DESIGN AND FABRICATION OF A SUGARCANE JUICE EXTRACTION MACHINE FOR DOMESTIC USE

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CERTIFICATION

The undersigned certify that this project report titled **DESIGN AND FABRICATION OF A SUGARCANE JUICE EXTRACTION MACHINE FOR DOMESTIC USE** was prepared by **ODULALU MUBARAK AKINOLUYELE** with matriculation number **HND/23/MEC/FT/0234**, meets the requirement for the award of Higher National Diploma (HND) in the department of Mechanical Engineering, Kwara State Polytechnic, Ilorin, and was approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This project is dedicated to the Almighty Allah, the giver of wisdom, knowledge and understanding.

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V	Volume of the fluid
A	Area considered

ABSTRACT

This project presents the design, development and optimization of a sugarcane juice extraction machine, aimed at improving the efficiency and convenience of extracting juice from sugarcane. The demand for sugarcane juice has been increasing due to its numerous health benefits and refreshing taste. The design process involved analyzing the existing extractors, identifying their limitations, and proposing innovative solutions. The final design was fabricated and tested to evaluate its performance. This machine is designed to be user-friendly, energy-efficient, and suitable for both commercial and domestic use. Performance tests show a significant improvement in juice yield and quality compared to traditional manual methods, demonstrating the machine's potential to enhance productivity in sugarcane processing industries. The machine demonstrated an average extraction efficiency ranging from 59.8% to 74.9%, depending on the quantity of sugarcane processed. The highest efficiency was recorded when 3 kg of sugarcane was processed, showing that the machine can handle larger loads effectively. The throughput capacity, ranging from 9.8 kg/h to 12.9 kg/h, demonstrates that the machine is capable of consistent performance across different load sizes.

CHAPTER ONE

INTRODUCTION

Sugarcane (*Saccharum spp*.) is a special crop plant that underwent anthropogenic evolution from a wild grass species to an important food, fodder, and energy crop. Unlike any other grass species which were selected for their kernels, sugarcane was selected for its high-stem sucrose accumulation. Flowering in sugarcane is not favoured since flowering diverts the stored sugar resources for reproductive and developmental energy needs (*Dineshet al*. *2022*).

Sugarcane is a well-known crop of the family *Poaceae.* India is the second largest producer of sugarcane, after Brazil. *Saccharum* is derived from the Greek word '*Sakcharon*,' which means sugar, especially sucrose. *S. officinarum Linn,* is a perennial grass, indigenous to tropical South Asia and Southeast Asia. It has a thick longitudinal stalk, generally three to five meters in height, approximately 5 cm in diameter, and is characterised by its sweet taste due to its high sucrose content. It is also known as chewing and noble cane (*Amandeep et al.2015*)

Sugarcane (*Saccharum spp.*) is a robust and vigorous tropical plant, with superior growth over most other crop species partially because of its high photosynthetic efficiency as a C4 grass. Further, it contributes about 70% of the world's sugar production and holds great potential for biomass and ethanol-based biofuel production. The global sugarcane production in 2018 crossed 1,907,024,730 tons (190.7 million metric tons/MMT) with Brazil and India being as top producers (FAO 2020, 2021). Evolutionarily, the genus Saccharum has diverged from maize around 15–20 million years ago (mya) and split from sorghum as recently as 6–9 mya (*Paterson et al*. *2004*).

Sugarcane belongs to a class of permanent grass of the group *Saccharum* belonging to the tribe of Andropogoneae, mostly found in humid regions of Southern Asia and has been utilized for the production of sugar. It accounts for about 62 % of the total world's sugar while only 38 % is produced from beet (Naidu 1981). The mature sugarcane itself is composed of 69-75 % water, 8-

16 % sucrose, 0.2-3.0 % reducing sugar, 0.5- 1.0 % other organic matter, 0.2-0.6 % inorganic compounds, 0.5-1.0 % nitrogenous bodies, 0.3-0.8 % ash and 10.0-16.0% fibre (*Gbabo, 2002*).

