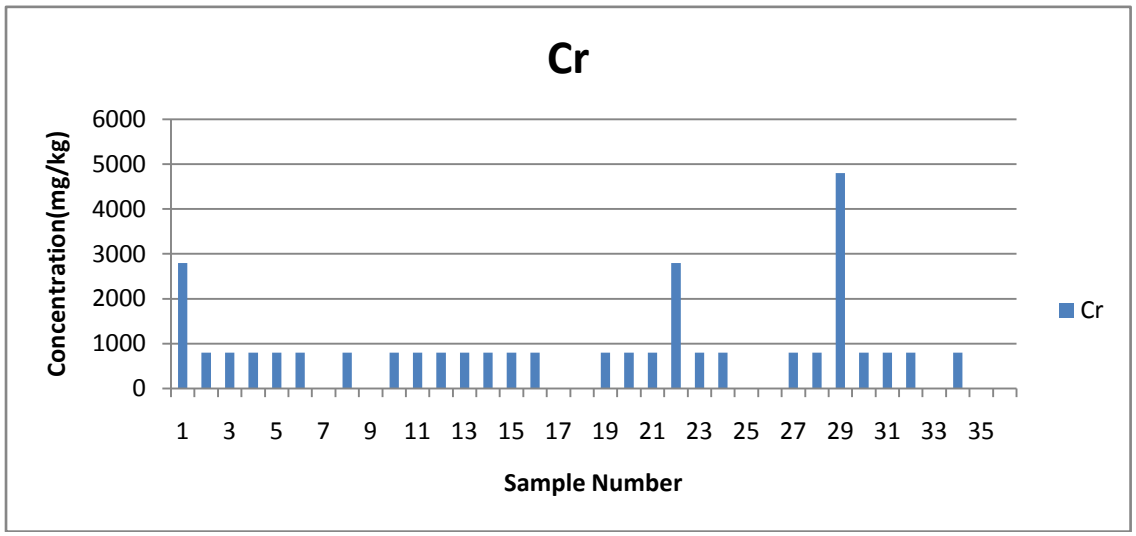
Soils samples have been collected from the Dana steel limited dumpsite in Katsina state and were analyzed for toxic metals' (Zn, Cu, Cd, Co, Ni, As, Pb and Cr) composition and concentration using flame atomic absorption spectrophotometry. The obtained concentrations (mg/kg) were used in computations of heavy metals hazard indices including contamination factors, pollution load index and degree of contamination index. On the basis of these indices, it has been established that the soils of Dana steel limited has been highly affected by depositions of heavy metals in the industry. These heavy metals can cause environmental problems in ecosystem of the area due to the release of toxic metals from the contaminated soil to the ground water system and also in the plants grown in the soil. This alarming situation should be regularly monitored for health related problems in the inhabitants of the area. It is therefore strongly recommended that Phyto and bio-remedial measures be considered by appropriate authorities in order to minimize the extent of accumulated pollutant loads.


Pb
Concentration(mg/kg)
1000
800
600
400
200
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Sample Number
Pb

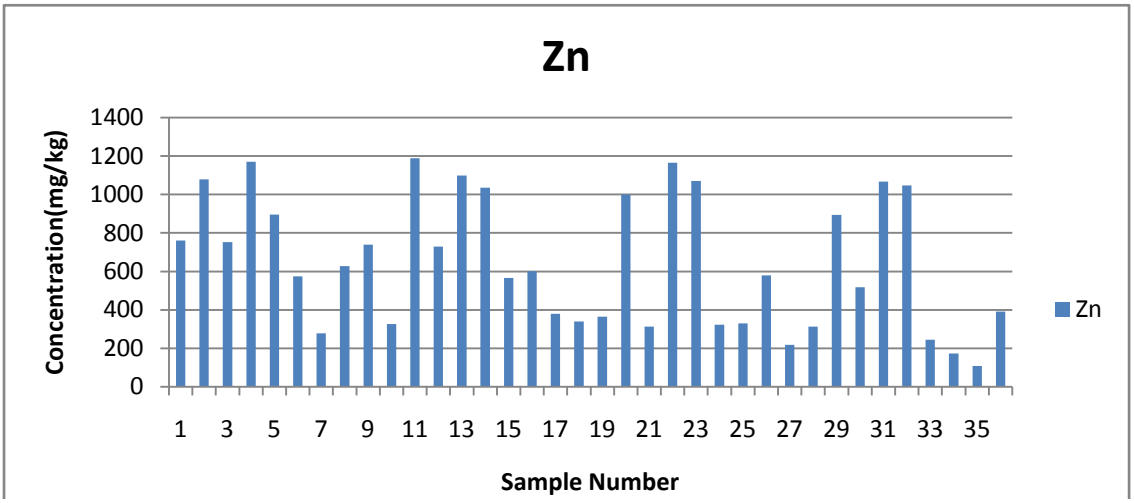
1(a)


As
Concentration(mg/kg)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Sample Number
As

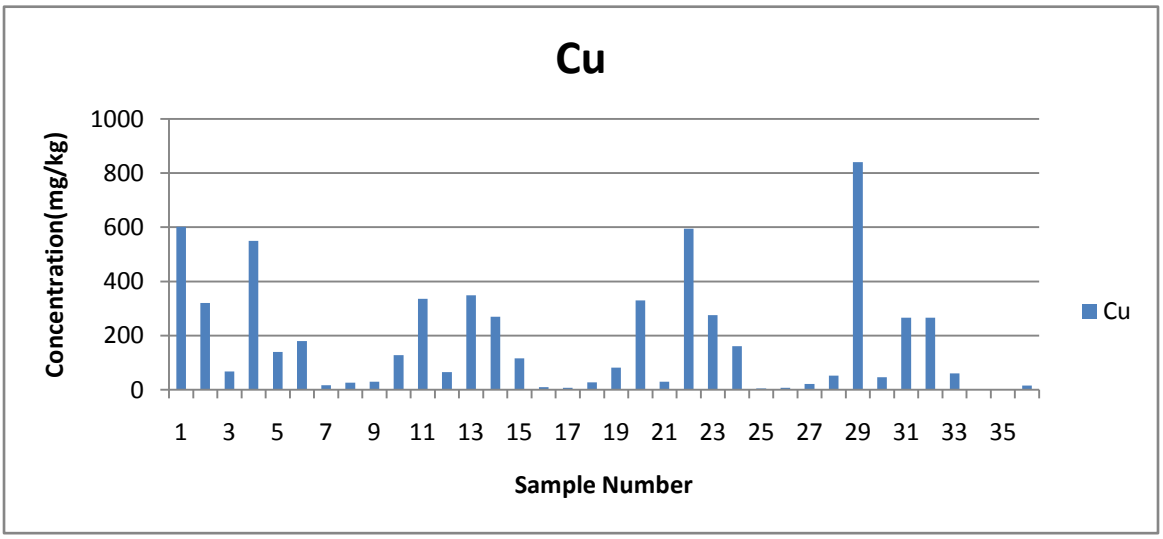
1(b)


