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Evaluating the Impact of Maintenance Principles and Strategies of a Steel Plant Performance in Nigeria: A Case Study

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ABSTRACT: *This study evaluated the impact of maintenance principles and strategies on the performance of machines and equipment used atAladja steel plant formally known as Delta Steel Company (DSC) now Premium Steel and Mines Limited in Nigeria. The study assesses the impact of maintenance on the output of steel production machines and equipment using the Overall Equipment Effectiveness (OEE) metric which provided holistic measures of manufacturing machines and equipment's overall operational performance. The OEE of the plant was evaluated as 39.76% before the implementation of a major scheduled preventive maintenance initiative and after successful implementation of the scheduled turn-around maintenance program, the computed OEE increased up to 51.22%. The increase in OEE score from 39.76% to 51.22% is a true measure of increase in machines and equipment performance that is as a result of the implemented maintenance initiative.The improved plant OEE of 51.22% is still far below the world class OEE value of 85% which means there is a lot of room for further improvement for machines and equipment utilization and performance. The research revealed that to get higher OEE which means improved productivity, the type of maintenance strategy that is implemented plays significant role in machines and equipment performance. The study recommends amongst others that the organization should consider full implementation of modern maintenance principles and strategies like Total Productive Maintenance (TPM), Condition Based Maintenance (CBM) and Reliability Centre Maintenance (RCM) to gain OEE's benefit.*

KEYWORDS: *Maintenance, Principles, Strategies, productivity,Overall Equipment Effectiveness,*

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I. INTRODUCTION

The steel industry is described as the bedrock of industrial growth of any nation. It is so important to the development of any nation that every country endeavours to acquire and take control of the iron and steel sector. A functional steel industry will contribute immensely to all the facets of the economy, including the significant role steel plays in economic development and industrial growth of a nation (Ocheri et al., 2017). Iron and steel production plant consists of different types of machines and equipmentandall of these machineries and equipment must have high availability, performance, reliability and quality in order to ensure a stable manufacturing process (Madu, 2000).

In order to be successful in today's world-class manufacturing environment, manufacturing organizations have to satisfy numerous requirements. The companies are making vigorous efforts to improve their productivity and quality to stay competitive. Total productive maintenance (TPM) provided a reliable quantitative metric tool, known as overall equipment effectiveness (OEE). OEE provides an efficient and effective method of measuring and analysing the efficiency of a single machine or an integrated manufacturing system (Bolaji, 2012). OEE is used as a key performance indicator and quantitative metric for improving the overall plant operational efficiency. The objective of OEE measurement in a manufacturing company is to enhance the equipment availability, machines performance and plant reliability by identifying and eliminating all the production losses that occurs during the manufacturing process and it continuously focuses the plant on the concept of zero waste (Ljungberg, 1998.

In the move towards world-class manufacturing firm, many companies are beginning to realizing the critical need for the use of appropriate maintenance that is a maintenance approach that is efficient and cost effective for the production facilities and systems (Baglee& Knowles 2010). Therefore, the significance of the

maintenance function has been greater than before, because of the role of maintenance in maintaining and improving availability, performance efficiency, quality products, on-time deliveries, safe environment, personnel safety requirements, overall plant efficiency and productivity at high levels (Luxhoj et al.,1997).

Maintenance is known to have a tremendous impact on organization's ability to optimize its production processes and systems. Maintenance has an enormous influence on customers, society, and shareholders. Afonja (2014) reported that companies attempt to capture new customers, satisfy them and retain existing customers by giving them assurance of timely supply of quality products at a competitive cost; which is contingent on adequate production capacity with minimum stoppages, complemented by high quality products. The influence of maintenance on society can be found through its effects on safety on the environment and on ecosystem. Also, the influence of maintenance on shareholders can be found by analysing the effect of maintenance on the profit generated, which is usually measured by indexes such as Return on Investment (ROI) percentage (Al-Turki et al., 2014)

The maintenance department of the organization is saddled with the responsibilities of keeping the machines and equipment in a specified operating condition and also to make ensure that the machines and equipment are able to deliver according to the original equipment manufacturer's specifications. This maintenance function is an important role in iron and steel manufacturing plants and if the task is performed in an effective and efficient manner through the implementation of modern maintenance principles and Strategies, it can facilitate the journey towards having a sustainable iron and steel industry through high asset utilization and improved productivity (Telsang, (2003).