Sugarcane is a tropical, perennial grass categorized as large, long-term grasses and forms lateral shoots at the base to produce multiple stems, typically 3 to 4 m (10 to 13 ft) high and about 5 cm (2 in) in diameter. The stems grow into cane stalks which, when mature, constitute around 75% of the entire plant. A mature stalk is typically composed of 11–16% fibre, 12–16% soluble sugars, 2–3% non-sugars, and 63–73% water.

The sugarcane crop grows well in tropical and subtropical regions. It will require a well-drained soil of pH 7.5 - 8.5 and high organic matter, along with a hot and humid environment (*Kohl et al*. 2009). As a result, Nigeria, which is located within the tropical zone, has enormous potential for sugarcane cultivation. As of the year 2000, over sixty (60) potential sugarcane estate sites were identified across the country (*Busari, 1999*).

Sugarcane has been used in various parts of the world for curing various diseases. In the Ayurvedic system of medicine, sugarcane is used either as a single drug or in combination with some other plant materials (*Anis et al.1986)* (*Vedavthy et al.1991)*. Some natives and traditional healers of the world have recommended sugarcane juice for its diuretic properties. It is thought that regular use of sugarcane juice will keep the urinary flow clear and fast, which will further help the kidneys to perform their function properly. It is also used as an aphrodisiac, laxative, coolant, demulcent, antiseptic, and as a tonic. According to the Unani system of medicine, sugarcane juice is considered good for patients with jaundice (*Agbaje et al.2019)*.

Sugarcane juice is the liquid extracted from pressed sugarcane. It is consumed as a beverage in many places. Sugarcane juice is well known as a raw material for producing refined sugar. Its wax is considered a potential substitute for the expensive carnauba wax, which is of cosmetic and pharmaceutical interest. Refined sugar is the primary product of sugarcane juice, but during its processing, various other valuable products are also obtained in an unrefined form, such as brown sugar, molasses, and jaggery. Sugarcane juice is widely used in India in the treatment of jaundice, hemorrhage, dysuria, anuria, and other urinary diseases (*Amandeep et al. 2015*).

Due to its richness of different minerals, it is useful to prevent cancer from occurring, for normal kidney functioning, it acts as an energy booster, can keep the skin hydrated and prevents ageing, helps to lose weight, and prevents tooth decay. Sugarcane also acts as a substitute for soft drinks or aerated drinks for diabetic patients; it facilitates safer pregnancy and quicker conceptions.

The problems related to sugarcane production and processing in Nigeria include small-scale farms and farm disintegration, land tenure system, inadequate transportation infrastructure and lack of appropriate technologies for micro, small and medium-scale processing. Other problems include poor storage facilities for harvested sugarcanes and extracted juice before further processing into sugar *(Olaniyan and Babatunde, 2012).*

Extracting juice from sugarcane traditionally involves manual labor, which is time-consuming and labor-intensive. To address these challenges, this study focuses on designing and fabricating a sugarcane juice extractor that enhances the efficiency and convenience of juice extraction.

1.1 PROBLEM STATEMENT

The extracting of sugarcane juice through manual labor, which is time-consuming and extracted juice before further processing to sugar has been the identified problem which brings about the designing and fabrication of low-cost, portable, devoid of technical complexity and can easily be operated and maintained.

1.2 AIM AND OBJECTIVES

The aim of this project is to design and fabricate a machine that is able to extract sugarcane juice automatically with maximum juice extraction efficienc**y.** The objectives of the project are to**:**

1. design and fabricate a sugarcane juice extraction machine.
2. evaluate the efficiency and performance of the extractor.

1.3 SIGNIFICANCE OF STUDY

The design and fabrication of a sugarcane juice extractor will benefit individuals, small-scale farmers, and the general public as this can significantly increase juice yields and speed for small-scale juice businesses or household use. This would facilitate access to sugarcane's nutritional benefits.

1.4 SCOPE OF WORK

- A detailed description of the proposed design of the sugarcane juice extractor.
- An analysis of the performance of the extractor, including estimates of the power requirements and the rate of juice extraction.
- A description of the materials and fabrication processes that will be used to build the extractor.

