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Design Parameters for a Sugar Cane Extractor

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ABSTRACT: *This paper Discussed the design and constructing a portable and cost effective juice extraction machine to expand sugarcane production in Nigeria. It will help to reduce the total cost of sugarcane production process and to avail farmers the opportunity of sugarcane business and to increase local production of sugar,.The design procedures is carefully described. The need for this design became necessary because the currently available sugarcane juice extractors require high energy and sophisticated mills, driven mechanically. These are out of the reach of small scale and rural farmers that are presently involved in processing of cane juice into ethanol, brown sugar and other related products in Nigeria.*

KEYWORDS*: Sugar cane, Juice, extraction,farmers.*

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I. INTRODUCTION

In recent times, many tones of fruits have been wasted in the past and many more are likely to be wasted if unchecked, the need for producingmachine that is capable of extracting juice from fruits without wastage and maintaining the quality and colour of juice is very obvious.(Rein, R.Wer al(2007.)

Juice extracted from fruits can be used as flavorings agents in other manufacturing industries. Some of the products used are cake, yoghurt, sweets; tea etc, a wide range of juice drink can be produced from fruits when the juice extracted from the fruit is mixed with sugar syrup and other ingredients.

The currently available sugarcane juice extractors require high energy and are application of more sophisticated mill driven mechanically (Muchow et al. 2000, Ou et al., 2002). Some of the available cane crushers are of high capacity mainly for industrial applications. These are out of reach of small scale and rural farmers that are presently involved in processingof cane juice into ethanol, brown sugar and other related products at small scale level. The problems associated with processing of sugarcane include small size of farms and farm fragmentation as a result of land ownership by inheritance. Poor storage facilities and practices to preserve harvested canes or extracted juice from being refined to sugar (Mello and Harris, 2000; Wegener, 1996). In addition to the above problems using the same carriage capacity/medium, it will further reduce production cost to transport extracted sugarcane juice from the farm to the factory for refining into sugar than transporting harvested sugarcane to the factory for processing. This is because the extracted juice from a trailer load of sugarcane many not be up to 30% of a trailer load of juice.

It was clearly indicated that processing of sugarcane starts with the extraction of juice from sugarcane stalk. Several methods of juice extraction were in used. These methods included boiling the cane to extract the juice, use of wooden presses and application of moresophisticated mills driven mechanically or by bullocks (Okogie, 1980). The high power requirements during processing of sugarcane constitute the major constrain in the development of small scale sugar processing plants. This also explains why natural sugar juice is not generally available. The recent upsurge of interest in generation of biofuels from plant material has necessitated current waves of interest in the partial mechanization of cane juice extraction and coupled with the production of bio ethanol for domestic and

industrial application (Galitsky et al., 2007). The development of a small scale sugarcane juice extractor was therefore to meet the needs of the small scale farmers who cannot avoid high capacity and complex cane crushers. The main objectives of this study were to design and construct a simple mechanical device for extraction of sugarcane juice. The functional performance and economics of operation of the machine were evaluated.

1.1 Significance Of The Study

Sugarcane juice crusher has been an important machine in our generation today and it plays a vital role in the sugar industries. Theproduction of crushers that can be affordable to individual and local industries can go a long way in satisfying the needs of the masses.

1.2 Scopeofthestudy

This design is aimed at constructing a portable and a cost free sugarcane juice extractor that can be affordable to both farmer individuals and local industries. The machine has an approximate height of 805mm, the length of 511.3mm and a breath of 459.96mm. The efficiency of the machine depends on clearance feeding rate and speed of rotation when feeding is more.

1.3 Sugarcane Juice

Juice from sugarcane is extracted by crushing the sugarcane between two rollers and one feeding crusher (gear) after they have been stripped of leaves and cut into suitable length. By this means, most of the juice is extract. The residual then passes through a collector and is further compressed by presser to remove the remaining juice. The juice extracted from the plant contain about 75% water 2O% sucrose, 4 organic matter and l% mineral matter. This crude juice is collected and freed from organic andnitrogeneous matter by heating and treating with lime which precipitates phosphoric acid as flocculent calcium phosphate, this absorbs the organic content. Another method is by treatment with sulphurdioxide which precipitates calcium sulphide. The cleaned juice is concentrated by evaporation at reduced pressure and then allowed to crystallize

1.4 Traditional Crusher

The earliest mills were probably malter and pestle arrangement operation press by human power, then by animals or water power, and screw press. These were widely used for juice extraction until it was taken over by roller mills which were invented by a cane grower in Sicily in 1449.