1.1 Statement of the Problem

A comparative analysis of Nigeria's Premier Steel Plant located at Ovwian-Aladja near Warri, Delta State of Nigeria that was commissioned for production more than thirty five years ago showed that similar modules elsewhere in Brazil, India, Saudi-Arabia, Egypt, Iran, Venezuela, Argentina and South Africa with the same plant configuration attained optimum installed production capacity in six to ten years, whereas the Nigerian module operated for more than 25years could only attain 25% of its installed production capacity (Obikwelu& Nebo, 2012)

Therefore, this study evaluates the impact of maintenance principles and Strategies as used in Aladja steel plant and the link between applied maintenance principles and strategies and production machines performance with a view to identifying and recommending appropriate maintenance principles and strategies that would increase productivity through optimal machines availability, utilization and performance (Adurokiya, 2018).

1.2 Aim and Objectives of the Study

The aim of this study is to evaluate the impact of maintenance principles and strategies on steel plant performance. In order to achieve the above mentioned aim the following objectives would be considered:

i. To assess the impact of implemented maintenance on machines and equipment performance
ii. To recommend maintenance measures that would improve Overall Equipment Effectiveness (OEE) in order to increase productivity of the plant.

To assess the impact of implemented maintenance on machines and equipment performance

1.3 Importance of Manufacturing Performance Evaluation

Manufacturing industries can only stay in a competitive market if their production facilities are available and productive. For this to happen, optimizing their productivity is a basic necessity that must be considered by searching for unnecessary production losses as well as eliminating them. This helps reduce cost of manufactured products, meeting customer demands and remaining competitive (Muchiri&Pintelon, 2008). Measurement of manufacturing machines and equipment performance enables management to ascertain performance gaps between present and desired performance and provides indication of progress towards closing the gap. It also assists management in decision making and help creates a bench mark for potential improvement in the manufacturing processes (Liyange&Kuma, 2003).

1.4 The status of Aladja Steel Plant: Case Study

The Steel Plant located at Ovwian/Aladja, near Warri, Delta State, formally known as Delta Steel Company, DSC now Premium Steel and Mines limited is the foremost steel plant in Nigeria and was designed as an integrated steel mill to produce one million tonnes of liquid steel per annum and to feed three inland rolling mills at Oshogbo, Jos and Katsina with billets (Ganiyu, 2015).

The designed was the German DIN standard adopting the Direct Reduction (DR) of iron pellets using domestic's natural gas that is in abundance supply in the Niger Delta region of Nigeria. The plant which was described as the engine of nation's industrial emancipation was commissioned in 1982 (Ajayi et al., 2012).

Production output of the plant from inception till date has been far below designed capacity. Low capacity utilization of installed machines and equipment has been identified as a major factor responsible for low production capacity of the plant. Exploring the benefits of appropriate application of maintenance using OEE askey performance indicator in optimizing the performance of the existing machines and equipmentwith a view to improving the plant productivity is the main thrust of this study (Ajayi, 2014).

II. MATERIALS AND METHODS

2.1 Data Collection

The analysis presented in this study is based on data obtained within a period of six months (October 2017 to March 2018.Data used for the calculation of the OEE were obtained through manual mode of data collection,where machine operators are required to fill in the duration of machines breakdown and causes as well as reliable comments about minor stoppages and speed losses. Data were collected from the production and quality control department, Central maintenance department and rolling mill maintenance department. Data obtained from the plant includes:duration of downtime losses, total planned production time, actual production time, ideal cycle time, quantity of good products and defect products produced in tonnes.