CHAPTER TWO

LITERATURE REVIEW

2.1 REVIEW OF RELATED LITERATURE

The development of sugarcane machines started hundreds of years ago in many countries. The Trapiche is a traditional wooden roller used by people of Panama and Columbia to extract sugarcane juice, the trapiche is a Spanish word for "sugarcane crusher". It varies in size and is made up of wood. It has two rollers that are vertically placed and held by a wooden frame *(Uti et al 2019).*

Due to the favourable climate of Nigeria, the sugarcane plant grows well and one would have expected Nigeria to be a huge exporter of sugar because of the high production of sugarcane stalk but this is not so at present. Sugarcane is the main source of obtaining sugar, the extraction of sugar from sugarcane is done through certain processes, which have undergone immense improvement. However, the two processes commonly used which are the milling and the diffusion processes *(Kehinde et al 2015).*

Crushing a sugar cane requires strong force due to its strong and hard characteristics. Juice extractor machines were built mostly focused on the mechanical of the machine. The efficiency of the machine depends on the mechanical system that has been designed for the machine. Mechanical power is the most essential need in these identified areas *(Olaoye, 2011).*

(MAKINDE-OJO, 2010) perform research on the improvement of the sugar cane juice extractor machine by constructing a casing for the operating chamber. This helps to shield off the intrusion of rust in the extracted juice. Furthermore, the casing would improve the safety of the operator. This is ensured by the covering of the moving parts such as the gears. Also, the aesthetics and the hygiene of the machine are improved since the presence of contaminants such as rust would be curbed. Besides, due to the adoption of the hopper section, the number of

sugarcane pieces and cutting that can be handled at the same time would be improved thus saving time losses and the activity of the employed labor.

Olaoye (2011), developed a sugarcane juice extractor for small-scale industries. The design is a simple mechanical device for the extraction of sugarcane juice. The output capacities of 10.50, 12.00 and 14.25 kg/hr. were obtained at operating speeds of 0.25, 0.3 and 0.36 m/s. The extraction efficiency of the machine ranged between 40 and 61% at operating speeds of 0.25 and 0.36 m/s. He observed that this optimum performance of the machine cannot be sustained over a long processing period due to the bluntness development of the perforated grating drum over time.

Designed conveyed screw press conveyors that gently squeeze the fiber (sugarcane) in each stage, improving extraction. The performance of a pilot-scale screw-press conveyor was tested for dewatering capabilities and power consumption. The un-optimized equipment decreased Megase moisture from 96 to 89% *(Uti et al 2019).*

(Olaniyan & Babatunde, 2012) designed a small-scale sugarcane juice extractor using a screw pressing system mainly intended for the techno-economic status of the micro and small-scale sugarcane farmers and juice processors. The machine is portable and it avoids technical complexity to be easily maintained by small-scale farmers in rural communities. The juice yield and extraction efficiency are improved to 2.5 % and 87.8 % respectively by improvement in the design, analysis, and optimization of the worm shaft and press cage.

(Priya & Lakshmi, 2018) designed instant cooling sugarcane juice machine. In their design, they mainly studied problems faced by the vendors during the extraction of sugarcane juice manually. According to the study, vendors faced pain in their body parts viz., shoulders, wrists, arms, and neck due to the improper height of the workstations on which they are working. So, they increase the height of the workstation, providing a waste bin at the reachable height, providing a flip to the machine so that the injuries can be avoided during the juice extraction. Also, the

machine has an instant cooling and no need for a large space to establish this unit, easy to operate, easy to clean, noiseless construction, has a body constructed from stainless steel, runs on a 1H.V. motor and has an inbuilt compress.

(Ambare et al., 2019) design and fabricate a machine that can extract sugarcane juice automatically with maximum juice extraction efficiency. From 1kg of sugarcane, approximately 300ml of juice can be extracted to get this amount of juice more pressure should be applied to the cane but sometimes the motor will not supply sufficient torque so the cane is stuck in between rollers and increase the chance of failure to the machine. So, to decrease the failure of the machine and to reduce human involvement to prevent injury to the operator they have added one more roller to the existing machine which will also help to extract maximum juice.