Cr
Concentration(mg/kg)
6000
5000
4000
3000
2000
1000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Sample Number
Cr

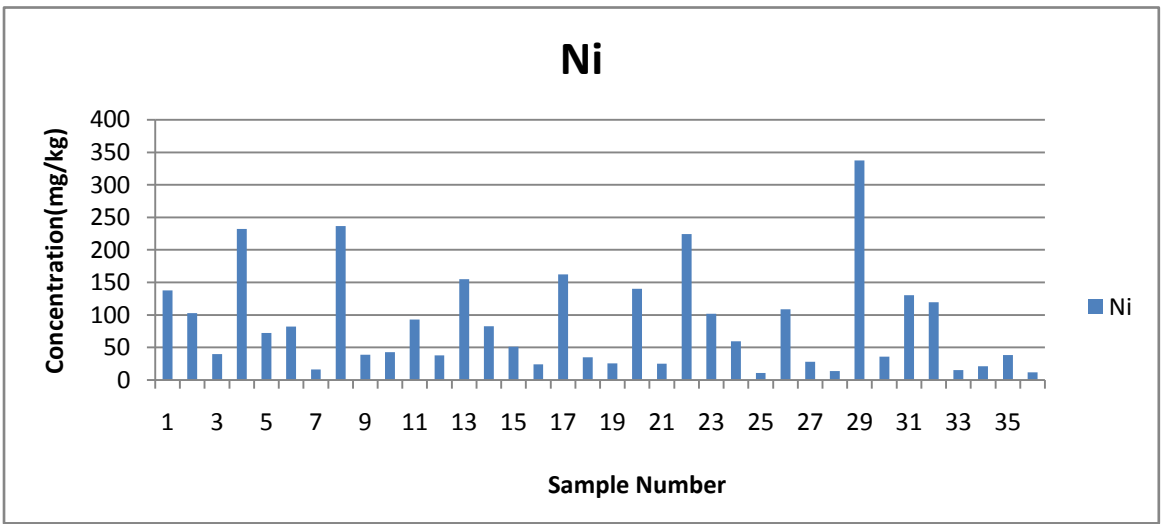
1(c)


Zn
Concentration(mg/kg)
1400
1200
1000
800
600
400
200
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Sample Number
Zn

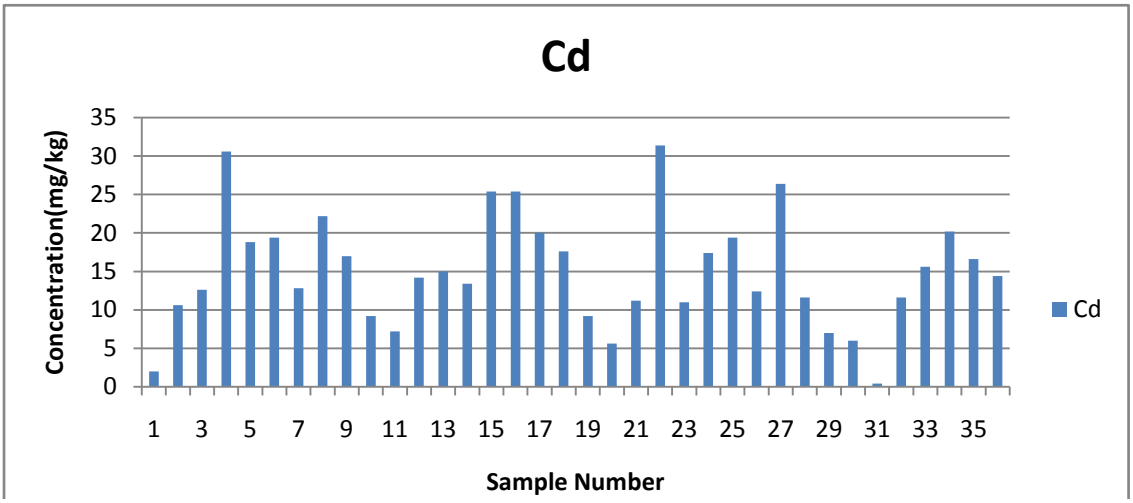
1(d)


Cu
Concentration(mg/kg)
1000
800
600
400
200
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Sample Number
Cu

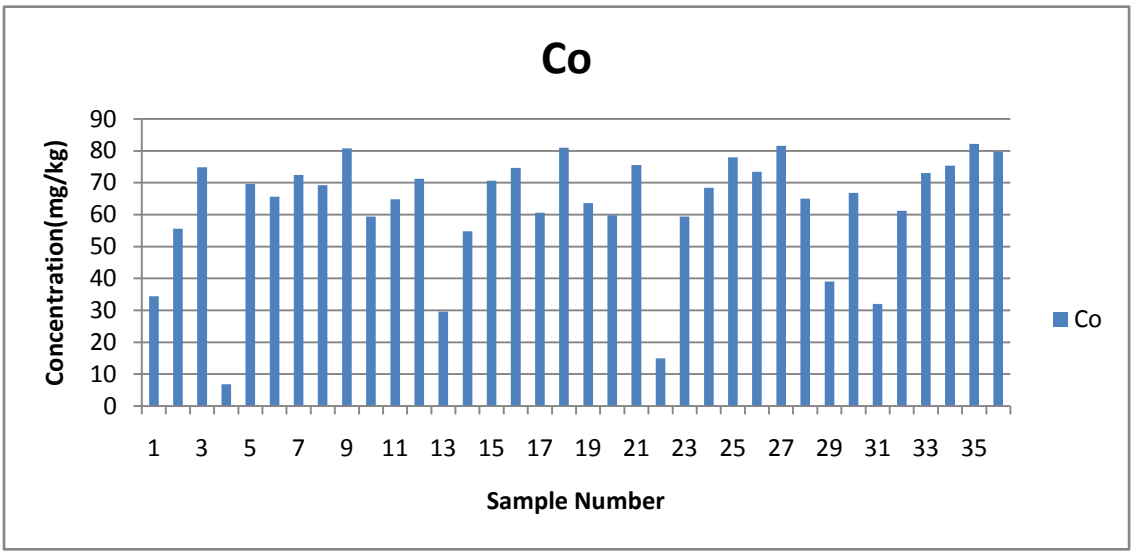
1(e)