1.5 Capacity Of Equipment

Many factory influence the selection of adequate equipments in the sugarcane factory. These factors includes: local conditions, the variety and readiness of the cane, the type of process, the desired quality of the output and many other considerations affect the sizeand capacity of the equipment at various stages of production in the different stations.

1.6 Juice Extraction

The common products from sugarcane extraction includes sugar, syrup and edible molasses, by-products extracted from juice also include black strap molasses, bagasses or stalk residue filter press cake and bagasses ashes, black strap molasses is largely used for the production of alcohol and for livestock feed.

The fibre from bagasses is used for manufacturing paper, hand board and insulation wallboard. Filter press cake has a fertilizer value equal to farm yard manure. Most of the surge used for syrup is milled on three roll mills operated by motor power.

1.7 Effect Of Compression On Cane

Crushers or compressive machine are heavy equipment and are used extensively in the food industry. In jaw crushers, the materials are fed in between two heavy jaws, one fixed and the other reciprocating so as to work the materials down in a narrow space, crushing it as it goes. The gyratory crusher consist of truncated conical crusher inside which its crushing head rotate eccentrically, the crushing head is shaped as an inverted cone and the material being crushed is trapped between the fixed point and the inner

gyrating cones and it is again forced into a narrower space as a result of which it is crushed. Crushing roll consist of two heavy cylinders mounted parallel to each other. They rotate in opposite direction and the material to be crushed is trapped, ripped and crushedbetween them as it passes through.

1.8 Juice Clarification

This is the treatment of the juice after collection to kill and destroy the action of germs and bacteria in the juice and to clear the juice from dirt, stalk etc.

1.9 Parts Selection

Machine part must meet the conditions for reliability i.e. the capacity to do their specified job, retaining all of their service indices during their predetermined service life and the condition of the economy i.e. cost, the least amount in manufacturing and operation.

1.10 The Basic Criteria:

i. **Strength:** The ability of a material to be tough and ductile.
ii. **Rigidity:** The capacity of component to resist changes in shape when subjected to forces
iii. **Wear resistance:** The ability to resist gradual reduction of the size of parts and a change in the shape of the machine along with various surfaces due to friction
iv. **Heat resistance:** The ability to resist heat due to friction.
v. **Vibration stability:** Is the ability of the machine to operate in the required range of duty without inadmissible vibration

1.12Components Of The Machine

(i) **Hopper:** Is made of galvanize mild steel, it has an area of 240 X 210 (mm) at the top and 200mm.
(ii) Rotating shaft (rollers): These are the rotation element, made of mild steal. Design to rotate by the transmitted power from the wheel through the electric motor to the gears and finally the rotating shaft and rollers which tears the can into shreds but extract no juice.
(iii) Bearing: The bearings are used to provide bearing surfaces for rotating parts.
(iv) **The stand:** The stand is meant to provide a support for the machine (gears, rollers, hopper, bearings and side plats), It has an approximate height of 505mm. The rest include side plats and rods which serve as supports to the rollers, gears and bearings and side bar.

II. DETAIL DESIGN OF SUGARCANE CRUSHING MACHINE

The design detail includes the following: actual crushing force (strength), Crusher diameter, length and actual power selected for the electric motor etc.

I Estimating Crushing Strength

An experiment was performed to estimate the crushing force. The test was conducted weighing three different samples of sugar cane that were labeled A, B and C., each of the samples were divided into four parts with two of the parts skinned and the other two parts remained unskined.

The diameter of the samples are: A= 35mm

B = 31mm

C = 21.39m

The above result are further explain in the table below. Table 5

	A		B		C	
s/no	**Weight (a)**	**Force of failure (N)**	**Weight failure (b)**	**Force of failure (N)**	**Weight (g)**	**Force of failure (N)**
1	79	42	37	46	20	30
2	61	35	30	33	19	27
3	52	25	26	30	18	20
4	53	27	20	27	17	15

From the experimental analysis, the maximum value of force of failure is used as the crushing force as seen from table (4i) above the crushing force value is 46 Newton.

Hence crushing force = F_s

F_s = force of failure * Factor of safety

= 46 * 1.5 = 69N

The maximum value of force of failure is obtained at a certain mass of the sugarcane from table (4i), this mass is obtained as 37g

$$M = \text{mass} = \frac{37}{1000}$$

= 0.037kg

Design of shaft:

Using the relation

F_s = M*W

Where Fs = Crushing force N
M - Mass of sugarcane kg
W -Angular speed red/sec
R - Radius of shaft mm
However

$$W_m = \frac{2\pi N}{60}$$

Where the value for 1800 r.p.m from table (4.ii) so as to achieve finer crushing sugarcane.