CHAPTER THREE

METHODOLOGY

3.1 CONSIDERATION FOR SELECTION OF MATERIALS

In any engineering project, it is necessary to properly select the appropriate materials to be used in constructing the machine so as to eliminate fatigue failure possible in the material when it is put into service. The sugar cane juice extractor machine consist of different parts assembled together to perform the required juice extraction function. These parts have to be made of a suitable material to perform the given application efficiently. The selection of proper material for the machine component is one of the most important steps in the process of machine design. The proper material for each part is selected by using different material selection method. There are different factors which should be considered while selecting a material for the machine component this includes availability, cost, mechanical properties, physical properties, and fabrication consideration. Mechanical properties are the most important technical factor governing the selection of material. Since the machine needs to give effective purpose with minimum price. It is of vital importance to select the materials that will suit the following requirements:

- Service requirements (functionality).
- Fabrication requirements.
- Economic requirements.

3.11 Service Requirements (Functionality)

A properly designed engineering equipments or machine must be operationally sound in service. It must be of suitable strength to resist the possible load intended to be subjected to. In addition to these basic requirements, certain other properties may also be required such as an acceptable life at high temperature and an acceptable degree of Corrosion resistance. Others include wear and vibration resistance. Appropriate materials to satisfy these requirements must be selected for the sugarcane extractor's construction.

3.12 Fabrication Requirements

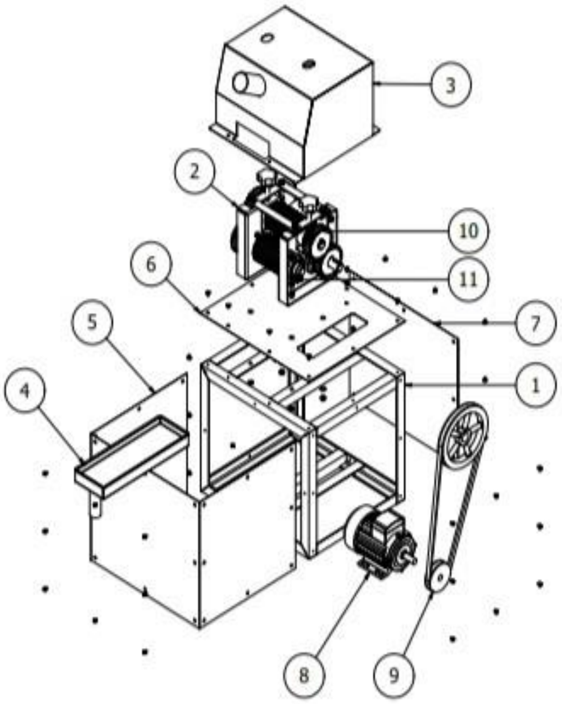
There are many ways of fabricating metals. Some metals are manipulated easily in the solid state to produce desired shapes, while some can only be produced to desired shape by casting. When metals are forged or rolled a lot of damage is done to them. The method and the ease with which material can be fabricated must therefore be considered in its selection.

3.13 Economic Requirements

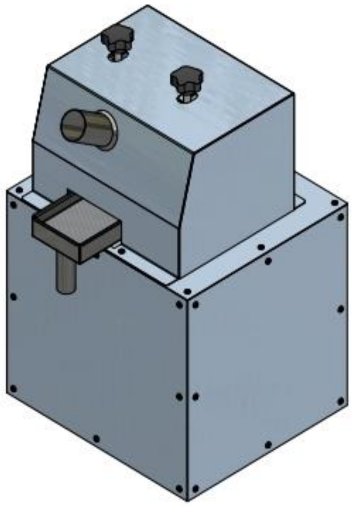
In any manufacturing or production, economic consideration has to be taken into account. The cost of raw materials and its manipulation (joining, finishing, machining etc) as well as labour, all adds to the total cost of the machine. Hence, all these cost has to be analyzed properly.