Ni
Concentration(mg/kg)
400
350
300
250
200
150
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Sample Number
Ni

1(f)



1(g)



1(h)

Fig 1(a-h): Histogram representing the determined toxic metals concentration of the dumpsite Soil Samples (mg/kg)

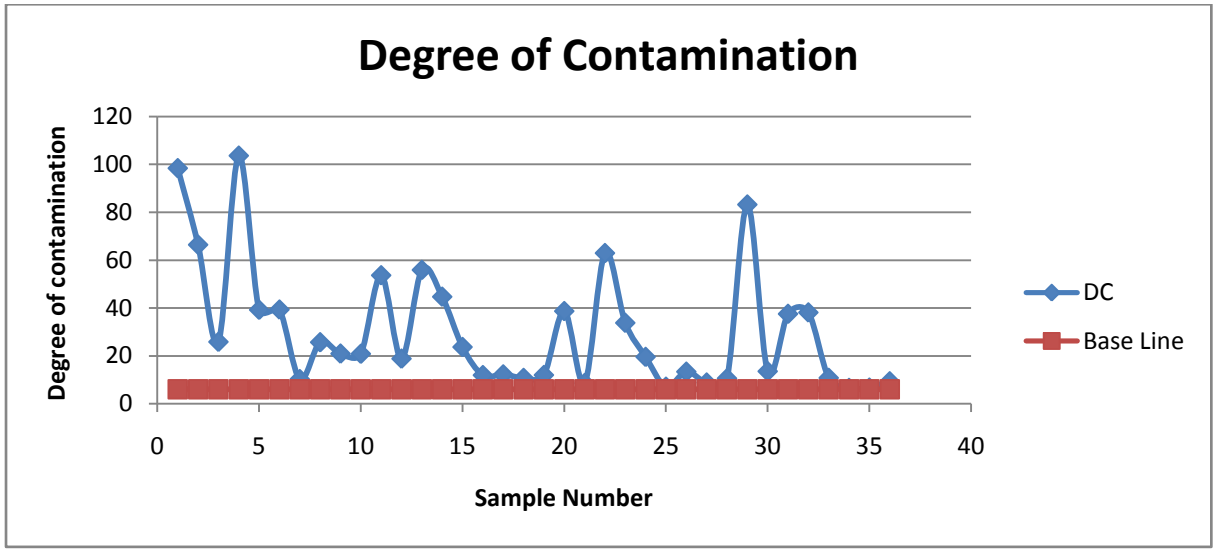


Fig2: A Scatter Plot showing the Degree of Contamination of the dumpsite soil samples

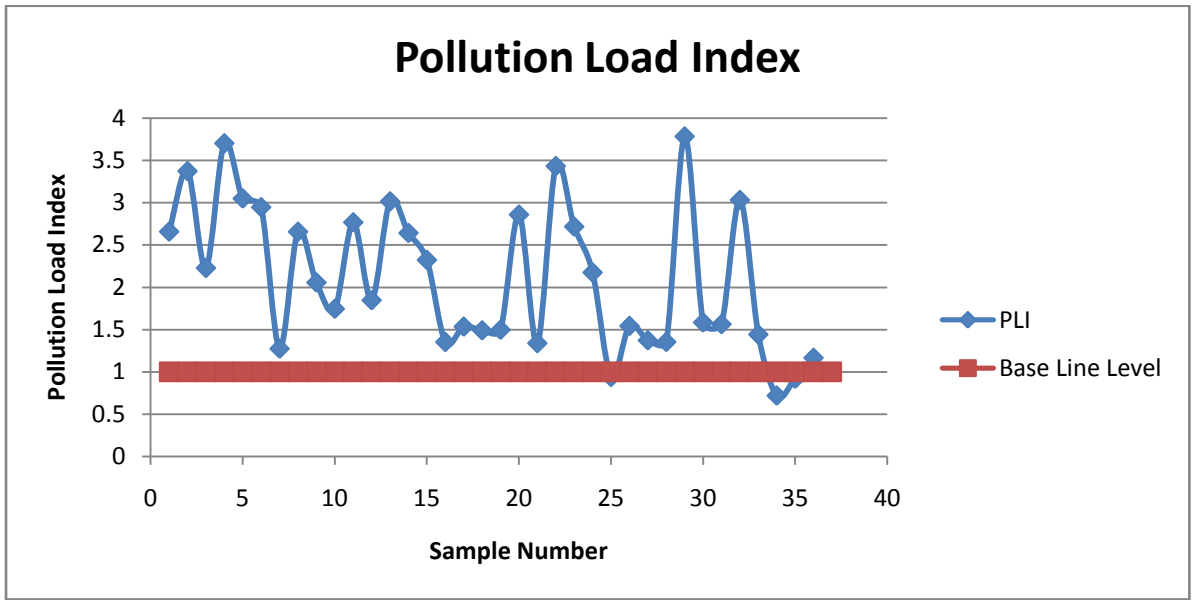


Fig3: A Scatter Plot showing the pollution Load Index of the determined toxic metals in the analyzed dumpsite soil samples.

Table5: Calculated contamination factors (CF) for some of the heavy metals analyzed in the dumpsite soil samples.

Depth	Sample No	CF(As)	CF(Zn)	CF(Cu)	CF(Ni)	CF(Cd)	CF(Co)
0-<20cm	1	1.097	12.772	79.158	4.825	0.154	0.427
	2	0.952	18.104	42.263	3.594	0.815	0.690
	3	0.855	12.638	9.026	1.392	0.969	0.928
	4	1.129	19.644	72.342	8.112	2.354	0.084
	5	0.919	15.030	18.421	2.524	1.446	0.864
	6	0.823	9.648	23.658	2.867	1.492	0.814
	7	0.790	4.671	2.316	0.559	0.985	0.898
	8	0.790	10.534	3.474	8.280	1.708	0.859
	9	0.855	12.389	3.974	1.364	1.308	1.002
	10	1.150	3.623	13.596	1.092	0.639	0.711

