American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-7, pp-91-97
www.ajer.org
Research Paper Open Access

Design And Fabrication of Sugarcane Juice Extractor

[1]Azeez, N.A, [2] Okpara, I.N and [3]Ologunye, O.B.

[1,2,3]Department of Mechanical Engineering Technology, Federal Polytechnic Ede Osun State, Nigeria.
Corresponding Author: Azeez N.A

ABSTRACT: *Over the years, small-scale farmers have supported Nigerian sugar cane production, which finally stop using its teeth to bite the rind and to chew the inner tissues to sweet the juice. At the concentration level, the juice is extracted. In order to boost the production of the sugar cane and its product, we have embraced a project called SUGARCANE JUICE EXTRACTOR. Assessment of the sugar cane extractor functionality as regards its effectiveness in the extraction of juice. The approach in this project is to design a machine that consists of the 2.0-hp gear motor and crush mechanism of the machine, consisting of gears, latchers and three rollers which have then been mounted with the juicer and inlet and outlet on the frame.*

KEYWORD: *Fabrication, Juice Extractor, Roller and Sugarcane*

Date of Submission: 30-06-2019 Date of Acceptance: 19-07-2019

I. INTRODUCTION

Sugar cane is commonly referred to as the source of grain of sugar for daily use. It is also difficult to crush the cane to extract the savory ones. There is strong fiber in the plant. It is also known for its power and shape, a long straight plant like bamboo. It is also used for the production of sugar by extracting a healthy juice. In the subcontinent of Nigeria, Asia, and India, sugar cane juice which migrates thousands of years ago is popular. The juice can be drunk directly after pressing the sugar cane (Abamaster, 2010). A very powerful roller is needed in order to crush this tough sugar cane and force it to crush and the juice is therefore squeezed from the plant. The sugar cane and juice was crushed by hand since early days. Over the years, small farmers have been promoting Nigerian cane production, who end up bite-rinding with their teeth and chewing the internal tissue for sucking juice at a comsuntional rate. (Soetan, 2018)The interest in drinking this juice at present is reduced, as it is difficult to find a clean and appropriate process during juice manufacture. Sugar cane juice was mostly sold on the side of the road that was not clean due to dust and wind germs. The sugar cane juice is best, fresh and chilled. A clean processing mechanism and the proper disposal of its fibers constitute an interesting option for better marketing for the crusher press. (Anonymous, 2018) After extraction, the sugar fiber plant is called bagasse.

1.1 STATEMENT OF THE PROBLEM

Most sugar cane juice was sold by a small business with a conventional extraction machine. The sugar cane farmer generally provides direct supply to small companies. It's the default method. A new transition in the sugar cane juice industry could change the chain cycle of farmers and cane sugar sellers. Sugar cane will be sent to the cleaning, skinning, cuts and packaging house of goods. The sugar cane will be transported from the warehouse to the sugar cane seller. An extractor of sugar cane juice with an orderly disposal shopping complex. A cane farmer uses bagasse as decomposed fertilizer from an extractor machine.

1.2 AIM AND OBJECTIVES

To produce a sugar cane extractor with an appropriate disposal for the bagasse and can be used in a closed room.

- Manufacture of sugar cane juice extractors with local materials.
- Evaluation of the functionality of the sugar cane extractor in relation to its juice extraction efficiency.
- Develop a prototype of the sugar cane juice bagasse extractor.

1.3 SCOPE OF STUDY

This project includes

1. The development of juice extraction mechanisms for the extraction of sugar cane juice.
2. Develop a system of cleaning.
3. Cut and collect the bagasse.
4. Set the sugar cane juice filter up.

The study would benefit industry people and the community as well. The study offers people information about sugar cane and the advantages it offers. This will provide a new company for the industry to sell the sugar cane juice as a drink.