Table 6
Standard horse power speeds frame numbers and polyphase. Squirrel cage induction motor, types A and B (National Electric motors Association) rating 1985.

HP	O.	E4	1800 rpm	1420 rpm	900 rpm	Size	A1	U
0.5	-	-	-	-	143	143	7	
0.75	-	-	-	143	145	145	7	0.75
1	-	-	143	145	182	182	9	0.76
1.5	143	143	145	182	184	184	9	0.88
2	145	145	145	184	213	213	10.5	0.88
3	186	182	182	213	215	215	10.5	1.1
5	182	184	184	215	254	254	12.5	1.1
7.5	184	213	213	254	256	256	12.5	1.4
10	213	215	216	256	284	284	14	1.6

From $W_m = \frac{2\pi N}{60}$

Substituting the value, gives:

$$W_m = \frac{2\pi 1800}{60}$$

= 188.5 rad/sec.

Substituting the value of w into equation

F_s = Mw^2r

69 = 0.37 $(188.5)^2$r

r = 69 1314.69

r = 0.0525m

= 52.5mm

Diameter crusher, d = 2 * radius (r)
= (2 x 52.5) = 105mm

Ii Power Selected From A.C Motor

Motor power, $P_m = \frac{2\pi NT}{60}$

Where T- Torque
N - Speed = chosen as 1800 rpm
Torque = force of shaft x radius of shaft
T = f* r
= 69 X 52.5 = 3097.5N

Substituting in

$$P_m = \frac{2\pi 3622.5(1800)}{60}$$

Pm = 682825 watts (w)
= 682.825kw

Horse power H.P = $\frac{682.825*10^3}{746.58*10^3}$

= 0.9147H.P

Hence, a 1 hp motor of 1800 r.p,m is selected

Iii Design Of The Crusher Length

Since length is a function of the angle of twist t, then the length can be obtained from

$$\theta = \frac{584MtL}{Gd^4}$$

Where θ = angle of twist deg.

L = Length of the shaft. M

M_t = Torsional moment Nm

G = Torsional modulus of elasticity

d = shaft diameter, m

The amount of twist permissible depends on the particular application, and varies about 0.3deg/m for machine tools shafts to about 3 deg/m.

Torsional moment is

$$M_t = \frac{9550Kw}{rev/\min} Nm$$

From equation P_m = 0.682825kw

$$Mt = \frac{9550*0.682825}{1800}$$

= 3.62277kNm

Also

G = 80 *10^9 N/m (for steel)

d = 0.105m

Hence, θ = $\frac{584*L}{80*10^9*0.105^4}$

And L=4.596θ

So θ increase as length increases

θ ∝ L

Assuming a machine tool shaft

whenθ = 0.3 degree

L = 4.596 * 0.3

L = 1.3788m

When θ = 0.6

L = 4.596 X 0.6

L = 2.757m

Substituting the value of L and θ in

K = $\frac{\theta}{L}$ = $\frac{0.3}{1.3788}$ — at θ = 0.3 deg.

Assuming a length of 300mm (0.3m) in the design of the sugarcane crushing machine we have

θ = 0.2176 X 0.3

= 0.6528 (Maximum torsional deflection) for axial deflection,

$$6 = \frac{F_s L}{AE_m}$$

Where σ = axial deflection m

E_m = modulus of elasticity, 207 x 10^9 N/rn

F_s = 69N (crushing force)

A = Area of the crusher $-\dfrac{\pi(0.105^2)Nm}{4}$

L = Length of the crusher = 0.3m

$$б = \frac{69*0.3}{\pi/4(0.105)^2*207*10^9}$$

б = 1.15 * 10^{-8}m

2.1 Materials Selection

The materials used in the construction of the construction of the machine are as follows

(i) Mild steel (low carbon steel)-because of its malleability, ductility and plasticity properties.
(ii) Stainless steel-Used as bearing material because of its ductility .
(iii) Cast iron is used for the manufacture of the pulley, since it can be machined and for it's cheapness.

III. CONCLUSION

The design parameters for the fabrication of a juice extractor have discussed in this paper, The output capacities of 10.50, 12.00 and 14.25 kg/ hr can be maintained at operating speeds of 0.25, 0.3 and 0.36 m/s, respectively. The extraction efficiencies will ranged between 40 and 61 % at operating speed of 0.25 and 0.36 m/s. It wasobserved that in most juice extracting machines the optimum performance cannot be sustained over a longprocessing period because of the observed bluntness in the perforated gratingdrum over time of use and this reduces the extraction efficiency of the machine.Further work would be carried out on the arrangement of the grating drum,crushing chamber and effects of some processing factors on expression of juicefrom cane fibre in a compression chamber.

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