20-<40cm	11	1.033	13.186	35.766	2.378	0.500	0.775
	12	0.850	8.084	7.043	0.969	0.986	0.852
	13	1.133	12.184	37.213	3.959	1.042	0.354
	14	0.800	11.481	28.702	2.107	0.931	0.656
	15	1.033	6.275	12.426	1.306	1.764	0.844
	16	0.833	6.659	1.128	0.617	1.764	0.892
	17	0.850	4.204	0.872	4.143	1.389	0.725
	18	0.933	3.765	2.936	0.893	1.222	0.969
40-<60cm	19	0.898	2.761	5.382	1.245	0.885	0.761
	20	1.254	7.573	21.711	6.873	0.538	0.715
	21	1.017	2.365	1.974	1.235	1.077	0.904
	22	0.797	8.818	39.118	11.000	3.019	0.179
	23	0.729	8.091	18.184	4.980	1.058	0.711
	24	1.017	2.448	10.645	2.912	1.673	0.818
	25	0.915	2.487	0.329	0.520	1.865	0.933
	25	1.017	4.380	0.539	5.324	1.192	0.878
	27	0.831	1.654	1.434	1.363	2.538	0.976
60-<80cm	28	0.889	3.789	3.403	0.648	0.921	0.893
	29	1.063	10.842	54.610	15.620	0.556	0.536
	30	1.143	6.289	3.013	1.657	0.476	0.918
	31	0.762	12.959	17.273	6.046	0.032	0.440
	32	0.825	12.714	17.273	5.528	0.921	0.841
	33	0.857	2.968	3.961	0.713	1.238	1.003
	34	0.762	2.092	0.052	0.991	1.603	1.036
	35	0.937	1.313	0.182	1.778	1.317	1.129
	36	0.762	4.740	1.026	0.537	1.143	1.096

REFERENCES

[1] Ahmad K, Khan ZI, Ashfaq A, Ashraf M, Yasmin S (2014): Assessment of heavy metal and Metalloid Levels in Spinach(Spinacia Oleracea) grown in waste soil of Sarghoda ,Pakistan . *Pak J Bot* 46(5):1805-1810.

[2] Akinbinu,V. A. (2010).Preliminary Investigation into Utilization of Wastes from Iron and Steel Industries in Nigeria as Fine Aggregate Replacement in Concrete Application. *Journal of Solid Waste Technology and Management.*

[3] Avwin, G. O, Olatubosin, S.A: Assessment of the Environmental radioactivity in selected dumpsites in Port Harcourt, Rivers State Nigeria. *International Journal of Scientific and Technology research.* vol. 3, Issue 4, April 2014.

[4] Boadu Theophilus Marfo, Heavy Metals Contaminations of soil and water at Agbogbloshie Scrap Market, Accra, Unpublished Thesis. Kwame Nkrumah University of Science and technology. M.Sc Thesis May, 2014.

[5] Hakanson I., (1980): Ecological risk index for aquatic pollution control, a sedimentological Approach. *Water resources*,14; 975-1001.

[6] Harikumar P.S, U. P Nasir and M. P. Mujeebu Rahma "Distribution of heavy metals in the core sediments of a tropical wetland system "*International Journal of Environmental Science Technology*, Vol. 6, No. 2, 2009, pp.225-232.

[7] Kachenko, A.G. and B. Singh, 2006.Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia". *Water Air Soil Pollution*, 169: 101-123.

[8] Martley,E., B.L. Gulson and H.R. Pfeifer, 2004. Metal concentrations in soils around the copper smelter and surrounding industrial complex of Port Kembla, NSW, Australia. *Science of Total Environment*, 325: 113-127 Merrington.

[9] Mmolawa K. B., Likuku A. S. and Gaboutioeloe G. K. (2011): Assessment of heavy metal pollution in soils along major roadside areas in Botswana. *African Journal of Environmental Science and Technology*, Vol 5 (3), pp. 186-196.

[10] Namasivayam C., Radhika R., and Suba S. (2001) ―Uptake of dyes by a promising locally available agricultural solid waste. *Waste Management* 21, 381-387.

[11] Olayiwola Olajumoke Abidemi, Accumulation and contamination of heavy metals in soils and Vegetation from industrial Area of Ikirun, Osun state, Nigeria, *Global Journal of Pure and Applied Chemistry Research* Vol.1 Issue No.1 pp.25-34, June, 2013.

[12] Onianwa, P.C. and S.O. Fakayode, 2000. Lead contamination of topsoil and vegetation in the vicinity of battery factory in Nigeria. *Environ. Geochemistry Health*, 22: 211-218.

[13] Rahib Hussain, Seema A. Khattak,Muhammad Tahir Shah,Liaqat Ali (2015): Multistatistical Approaches for Environmental geochemical Assessment of pollutants in soils of gadoon Amazai Industrial Estate, Pakistan. *J soils Sediments* (2015) 15:1119-1129.

[14] Tomlinson D. L., Wilson J. G., Harris C. R and Jeffrey D. W (1980): Problems in the Assessment of heavy metal levels in estuaries and the formation of pollution index, *Helgol. Wiss. Meeresonters*, Vol. 33 PP 566 - 572 .

[15] Yang YB, Sun LB. 2009.Status and control countermeasures of heavy metal pollution in urban soil. *Environmental protection Science*, 35(4): 79-81.

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An adaptive model predictive controller for turbofan engines

Xian Du*, Yingqing Guo, Hao Sun
Northwestern Polytechnical University, Xi'an 710072, PR China

ABSTRACT: *An adaptive model predictive controller of turbofan engines that can transfer working states within a certain flight envelope was proposed. Due to a very wide range of flight and operation conditions for turbofan engines, a series of model predictive controllers should be well established and arranged. First, constrained linear model predictive control algorithm is investigated and a number of model predictive controllers were designed based on linear models at different nominal points. Then, control domain in the flight envelope was divided according to the inlet parameters of aero-engines, and the nominal points were determined in all subsections. Finally, an adaptive predictive controller was achieved using a multilayer parameters scheduling scheme, which possesses the ability to realize the regulation of engines under different flight and working conditions. Simulation results show that the proposed adaptive predictive control system displays good performances in the control domain, which provides an effective approach for the design of the whole envelope controller.*

Keywords - *Turbofan engine, transition state, adaptive model predictive control, flight envelope, parameters scheduling*

I. INTRODUCTION

In the process of aero-engine control, input and output variables are subject to all kinds of physical and operational limits [1-3]. For example, a fuel flow metering valve, as one of the actuators, cannot deal with too fast of a fuel flow rate fluctuation arbitrarily due to mechanical or hydraulic limit; and the controlled output rotor speeds or exhaust temperature cannot exceed their limits for security reasons. In addition, a variety of sensors are also limited due to their measuring range, therefore, an unconstrained control system cannot exist. Not only limit management, but also good dynamic response is a critical element in the aero-engine control [4]. With the increasing complexity and improved performance of aero-engines, commercial and military aircraft put forward higher requirements on the control of the propulsion system, where advanced control method is the main way to face this challenge [5]. Model predictive control (MPC) is a kind of advanced closed-loop optimization strategy, which has the ability to process all kinds of constraints directly and conveniently [6-7], and be more powerful than traditional PID control method [8].