II. LITERATURE REVIEW

2.1 HISTORY OF SUGARCANE

Depending on the taxonomical system, sugarcane is one out of 6 to 37 species in large, long-term grasses (Naturland, 2010). Sugarcane is a tropical grass in the same family as sorghum, johnsongrass and maize (Purseglove 2018). It is of the kingdom of Planteae, phylum magnoliophyte, Poales, Poaceae and Saccharum L genus. Only rarely can sugarcane make sprouting seeds. It is from the kingdom of Plantea, phylum magnoliophyte, Poales, Poaceae and Saccharum L genus (munocotes, commelinides). Cross-fertilization between S is most of the several hundred used clones. S.sinensis (adjustable), S. officinarum (high sugar content). S. and spontaneum. Strength (resistant disease). The most common clones are octaploid and propagated vegetatives (Naturland 2010), with eight corresponding clones, similar in position, structure, function or characteristics in a cell of chromosome sets.

2.2 MILLING AND JUICE EXTRACTION

The picked sugar cane is cleaned and washed first in the mill. They are then broken down for removal, and several rollers (2-18 roll combinations) are made before they are transmitted to roller mills. The sugar cane juice extraction machine would be suitable for the factory's design and function. The collected juices contain between 10 and 15% of sucrose and fibrous substances, called bagasse, which are burned for fuel. For sugar mills, Bagasse makes energy self-sufficient. In the production of animal feed, paper or electricity for sale, surplus bagasse is used. 24 The next thing to adjust pH to 7 is the cinnamon juice. (Boyel, 2019). This mix arrests sucrose decline and precipitates certain impurities into glucose and fructose. The mixture sediments and allows for the calyx to settle and other hanging solids. In a multi-effect evaporator, the clarified juice is concentrated to form syrup of approximately 60% by weight. It is concentrated further in vacuum and is over saturated until crystalline sugar is added to the syrup to activate syrup-like sugar crystallization. More sugar crystallizes the syrup when cooled. The sugar is separated from the molasses by a centrifuge. More sugar are extracted from additional crystallizations, the final residue is called blackstrap.

2.3 EXISTING SUGARCANE EXTRACTORS

Modern sugar cane juicer has gone far from the traditional wooden roller used by native people in countries such as Panama and Colombia. The commercial cane juice extractor is very expensive. The search for a home model can also prove difficult. This can be difficult to find and could require an order from another country, such as Malaysia, Singapore and India, which provides a sugar cane tabletop press (Naturland, 2010). Some food traders in the United States have become a cane extractor to tap the market for organic juices. Some extractors can process around 170 ducks an hour while others have an easy filter system. Extractors by Munoz, (2018) also have differing prices. A less expensive model can be found in a highly powerful savory and vegetable extractor where true sugar cane extractors can amount to up to $3000 to large industrial plants.

THE TRAPICHE

The Panamanian and Colombian people use a traditional timber press for extracting sugar cane juice as trapsiches. This is the Spanish language for sugarcane crousher, when it is applied in a machine or a sugarcane mill. (DEP, 2018). The machine consists essentially of wood and has various sizes. There are two vertical rollers in the sugar cane. These rollers are held in place by a wood frame, while a longitudinal twisting grove receives and transmets the rotating movement towards the second crushing roller. The extraction of juice is done by hand or by boiling animals (mostly for the larger and the static ones found in the molding).

Figure 2.1: *The Trapiche (*Heiser, 2013)

III. MATERIALS AND METHOD

The extractor machine consists of gears, crushing rollers, rollers, coupling, fixtures, metal frames and gear engines. The following are the various parts of the extractor of sugar cane juice:

3.1.1 THE CRUSHING UNIT/ ROLLER

The crush unit consists of three rollers, one big roller and two tiny rollers. The wide roller with a diameter of 100 mm and the longer, mild steel and the two wide rolls of 77 mm with a length of 300 mm and a mild roller of steel. The diameter of the rollers is 300 mm. These rollers are made of mild steel due to their resistance to compression. The mild steel bars have been coated by a lathmachine and become aggressive, forming a rib-like structure. These provisions ensure that, unless removed, slipping in the case of plain crushing rollers occurring during feeding with sugar cane will be reduced to minimal.