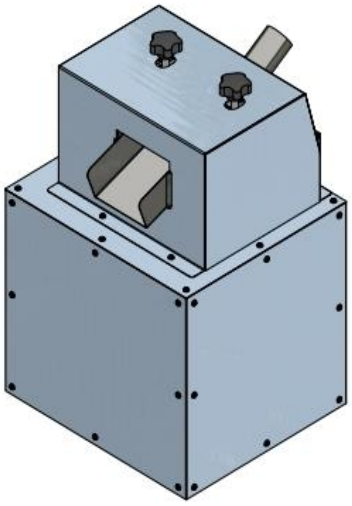
3.2 MACHINE COMPONENTS

A sugar cane juice extractor is a machine that can extract juice by squeezing and grinding the hard sugar cane pulp. The machine might be manually driven by human power or automatically driven by an electrical motor. In recent years, the manual machine becomes obsolete and replaced by the automatic one since it is not efficient and time-consuming. This electrical machine is made up of different systems which collectively give its efficient function. Those are: -



PARTS LIST			
S/N	PART/SUB-ASSEMBLY	QTY	DESCRIPTION
1	Frame	1	Machine Frame
2	Extraction Unit	1	Extracting Unit Assy
3	Hood Assy	1	Extracting Unit Cover
4	Sieve Tray Assy	1	Juice Tray Assy
5	Frame Cover A	1	Frame Main Cover
6	Frame Cover B	1	Frame Top Cover
7	Frame Cover C	1	Frame Rear Cover
8	Motor	1	AC Geared Motor
9	V-Belt transmission	1	Belt and Pulleys
10	Spur Gears	2	Spur Gears (2 pairs)
11	Bearing - FL004	4	Bearing with housing
12	Bearing - A 7004	2	Contact ball bearings
13	Key 6 x 6 x 22	3	Rectangular keys
14	Key 6 x 4 x 20	1	Rectangular key
15	Bolt - M6 x 20	16	Hex head bolts
16	Bolt - M6 x 16	2	Hex head bolts
17	Bolt - M4 x 5	43	Pan head bolts
18	Nut - M6	18	Hex nuts
19	Washer - 6	28	Plain washers





3.21 Crushing unit

The main parts of the machine are used to crush the cane and squeeze the juice from the raw cane. The crushing unit has3 rollers called the top, feeding, and discharge rollers. All three rollers have the same structure and size. The three rollers have a knurling like structure on their face to increase the surface roughness for easy gripping of sugarcane. Both the feeding and discharge rollers always rotate in the same direction. However, the top roller rotates opposite to the rest of the two.

3.22 Power source

The machine works automatically driven by an electric motor. An electric motor is a machine that converts electrical energy into mechanical energy. It operates through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of torque applied on the motor's shaft.

3.23 Power transmission unit

The power transmission unit is used to transfer energy from where it's generated to a place where it is used to perform work (from the motor to the crushing unit). Rotational power is produced by the motor transmitted through a series of chain drive, gears, shafts and keys to perform its work. The power transmission unit comprises the following:

- **A shaft** is a mechanical power transmission unit having a circular cross-section used to transmit the rotational power of the motor to the crushing unit and also it is used to mount another power transmission unit such as gears, chain drive and keys.
- **Gears** are rotating circular machine part having cut teeth which mesh with another gear or toothed part to transmit torque. They are considered a simple machine because different size gears can produce a change in torque and speed through their gear ratio.
- **Chain drive** is a type of mechanical power transmission system that uses chains to transfer power from one place to another. A conventional chain drive consists of two or more sprockets and the chain itself. The holes in the chain links fit over the sprocket teeth. When the prime mover rotates, the chain wrapped on the shaft's sprocket rotates with it. This applies mechanical force onto the driven shaft; transmitting mechanical power in the process. One of the main advantages over a belt drive is that a chain drive **maintains a constant speed ratio**, thanks to its zero slip features. There is no lag in power transfer and hence, it serves as a timing chain in applications such as internal

combustion engines. Having no slippage also ensures high mechanical efficiency. The only losses in a chain drive are due to friction between the chain links and the sprocket.

- **Keys** are a piece of mild steel inserted between the shaft and hub or boss of the pulley to connect these to prevent relative motion between them. It is always inserted parallel to the axis of the shaft. Keys are used as temporary fastenings and are subjected to considerable crushing and shearing stresses. A keyway is a slot or recess in a shaft and hub of the pulley to accommodate a key.