In general, predictive controller could adapt to a wide range of disturbances and achieve good control performance, even in the case of a model mismatch [9]. For aero-engines, which are nonlinear complex systems, it is difficult to ensure that a predictive controller can achieve satisfactory dynamic response in the full flight envelope. Specifically, taking a predictive controller based on a fixed linear engine model as an example, a series of simulations are conducted in the entire flight envelope at step inputs. The results showed that the system is stable with no steady-state error in any sections and is able to meet the control requirements. While in some parts, there exist large overshoot, frequent oscillations, and even instability during the transitions, which is beyond the scope of performance requirements [10].

In this paper, a multilayer parameter scheduling scheme is proposed to design an adaptive model predictive controller for a commercial turbofan engine. The rest of the paper is organized as follows. Section II introduces the mathematical models of the turbofan engine and the design of model predictive controllers at nominal points. The regional divisions about the control domain in the envelope are established in Section III. Section IV investigates the multilayer parameters scheduling scheme to construct an adaptive model predictive controller. Section V discusses the model predictive controller design for acceleration/deceleration transition state and analyzes the simulation results. The conclusions are summarized in Section VI.

II. Model Predictive Controller Design at Nominal Points

For a certain type of high bypass commercial turbofan engine, the literature [11] realizes the usage of a packaged component level nonlinear dynamic model in Matlab/Simulink platform via dynamic link library technology, which was originally constructed and tested perfectly in the GasTurb software. To design model predictive controllers at nominal points, linear engine models are obtained using the fitting method at given flight conditions and working states. Note that the final adaptive model predictive controller based on multilayer parameters scheduling scheme is tested in the nonlinear component level engine model, although a series of linearized models are prepared for model predictive control designs.

The purpose of an aero-engines control system is to provide required thrust by changing fuel flow according to throttle positions [1]. However, in practice, thrust cannot be sensed and therefore cannot be controlled directly. Generally, speeds or engine pressure (EPR) is used as the indicator of thrust. In this paper, the control objective is to track fan speed setpoints while considering input and output constraints. Therefore, discrete single-input state space based linear models of the engine can be expressed as:

$$\begin{cases} x(k+1) = Ax(k) + Bu(k) \\ y(k) = Cx(k) + Du(k) \end{cases} \tag{1}$$

where $x = \left[\Delta N_f \quad \Delta N_c\right]^T$, $u = \Delta W_f$, $y = [\Delta N_f \quad \Delta T_{45} \quad \Delta smHPC]^T$. The control variable is the deviations of fuel flow (W_f) in kg/s from the steady state, state variables are the deviations of fan speed N_f and core speed N_c in r/min. Three output variables are considered here, where fan speed is used for tracking and the other two output variables (high pressure compressor outlet temperature ΔT_{45} in $^\circ$R and high pressure compressor stall margin $\Delta smHPC$ in %) are regarded as limited outputs. The values of matrices A, B, C and D are different corresponding to different flight conditions (e.g. flight altitude H and Mach number Ma) and working states (expressed as a percentage of the max cruise speed or fan speed N_f).

Model predictive control algorithm consists of three parts [9]: predictive model, receding horizon optimization and feedback emendation. Eq.(1) is utilized as the predictive model. The cost function of the optimization section is defined as follows:

$$\begin{aligned} J &= \sum_{i=1}^{i=n_y} e(k+i)^T e(k+i) + \lambda \sum_{i=0}^{n_u-1} \Delta u(k+i)^T \Delta u(k+i) \\ s.t. \quad & U\min \le u(k+i) \le U\max \qquad i = 0,1..n_u - 1 \\ & Y\min \le y(k+i) \le Y\max \qquad i = 1,...n_y \end{aligned} \tag{2}$$

where $e(k+i) = r(k+i) - y(k+i)$. $r(k+i)$ is the reference value. $y(k+i)$ and $\Delta u(k+i)$ are the predicted outputs and inputs in the future i time steps respectively. $U\max$, $U\min$ represent the maximum and minimum input constraints. $Y\min$, $Y\max$ indicate the output constraints. n_u and n_y are control horizon and prediction horizon respectively. $\lambda > 0$, is the control variable weight. As for feedback emendation, a simple method that correct the reference values according to the errors between the actual N_f output and the predicted N_f output at every sampling time is used, which can be defined as:

$$\delta(k+1) = q \times (N_f - \hat{N}_f) \tag{3}$$

where q is the correction factor, which can be adjusted by trial-and-try.

Conveniently, graphical user interface (GUI) design toolbox in MATLAB/Simulink can be used to design model predictive controllers at nominal points. Key parameters mentioned above are included in the Graphical design interface. According to the influences of each parameter on the system, appropriate values can be finally tuned based on simulation results at nominal points for these model predictive controllers.

III. Divisions of the Control Domain and the Selection of Nominal Points

It is supposed that the control domain, part of the entire flight envelope, considered in this paper is shown in Fig.1.

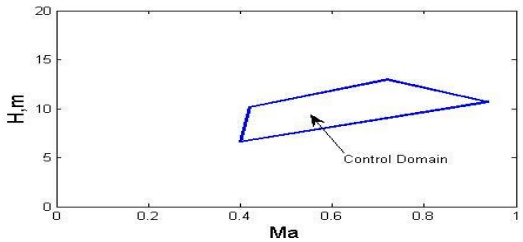

Fig.1 Control domain

Although MPC has good robustness, simulation results show that one predictive controller alone cannot satisfy the requirements of dynamic performance for the turbofan engine in the entire control domain, as shown in Fig.2, where the nominal point is H=11km, Ma=0.8, and power=100%.