3.1.2 GEARS

The top-mounted roller controls the movement of two bottom-mounted rollers. The roller gears are 23 teeth mesh, which means that the three rollers depend on each other. The two other rollers move at the same speed as the top roller shaft, but in the same direction. The transmission is carried through the gear motor to two more rollers. The dental gear decreases the transmission rate to the broken roller so that the transmission torque on every roller increases. This increases the crushed strength of the roller surface.

3.1.3 POWER SOURCE

The electric gear engine is 2 hp. The input is connected with the input. The engine speed is reduced to 1:55 of the speed reducer from the engine, which is 1440rpm. The gear motor speed is 26.2 rpm for this power source.

3.1.4 THE MACHINE FRAME

This part consists mainly of the mild steel angle bars. Two flat shaped "H" profiles are made from mild steel. This is mounted on an angle bar stand ; the engine is placed on top of the stand.

3.2 MATERIALS

- **T he Steel plate:-** the stainless steel plate would be used.The used plate is 1.5 mm thick and the buying measurement reaches 700 mm by 500 mm.

- **Bolt and nut: -** For coupling the cut out details together, selecting bolts and nuts having a threading diameter of 10mm.
- **Cutting disc and grinding disc: -** These are attached to the angle grinder to power its operation. The cutting disc when it is attach it would be used to cut the plate metal to the desired shape and orientation, while the grinding disc would also be used to smoothed the roughness on the cut detail.
- **Welding electrode: -** A welding electrode of the required specification is used. Details which need to be permanently held together are joined through welding process.
- **Non-polar solvent: -** This is chosen based on market availability. The purpose of the solvent is to wash and clean the metal parts which have been packed with dust and debris. The choice of solvent was one of the petroleum hydrocarbon products e.g. petrol, kerosene.
- **Iron Wire brush: -** It would be used to brush off the corroded surfaces. This would prepare the surface for painting.
- **Paint: -** Silver-colour paint would be used to coat, protect and add lustre to the extractor.
- **Painting brush: -** This is used in paint application to the machine surfaces.

3.3 DESIGN CALCULATION

- Based upon research, on this two 2 mm average sugar cane squeeze its juice manually at a thickness of 2.5 - 3.5 mm, the thickness with assumed thickness was used with these 100 mm, 75 mm and 65 mm rollers.

Design Analysis

Maximum force of failure (Mf) = 120 N
Safety factor (SF) of 1.6
RPM=1440rpm
Gear motor ratio: - 55:1
Gear motor rpm: - 26.2rpm
Force require to crush the sugarcane= 120n
Crushing force for the design $Fc = M\ f$ x Sf
Fc = 120 x 1.6 = 192N
Ms= 130 g = 0.13 kg s

- **Design of Roller Size**

Diameter of big roller, D = 100mm=0.1m, r = 0.05m
Angular velocity (ω) =2 πN/60= 3.142 x 2 x 1440/60 =150.8rad/s
Velocity (v) = ω x r = 150.8 x 0.05 = 7.54m/s

- **Power Selection for Motor**

Torque transmitted to the big roller
$T = F\ x\ r$
T= 192 x 0.05= 9.6Nm
Power required P = Tω
P= 9.6 x 150.8 = 1447.68w=1.448Kw
1hp = 746w ---------- constant
x = 1447.68
x = 1 x 1447.68 / 746 = 1.94= 2hp
i.e. 2.0Hp motor of 1440 rpm is required

- **Determination of Actual Motor Torque**

The angular velocity of motor,
ω = 148.72 rad/s
Motor torque, $Tm = motor\ power\ (Pm)$ An$gular\ velo(\omega)$