3.24 Body

Body or frame is used to prevent the intrusion of dust material and to prevent the occurrence of hand injuries. A wide variety of mechanical motions and actions may present hazards to the worker. These can include the movement of rotating members, meshing gears, and any parts that impact or shear. Additionally, it improves the aesthetics of the machine by balancing color, movement, pattern, scale, shape, and visual weight.

3.3 SELECTION OF MATERIALS

Having considered the service requirements, fabrication requirements and economic requirements above, the various components that made up the sugar cane extraction machine are therefore analysed and selected subsequently.

3.31 Selection of Material for Rollers

The rollers are subjected to external load from the motor as well as force exerted by the cane when it passes through the rollers during the juice extraction process. The rollers used in the sugarcane extraction machine are required to have high degree of corrosion resistance due to the high rate of moisture presence around them as a result of the direct contact with the sugarcane juice during extraction process. They are also required to be of high wear resistance. To resist this external force and to minimize wearing rate the material selected for this part should have high strength, stiffness or rigidity, wear-resistance, and minimum cost. The machinability also has to be excellent because there is different machining process done on the roller like turning, facing, drilling, boring, and knurling to have a better ground to extract the juice.

Two materials are identified of which one is to be selected for fabrication of the rollers. They are mild steel and stainless steel. The properties of these materials were compared to determine the most suitable and cost effective one among them. The comparison is contained in table 3.21.

Table 3.1 Property of Materials Used for the Design of Rollers

Material Property	**Materials**		**Remarks**
	Mild Steel	**316 Stainless Steel**	
Ultimate Tensile Strength (Mpa)	400-550	515-750	
Hardness (Brinell)	20-180 HB	160-250 HB	
Machinability	70%	45%	
Thermal Conductivity (W/mk)	51.9	16.3	
Corrosion Rate	0.5 to 1.0 mm/year in atmospheric condition and 0.02 to 0.08 mm/year in water	< 0.001 mm/year in industrial or marine environment.	
Corrosion Resistance	Poor corrosion resistance especially in humid and corrosive environments.	Highly resistance to corrosion due to its chromium and molybdenum content.	
Cost	Cheaper	Expensive	

Table 3.2 shows that Stainless steel is the best material for the rollers in terms of ultimate tensile strength (Mpa), hardness and corrosion resistance, while mild steel is the best based on machinability and cost. However, the rollers based on the requirements are required to be of high strength, wear resistance and corrosion resistance and stainless steel posses all these properties. Additionally, corrosion resistance is the most important factor to consider here due to direct contact the rollers have with the sugarcane juice because if the rollers corrode it will hamper

consumption safety of the juice. For that, Stainless steel meets this requirement, therefore selected to be used as roller material.

3.32 Material selection for shafts

A shaft is a rotating machine element which is used to transmit motion and power from one machine part to another. In our design, the shafts are used to transmit power and motion from the motor to the roller through pulley, v-belts, and gears. The gears and pulleys are mounted on the shaft they exert an external force on shafts. These shafts are subjected to shear stress, bending stress, and torsional stress. Due to this factor material selected for the shafts should have to be rigid, high strength, toughness, and wear-resistant. Steel are stiff materials and all steels have the same rigidity. For our design, we have selected two materials which are high carbon steel and alloy steel which are suitable for the fabrication of transmission shafts. The material properties of selected materials are listed in the table 3.22.

Table 3.3 Properties of materials used for the design of the shaft

Material property	**Materials**		**Remarks**
	High carbon steel (50%C)	**Alloy steel (35%Ni, 5%Cr2)**	
Ultimate Tensile Strength (Mpa)	690	765	
Hardness (Brinell)	197 HN	225 HN	
Machinability	55	65	
Thermal Conductivity (W/mk)	49.8	42.6	
Cost	Cheaper	Expensive	

Table 3.2 shows that both the high carbon steel and alloy steel have all the desirable properties and have made the minimum requirement for shaft material. However, high carbon steel is

cheaper compared to the alloy steel, hence, selected as a suitable material for the design and fabricate of the shaft.