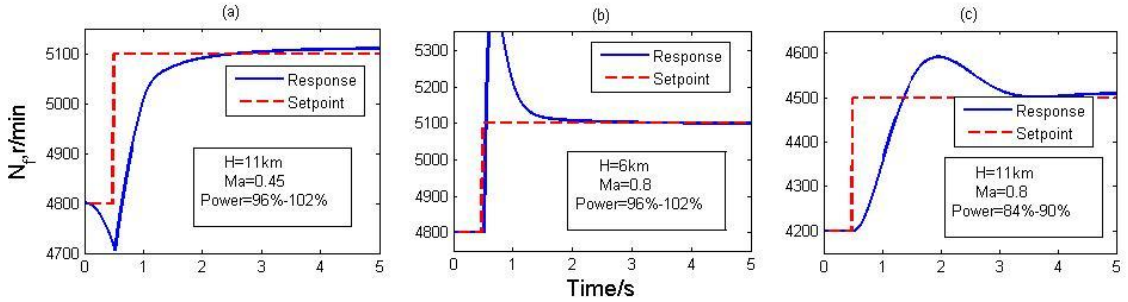

Fig. 2 N_f response at non-nominal points

Fig. 2(a) shows that the response speed is too slow when Ma is far from its nominal point; Fig. 2(b) represents that the overshoot is too large when H is off its nominal point; and bad dynamic response appears when working state is off its nominal point, as shown in Fig. 2(c). After all, model predictive controllers are designed based on small deviation linear dynamic models, which are only applicable to small areas around nominal points for better dynamic response. In order to obtain better control effects, the control domain should be divided into subsections and a reasonable nominal point is to be picked out for each subsection. In this way, a series of model predictive controllers can be designed for subsections, ensuring the performance requirements in the whole control domain.

In this paper, the control domain is divided according to the relative variation of aero-engine inlet parameters [12]. For the given fuel flow supply and the fixed nozzle area, the fan speed and the turbine expansion ratio, as well as other engine outputs are a function of only the flight altitude H and Mach number Ma. Furthermore, if the inlet of the turbofan engine is determined, the total temperature $T1$ and total pressure $P1$ of inlet are a function of H and Ma, as presented in Eqs.(4) and (5). Therefore, it can be concluded that the small deviation linear state space models are closely related to parameters $P1$ and $T1$.

When H≤11km, there exists:

$$\begin{cases} T1 = (288.15 - 6.5 \times H) \times (1 + 0.2 \times Ma^2) - 273 \\ P1 = 1.03323 \times (1 - \dfrac{H}{44.3})^{5.2553} \times (1 + 0.2 \times Ma^2)^{3.5} \end{cases} \tag{4}$$

When H>11km, there exists

$$\begin{cases} T1 = 216.6 \times (1 + 0.2 \times Ma^2) - 273 \\ P1 = 0.2314 \times e^{(\frac{11-H}{6.318})} \times (1 + 0.2 \times Ma^2)^{3.5} \end{cases} \tag{5}$$

If the sensed parameters $T1$ and $P1$ change within a certain small range, it is assumed that a model predictive controller can be used to regulate this subsection. So the selection rules J for subsection divisions can be defined as:

$$J = \sqrt{(\frac{P1_x - P1_0}{P1_0})^2 + (\frac{T1_x - T1_0}{T1_0})^2} \le \varepsilon \tag{6}$$

where $P1_0$, $T1_0$ are the inlet total pressure and temperature at nominal points respectively, $P1_x$, $T1_x$ are the inlet total pressure and temperature at a given place in this control domain, and ε is the acceptable range from nominal points.

Simulation results show that when $\varepsilon \le 0.2$, good dynamic and static performance can be achieved within the subsection by one controller that was designed based on nominal points. Here, ε is selected as $\varepsilon = 0.2$ and nominal points should be chosen so that their subsections can cover the entire control domain. Through continuous attempts, three nominal points in the control domain are finally selected as (H=11km, Ma=0.8), (H=11.7km, Ma=0.65) and (H=9.5km, Ma=0.75), as pointed out by "*" in Fig.3. Different colors in Fig.3 represent different subsections. It can be seen that the predictive controller designed at these three nominal points can cover the entire control domain.

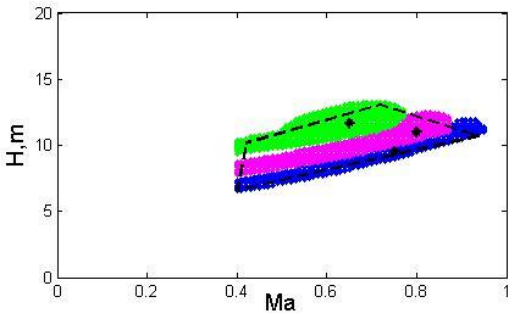

Fig. 3 Nominal points and subsections

In addition, if the control domain is extended to the whole flight envelope, the method for regional divisions and nominal point selections is the same, but a few more nominal points must be chosen to cover the full envelope, which increases the workload. In this paper, we just take a part of the whole envelope, known as control domain, for example.

IV. MULTILAYER PARAMETERS SCHEDULING SCHEME

In this paper, an adaptive predictive controller is designed to realize the control of the turbofan engine that work from 80% to105% speed changes in the entire control domain (*H*, *Ma*) of Fig.1.

Take three speed nominal points 85%, 93% and 100% for example, covering the 80%-105% working states. Considering the fact that there are three flight nominal points in the control domain in Fig.3, a total of $3 \times 3 = 9$ nominal points need to be included under different working states and flight conditions, as listed in Table 1.

Table.1 Different Nominal Points (NP)

NP	Power	Speed (r/min)	*H* (km)	*Ma*
1	85%	4250	9.5	0.75
2	85%	4250	11	0.8
3	85%	4250	11.7	0.65
4	93%	4650	9.5	0.75
5	93%	4650	11	0.8
6	93%	4650	11.7	0.65
7	100%	5000	9.5	0.75
8	100%	5000	11	0.8
9	100%	5000	11.7	0.65

A multilayer parameters scheduling scheme is proposed to design the adaptive predictive controller, as shown in Fig. 4.

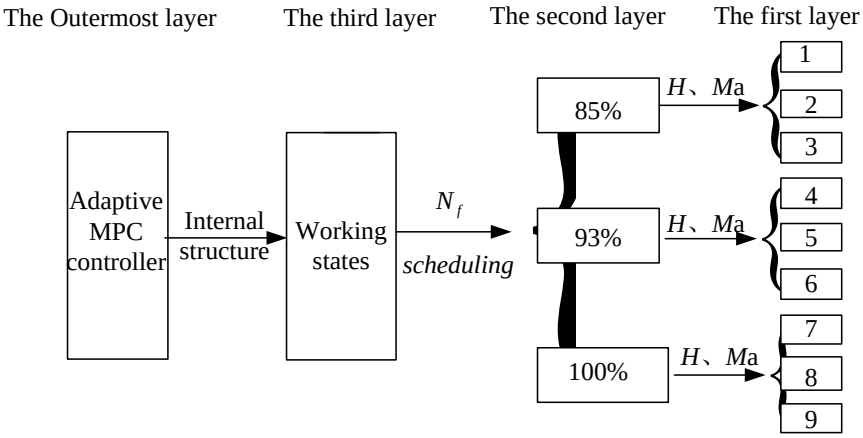

Fig. 4 The principle diagram of the multilayer structure

In the first layer, the 9 predictive controllers are designed based on 9 different working states and flight conditions, where numbers 1 to 9 correspond to the 9 different nominal points in Table 1. As mentioned in Section II, each MPC controller in this layer can only control the working states and flight conditions around the nominal speeds and nominal flight points.