- **Gear Mechanism**

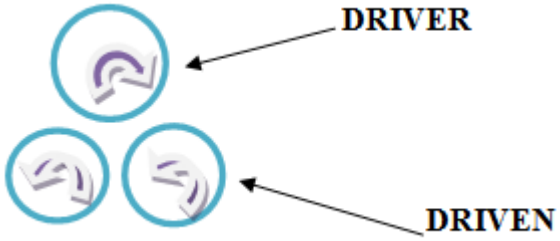

Figure 3.1 Gear movement and direction of rotation

❖ **Gear Data**

Depth = circular pitch /2
Number of teeth = 31
OD = 100mm
Width = 20mm
Bore diameter = 28mm

3.4 PROCEDURE OF FABRICATION

Following the designed work drawing for each section, the materials were sorted. Rotation of rollers, gear cutting and gear motor sorting. The angle bar was trimmed to the necessary size and the frame was covered with mild steel plate material.. Before the major joint and assembly processes started, the required drilling was done. When the details are taken, four (4) major components constitute the mechanism of the work on the sugarcane juice extractor. These include::

1. Electric gear motor
2. Spur gear
3. Rollers
4. Bearings

3.5 OPERATION INVOLVED

3.5.1 LATHE OPERATION

The Lathe machine used to manufacture roll shaft turning steps in both ends; the first stage with 30 mm and 58 mm diameter and length, the second step with 100 mm and 150 mm diameter and lenght, and the next step with diameter and length, 30 mm and 132 mm. Last step with 30 mm diameter and 77 mm length, from the end of second end. Twists of 50 mm diameter and 50 mm length coupling and the bore and boiling of the coupling also produce a diameter of 229 mm.

3.5.2 SHAPING OPERATION

The shaping machine was used to cut and shape the spur gear of 3 Nr 4(involute) module, outer diameter of 99mm,depth of 7mm, width of 20 and the number of teeth of 31.

3.5.3 DRILLING OPERATION

The pillar drilling machnine is used to drill 6mm thick plate and bore to the diameter of 32mm. The hand drilling machine was also used to drill the body for easy fasterning.

3.5.4 CUTTING OPERATION

The use of the cutting machine is used for detailed measurements.

3.5.5 WELDING OPERATION

For all joints of the single component of the sugarcane juicer, the welding machine was used. **3.5.6 GRINDING OPERATiON**

The grinding machine was used to mow the joint, component surface in deburr, and the sharp ripples in order to have a smooth surface before painting the body.

3.6 PRINCIPLE OF OPERATION

The 3 rollers in a sugarcane juicer with a larger diameter of up to 100 mm, the transmission by coupling of torque by the electric gear motor, and a reverse rotation of both rollers with the diameter of69 mm and 79 mm

as shown in Figure 3.1 above, draw the sugar cane and squeeze the baggage (residue) on the outside, respectively.

3.7 TEST PARAMETERS AND PROCEDURE

After the machine was assembled, the machine was checked for efficiency to know whether the modification was adverse to or beneficial to the machine.

3.7.1 TEST PROCEDURE

For the test, the following equipments and materials were used.

1. Lengths of harvested sugarcane.
2. The sugarcane juice extractor.
3. A 2.0 hp electric gear motor
4. A weighing balance for weighing the sugarcane, juice or bagasse.
5. Vernier calliper for measuring diameter.
6. A measuring tape for measuring the sugarcane length
7. A container for collecting the extracted juice.
8. A stopwatch.
9. Calculator
10. polythene bag

When the sugar cane was purchased from the market, it had been cleaned prior to the production and registration of large dimension quantities like the average diameter, length and weight. In addition, sugar cane was split and labelled A to G in specimens. The motor is warmed up for 10 minutes before the sugar cane juice extractor is used. Preliminary testing was progressively performed on the machine using specimens A, B and C, while the main final test was performed using specimens D to G. At 75 ° angle between the rollers in the operating chamber, all specimens were fed into by hand, and the juice collected downwards while the bagasse was extracted by the channel on the rear. The stop-clock is activated from the beginning and stop at the end of the extraction process for each specimen extraction. After each specimen of sugarcane has been subject to a 5-fold process of extractions, the bagasse is collected in a marked polythene bag and its weight is recorded, the calculations to check the machine efficiency are carried out when the process is read.