3.33 Material selection for the cover

Covers are used mainly as a protection for the safe operation of the machine and give aesthetics to the machine. The material selected for this part should have to be ductile which is measured in terms of the percentage of elongation. This is since the sheet has to be folded easily, welded, and strong enough to withstand this machining process. We have selected two ductile materials and have a good machinability rate which is low carbon steel and alloy steel. Their material properties are listed in table 3.4.

Table 3.4 Properties of material used for the design of the cover

Material properties	**Materials**		**Remarks**
	Low Carbon Steel (Mild Steel 7%C4)	**Alloy Steel (Low Alloy Steel) A572**	
Ultimate tensile strength (Mpa)	420	450	
Elongation (in 50mm)	15	18	
Machinability (100%)	65	66	
Thermal Conductivity(W/mk)	45	42.6	
Cost	Cheaper	Less cheaper	

Table 3.23 shows that both the 2 materials are in close semblance in their properties. However, Low Carbon Steel is cheaper and more readily available, therefore, considered and selected for use as a material for the design and fabrication of the cover.

3.34 Material selection for bolt and frame

The frame is the load carrying member of the sugarcane extractor on which all other components of the machine are assembled on. It is threaded to allow bolts be tightened in to them. The material for the frame must be of high strength to ensure durability and structural integrity. On the other hand, the bolts are used on the machine to fasten and assemble parts of the machine to the frame. It is tightened on the frame so the frame acts like a nut. Therefore, for better tightening and gripping, same material will be used for both the bolts and the frame. Three materials are selected for that and they are high carbon steel, free cutting steel, and alloy steel. Their material properties are detailed in table 3.5.

Table 3.5 Properties of material used for the design of the frame

Material property	**Material**			**Remarks**
	High carbon Steel(60C4)	**Free Cutting Steel 40C15S12**	**Alloy Steel 40%Cr4MO2**	
Ultimate Tensile Strength (Mpa)	750	640	700–850	
Hardness (Brinell)	255	197	201–248	
Machinability	55	65	64	
Cost	Less Expensive	More Expensive	More Expensive	

Table 3.5 shows that both the 3 materials have excellent properties listed in the table. However, Cost and ultimate tensile strength are the most desirable factors and high carbon steel emerged as the most suitable based on these 2 factors. Therefore, high carbon steel is considered and selected as the most suitable material suitable material for the design and fabrication of bolt and frame.

3.35 Selection for Power Transmission

Mechanical power transmission system retrieves mechanical power from prime movers and subsequently delivers the same to the machine unit. It can also change the direction of rotation and alter the rotational speed to better match the requirement. The transmission system includes four drives (gear drive, belt drive, chain drive, and rope drive). Each drive has certain advantages over others and is suitable for specific applications.

These four mechanical drives can be classified in several ways. Based on the means of power transmission, such drives can be classified as friction drive and engagement drive. In friction drives, power is transmitted employing friction force between two mating parts, as in the case of belt drive and rope drive. In engagement drive, power is transmitted through successive engagement and disengagement, as in the case of chain drive and gear drive.

Table 3.6 Selection of Power Transmission Method

S/N	Criteria	Types Of Mechanical Drive			
		Flat Belt Drive	**V- Belt Drive**	**Chain Drive**	**Gear Drive**
1	Velocity ratio	Not constant	Not constant	Constant	Constant
2	Power transmission	Low	Good	High	High
3	Slip	Slippage	Comparatively small slip	No slip	No slip
4	Center distance	Long	Comparatively short	Medium	Short
5	Efficiency	Very good	Good	Excellent	Excellent
6	Absorb shock and damp vibration	Excellent	Excellent	Not good	Not good
7	Noise	More noise	Less noise	Higher noise	Have a noise
8	Compact layout	Not suitable	Suitable	Not suitable	Suitable
9	Ease of maintenance	Relatively simple	Relatively simple	Complex	Complex
10	Cost	Cheapest	Relatively cheap	Comparatively costly	Costlier

Table 3.6 above shows different criteria for each mechanical drive. Priority is placed on power transmission, efficiency and cost. Comparing these criteria in our design, high performance power transmission is required to be transmitted for the crushing of the sugarcane with maximum efficiency which can best be achieved with either gear drive or chain drive. Therefore, chain drive emerged as the best suitable mechanical drive to be used for transmission of power from the motor to the gearbox of the sugarcane extraction machine.