There are three MPC controllers in the second layer, each of which can achieve the management of the entire control domain around a certain nominal speed state. Every MPC controller in the second layer dispatches the three corresponding controllers in the first layer according to the flight altitude H and Mach number Ma, which has been discussed in Section III.

The MPC controller in the third layer owns the ability to realize the objective that the turbofan engine can operate randomly during 80%-105% working states in the entire control domain. The fan speed N_f is used as the scheduling variable to regulate the MPC controllers in the second layer (detailed descriptions will be followed later). Therefore, the MPC controller in the third layer can govern all the 9 controllers in the first layer. In this multilayer format, the design of an adaptive model predictive controller is accomplished, being able to realize the scheduling process based on the working states being expressed as N_f , and the flight conditions expressed as H and Ma at that point in time.

The outermost layer is the external structure of the third layer, which has the purpose of making the adaptive predictive controller intuitive and clear. The inputs of the outermost layer is composed of fan speed N_f , the driver's instruction (the percentage of the speed), the flight attitude H, as well as the Mach number Ma, and the output is the main fuel flow W_f.

Now we turn our attention to the principle of the third layer as it relates to how the fan speed N_f is utilized as the scheduling parameter variable. A set of linear MPC controllers are obtained based on different speed nominal points, and the switching problem between two adjacent MPC controllers at speed nominal points need to be studied to ensure the smooth transitions. From Table 1, it is obvious that working states (expressed as a percentage of the max cruise speed) correspond to a fixed physical speed at steady state. Therefore, the fan speed N_f can be chosen as the scheduling variable. For any working state between k and k+1, two nominal points, the output value of the adaptive predictive controller (fuel flow) is obtained by interpolation of the output values of the MPC controllers based on the k and k+1 nominal points. In other words, N_f is used to describe the current fan speed, whereas N_{fk} and $N_{f(k+1)}$ indicate the steady-state speed corresponding to the k and k+1 nominal points. Control variables W_{fk} and $W_{f(k+1)}$ are the control values corresponding to the k and k+1 nominal points. Suppose that the inequalities $N_{fk} \le N_f \le N_{f(k+1)}$ hold, then the final output value u_{cmd} of the adaptive predictive controller can be defined as:

$$u_{cmd} = W_{fk} + \frac{N_f - N_{fk}}{N_{f(k+1)} - N_{fk}} \times (W_{f(k+1)} - W_{fk}) \tag{7}$$

Next, simulations are studied to verify the effectiveness of the proposed adaptive model predictive controller. The controller is connected with the packaged nonlinear component level engine model in the Matlab/Simulink platform.

The control objective here is to maintain the working states, regardless of the changes in the flight conditions. In this example, the desired working state is 90% (N_f equals 4500r/min), and the flight conditions (H, Ma) changes frequently with time, as shown in Fig. 5. In this situation, the changes of flight conditions can also be regarded as disturbances applied to the system. The input and output dynamic responses are then displayed in Fig.5.

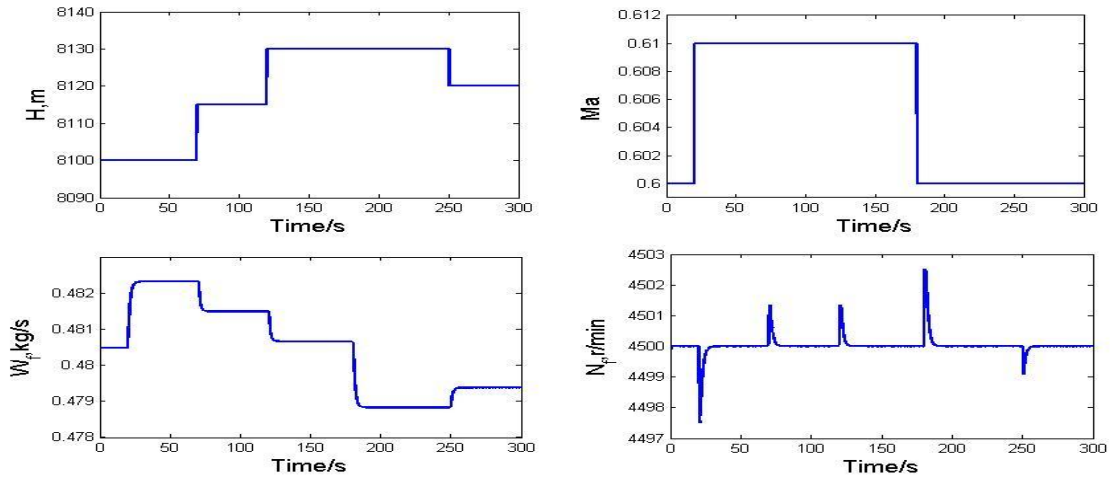

Fig. 5 Input and output response with flight conditions changes

In Fig.5, it is observed that when flight conditions change, the regulated output N_f can be restored to the original setpoint in a very short time with minor deviations, which indicates that the MPC controller can deal with flight disturbances in an effective manner during the steady state. Similarly, for other desired N_f constant values, it can be validated that the control effects under small disturbances are consistent with good disturbance rejection.

V. DESIGN FOR ACCELERATION AND DECELERATION TRANSITION STATE

The controller design of transition state accounts for a large part of aero-engine control system. During the transition state, a variety of limits should be considered to ensure the safe operation of aero-engines, such as speeds limits, temperature limits, compressor stall margin limits and both acceleration and deceleration limits. In this paper, only the acceleration and deceleration design for transition state is considered, which is based on schedule scheme [1].

This method involves the acceleration and deceleration schedule. In other words, the idea of an acceleration schedule is to limit the maximum change rate of fuel flow WFM. On the contrary, the deceleration schedule control is to limit the minimum change rate of fuel flow WFM. Unlike traditional transition controls (e.g. PID controller) where anti-windup (IWU) must be taken into account, MPC is well-known as a good way to deal with input constraints directly within the process of optimizations. However, such constraints are not included in the conventional control algorithms, which cannot produce a control input that breaks away from constraints to overcome the "IWU" phenomenon. Therefore, for the adaptive MPC controller, there is no need to consider the "IWU" problem during the transition state.