IV. RESULTS AND DISCUSSION

4.1 DIMENSIONS OF SUGARCANE SPECIMEN

The dimensional characteristics of the purchased specimen of sugarcane were highlighted in the previous chapter.

Table 4.1: Dimensions and weight of the sugarcane specimens

Sugarcane specimen	Head diameter (mm)	Middle diameter (mm)	Tail diameter (mm)	Average diameter (mm)	Length (mm)	Weight (g)
A	31	32	32	31.67	600	806.3
B	36	37	35	36	550	1000.5
C	34	35	36	35	490	997.3
D	37	36	36	36.33	600	1130.4

Following measures, specimens A and B were used as described in the previous ch. for preliminary testing, while specimens C and D were used to test the improved machine finally. As shown in the previous chapter.

4.2 TESTING

When the sugar cane was inserted into the sugar cane extractor, the juice is then extracted and the baggases removed by turning the three rollers.

4.2 EFFICIENCIES OF JUICE EXTRACTION

The values and result of the preliminary test carried out at the first test of the machine are shown in Table4,2, which estimates and assumes the maximum juice release of the sugar cane to 85% of its initial weight (Soetan, 2008). The machine's main test is then performed and presented in Table 4.3. In order to obtain machine efficiency results, all formulas are used as appropriate.

Table 4.2: Result Of Performance Text

Specimen	Length (mm)	Initial weight (g)	Bagasse weight (g)	Weight of juice extracted (g)	85% of initial weight (g)	Extraction efficiency (%)
A	600	806.3	486	320.3	685.4	46.7
B	550	1000.5	580.3	420.2	850.4	49.4
C	490	997.3	530.2	467.1	847.7	55.1
D	600	1130.4	630.1	500.3	960.8	52.1
Mean/Average						50.8

4.4 THE RATE OF JUICE EXTRACTION

The total weight of the extracted sugar cane juice (wj) is calculated to be 17079 g, parameter as shown in Table 4.2 above. The total time required for the removal process (tj) is 160 seconds. The machine extraction rate of the juice extraction rate is measured.

Thus, the rate of extraction $\eta r = \frac{17079g}{160} = 106.74g/sec$ or 384.3kg/hr

(Rate of extraction in litres) = 0.10674 l/s or 0.3843 l/h

Therefore, this sugarcane juice extractor can produce 0.10674 liters /seconds

V. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The extractor of sugar cane juice has a unique design that is quiet during operation (can be operated in an enclosed door) as well as compact. It squeezes any sugar cane of a diameter of less than 52 mm. The interaction between contaminants and extracted juice is considered negligible with the supplied isolation of the extraction process from the environment. Due to the electric transmission motor used, the rollers worked without being stuck independent of the sugar cane juice.

5.2 RECOMMENDATIONS FOR FURTHER IMPROVEMENTS

Therefore, if additional work is to be carried out on the machine, the following and modifications to the manufactured machine are recommended.

1. In areas where contact is made between the juice and the side plate which holds the rollers of the machine when used industrially, stainless steel can be used. This would improve the machine's hygiene.
2. A sieve can be used to collect small bagasse particles which can be drawn with the extracted juice via the juice chute or exhaust.
3. Add a travel wheel to help the machine mobility from one area to another.
4. A cutting section to cater can be constructed and attached to the machine to complement its operation and scrap the sugar cane before the juice is extracted.
5. The crushing mechanism, when feasible, can be adjusted to vary the gap between the rollers and thus vary in crushing and extracting juices in different diameters.

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Azeez N.A " Design And Fabrication of Sugarcane Juice Extractor " American Journal of Engineering Research (AJER), vol.8, no.07, 2019, pp.91-97