Based on the data available from the operational log books of the production and quality control department, Central maintenance department and rolling mill maintenance department of the plant, the secondary data over a period of six months (October 2017 to March 2018) was obtained, tabulated and presented in table 2.1

Table 2.1 Prod. Data.

Production data	October	November	December	January	February	March
Shift length (Mins)	11880	11880	11880	11880	11880	11880
Short breaks (Mins)	660	660	660	660	660	660
Meal break (Mins)	990	990	990	990	990	990
Down time (Mins)	3100	2997	3219	2103	2089	2114
Ideal Cycle time (TPM)	8	8	8	8	8	8
Total product (Tons)	32405	33596	32000	41405	42368	42124
Defect product (Tons)	60	52	65	52	50	53

2.2 Calculation of OEE value

Overall Equipment Effectiveness (OEE) is the ratio of Fully Productive Time to Planned Time. It is calculated as:

$$OEE = \text{Availability (A)} \times \text{Performance (P)} \times \text{Quality (Q)} \quad (2.1)$$

$$\text{Availability (A)} = \frac{\text{Planned Operating Time- Unplanned Stop Time}}{\text{Planned Operating Time}} \quad (2.2)$$

$$\text{Performance (P)} = (\text{Total Pieces} / \text{Operating Time}) / \text{Ideal Cycle Time} \quad (2.3)$$

$$\text{Quality (Q)} = \frac{\text{Total Number Produced} - \text{Number Scrapped}}{\text{Total Number Produced}} \quad (2.4)$$

OEE takes into reckoning three of its main parameters and presents them as percentage of production time spent making good products (no quality loss) as fast as possible (no speed loss), without interruption (no down time loss). It score present a single number that provides a complete measure of the manufacturing machines and equipment efficiency and effectiveness

III. RESULTS AND DISCUSSION

3.1 Results

To assess the impact of implemented maintenance on the performance of the steel plant machines and equipment, OEE score for the months of October, November and December 2017 were calculated using equations (2.1), (2.2), (2.3) and (2.4). Thereafter, an annual turn-around scheduled (preventive) maintenance was carried out in December 22nd to 30th 2017. After the scheduled turn-around maintenance implementation,

OEE of the plant for the months of January, February and March 2018 were also computed to evaluate (measure) the impact (direct contributions) of maintenance on machines and equipment performance and the results obtained are presented in Table 3.1and 3.2 and Figure 4.1and 4.2.

Table 3.2 CalculatedOEE score for October 2017 to March 2018

	2017			2018		
OEE Factor	**October**	**November**	**December**	**January**	**February**	**March**
Availability (%)	69.68	70.71	68.53	79.44	79.58	97.34
Performance (%)	56.81	57.73	57.05	63.68	65.05	64.88
Quality (%)	99.82	99.84	99.78	99.87	99.88	99.87
Overall OEE (%)	39.52	40.75	39.02	50.53	51.71	51.41

Table 3.3 Comparison of plant with world class OEE

OEE factors	Before turn-around Scheduled Maintenance	After Turn-Around Scheduled Maintenance	World class
Average Availability (%)	63.64	69.64	90
Average Performance (%)	57.21	64.21	95
Average Quality (%)99.81	99.87	99.9	
Average OEE (%)39.76	51.22	85	

3.2 Discussion of Results

Figure 4.1 Graphical representation of OEE of the plant

Figure 4.1 shows a graphical representation of the plant OEE before and after implementation of annual turn-around maintenance program. The machines and equipment performance were measured (evaluated) before and after a scheduled maintenance program implementation and the results is presented in table 3.2. After the implementation of the annual scheduled turn-around maintenance, it is found that OEE of the plant increased from 39.76% to 51.22%. The increase in OEE score from 39.76% to 51.22% is a true measure of machines and equipment effectiveness as a result of maintenance initiative. The improved plant OEE of 51.22% is still far below the world class OEE value of 85% which suggests there is a lot of room for further improvement for machines and equipment utilization and performance.