Suppose the maximum limit of the W_f change rate is 0.35kg/s for the acceleration schedule and the minimum limit is -0.25kg/s for deceleration schedule based on the equilibrium values at steady state. In addition, output limits, $\Delta T_{45} \le 600K$ and $\Delta smHPC \ge -20\%$ are also taken into account during the transition state. These constraints are then added to the adaptive MPC controller designed in Section IV. The acceleration and deceleration simulations of transition state are then carried out to realize the working states transfers for a large range from 80% to 105% (N_f, 4200r/min-5200r/min), as shown in Fig.6.

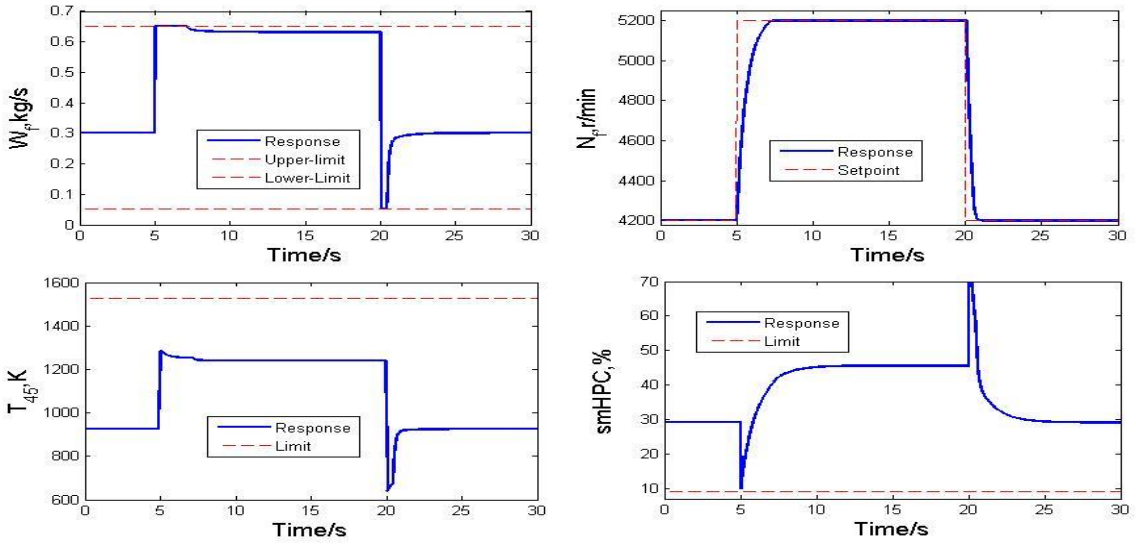

Fig. 6 Response during transition state

As seen in Fig.6, acceleration and deceleration schedules play an important role in the process of transition state changes, where the maximum increments are limited to 0.35kg/s and the minimum increments are limited to -0.25kg/s compared with equilibrium values at steady state. It is shown that N_f can track the setpoints with good dynamic performance. In addition, the steady-state adaptive MPC controller operates in the first 0s-5s, then the acceleration schedule works during 5s-7s, followed by the steady-state controller working during 7s-20s, and then the deceleration schedule takes over to work in 20s-21s, with the steady-state controller working again at the end. It is also observed that the change values of limited outputs, ΔT_{45} and $\Delta smHPC$, are within their limits during the transition state.

The simulation results show that the designed adaptive MPC controller meets the performance requirements of both the steady state and the transition state processes. Therefore, it is feasible for the adaptive MPC controller to be applied into turbofan engines.

VI. CONCLUSIONS

An adaptive model predictive controller based on multilayer scheduling scheme was designed and tested with nonlinear component level turbofan engine model, which can drive the engine to operate randomly under the working states from 80% to 105% in the entire control domain. Acceleration and deceleration schedules are realized by adding input constraints to the control system. In addition, the output constraints can also be considered in the adaptive MPC controller. Although the control domain considered in this paper is just a section of the full flight envelope, the method to divide the entire envelope is the same, and so it is easy to extend the controller to realize the control in the whole flight envelope. For the similar reason, wider working states can also be achieved using the multilayer parameters scheduling scheme. Therefore, the method proposed in this paper gives instructions for the controller design involving the whole working states and the entire flight envelope.

REFERENCES

[1] L. C.Jaw, J. D.Mattingly, Aircraft Engine Controls Design, System Analysis and Health Monitoring. *Reston: AIAA*, 2009: 96 – 100.

[2] J. Csank, R. D. May, J. S. Litt, and T. H. Guo: *Control design for a generic commercial aircraft engine, AIAA* 2010-6629.

[3] H. Richter: *Advanced control of turbofan engines*. Springer New York, 2012, pp. 203-250.

[4] Thompson, J. Hacker, C. Cao. *Adaptive engine control in the presence of output limits, AIAA* 2010-3492.

[5] G. Nathan. *Intelligent engine systems—Adaptive Control. NASA/*CR-2008-215240

[6] H.X. Qiao, S. Q. Fan, L. Yang. Constrained predictive control based on state space model of aero-engine. *Journal of Propulsion technology, 26(6) , 2005*, 548-551.

[7] X. Du, Y.Q. Guo, X.L. Chen. Multivariable constrained predictive control and its application to a commercial turbofan engine. *Advanced Materials Research*, V*ol.909*, 2014, 281-287.

[8] X. Du, Y.Q. Guo, X.L. Chen. MPC based active fault tolerant control of a commercial turbofan engine. *Journal of Propulsion Technology, 36(8),* 2015, 1242-1247

[9] J. X. Qian, J. Zhao, Z. H. *Xu. Predictive Control.* Beijing: Chemical Industry Press, 2007.

[10] H. X. Qiao, S. Q. Fan. Predictive control of aero-engine with model mismatching. *Journal of Propulsion technology*, 27 (5), 2006, 455-458.

[11] S. G. Zhang, Y.Q. Guo, J. Lu. Component level model of Aero-engine based on GasTurb / MATLAB and its Implementation. *Journal of Aerospace Power, 35(2),* 2014, 381-390.

[12] H.Q Wang, Y.Q. Guo. Design of Full Flight Envelop Controller for Aero-Engine. *Measurement and control technology*, 28(5), 2009, 48-51.