The results obtained from the computation of the main components of the OEE: availability, performance and quality in Table 3.2 revealed that the low OEE value came mainly from availability and performance components of the OEE.It was observed that equipment downtime has the highest of all the losses responsible for lowering the OEE value and thatmachines availability was directly responsible for thedowntime losses. Aging machines and poor maintenance practices were some of the factors traceable to low availability of machines and equipment.

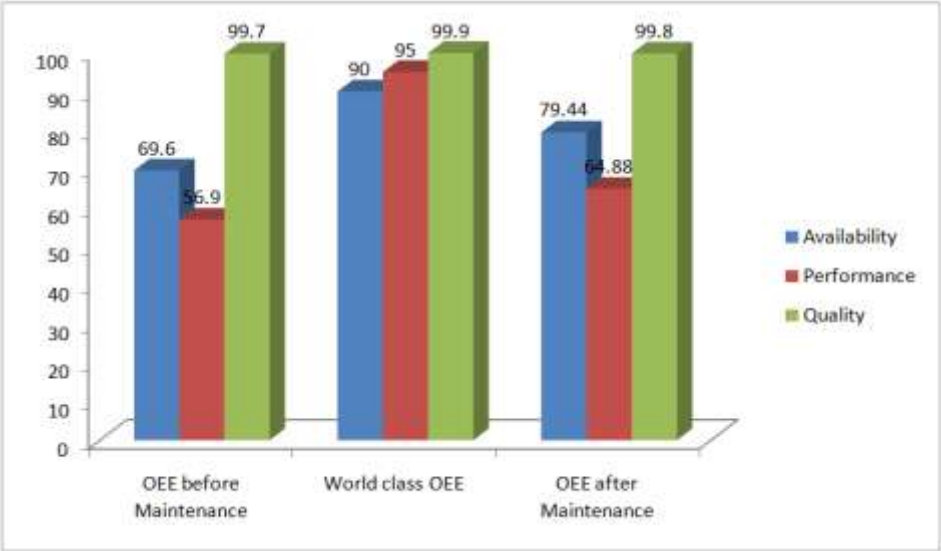

Figure 4.2 Comparison of plant OEE before and after maintenance with World class OEE

As shown in Table 3.3 and Figure 4.2 OEE score of 51.22% for the plant is low compare to the world class OEE value of 85%. Although the quality indicator99.84 % is satisfactory, almost the same as the world class value of 99.9%. However, the availability and performance indicators are much lower than what it should be. This indicates that the machines and equipment are not performing optimally partly due to frequent breakdown of machines caused by aging machines and inadequate maintenance.The unplanned downtime occurrences were the real factors that resulted in decreasing the OEE. This was because it took a huge bulk of time out of a planned production time.

IV. CONCLUSION

The OEE measurement of the plant facilities done before the implementation of a major scheduled preventive maintenance was evaluated as 39.76% and after successful implementation of the scheduled turn-around maintenance program, OEE increased up to 51.22%. The increase in OEE score from 39.76% to 51.22% is a true measure of increase in machines and equipment performance (effectiveness) as a result of the maintenance initiative. The improved plant OEE of 51.22% is still far below the world class OEE value of 85% which means there is a lot of room for further improvement for machines and equipment utilization and performance in the steel plant. The study revealed that to get higher OEE value which means improved productivity, the type of maintenance strategy that is implemented plays significant role in machines and equipment performance. Hence,the study recommends amongst others that the organization should consider full implementation of modern maintenance principles and strategies like Total Productive Maintenance (TPM), Condition Based Maintenance (CBM) and Reliability Centre Maintenance (RCM) in order to achieve OEE's benefit. The benefits gained with an incremental improvement in OEE related to productivity, profitability and competitiveness.

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