3.36 Selection of gear type for gearbox

Gears are toothed parts that convey motion, alter the speed or change direction. Gears are of so many types. However, four types of gears are generally in use in engineering. They include spur gear, helical gear, bevel gear, and worm gear. The first two gears are used for parallel shafts and the second two gears are used for non-parallel and perpendicular shafts. For our machine design, we use a parallel shaft because the rollers are assembled parallel to each other. Therefore, spur and helical gears are compared in order to come up with the best gear suitable for the design and construction of the machine. The properties of the gears are listed in table 3.26.

Table 3.7 Comparison of the spur gear and helical gear

Properties	**Types of gear**	
	Spur Gear	**Helical Gear**
The layout of the shaft	Parallel and coplanar shaft	Parallel shaft and non-parallel shafts
Velocity ratio	1:1 to 1:3	1:1 to 1:5
Speed	Low and moderate speed	Low to high-speed application
Power transmitted	Low power transmission	High power transmission
Load tolerance	Holding Less load	Holding More load
Durability	Shorter life	Longer life
Noise	Louder	Quieter
Efficiency	More efficient	Less efficient
Ease of fabricate	Easy	Comparatively complex
Cost	Cheaper	More Expensive

Table 3.7 above shows properties of the 2 gear types (Spur and Helical) considered for selection. However, for the purpose of designing a small portable sugarcane extraction machine, an easily manufactured and maintained, lower speed, efficient and cheaper gear type is required and spur gear satisfies these requirements. Thus, considered and selected for this design.

3.37 Selection of bearing type

Bearings are generally two types sliding contact bearing and rolling contact bearing. Sliding contact bearings are used in crankshaft bearings in petrol and diesel engines, centrifugal pumps, large size electric motors, steam and gas turbines, concrete mixers, and rope conveyors. On the other hand, rolling contact bearings are used in machine tool spindles, automobile front, and rear axles, gearboxes, small size electric motors, rope sheaves, crane hooks, and hoisting. Since a small sized electric motor is to be used to power the sugarcane extraction machine, therefore, rolling contact bearing is more suitable and hence, selected for this purpose.

3.4 DESIGN THEORY OF VARIOUS MACHINE COMPONENTS

Designing sugarcane juice extraction machine just like every other machine design, it require careful considerations, assumptions guided by theories and principles in order to develop a successful design. Therefore, during the design of our sugarcane juice extractor, the following were considered:

- The machine is composed of 3 rollers.
- The rupture force is gotten from compressive strength test as 1,140 N
- Roller diameter of 83 mm for the upper roller and 65 mm for the 2 lower rollers so as to achieve effective compression of cane are adopted.
- The length of the roller is selected to be 200 mm.

3.41 Design of Roller

3.411 Determination of cane size

Samples of different sizes of cane were obtained and diameters as well as masses of the samples were measured to obtain the maximum and minimum size of cane that can be crushed by the machine. The Measured values are listed in the table below: -

Table 3.8Measured value of different size sugarcane

S/N	Sugarcane Type	Mass(kg)	Diameter(mm)
1	Small	0.6	32.5
2	Medium 1	0.9	47.75
3	Medium 2	1.3	52.5
4	Large	1.5	59.8

So, the max size of the cane is 60mm and the minimum size is 33mm.

3.412 Size of roller to accommodate the varying sizes of sugarcane

The clearance that can accommodate the maximum and minimum size of sugarcane stalks that can be fed into the extractor is determined using equation (1)

$$x_1 = 2\left(\frac{R+\frac{i}{2}}{\cos\emptyset} - R\right) \qquad (3.1)$$

Where;

X_1 = Maximum size of sugarcane that can be fed into the machine

R = Radius of the roller, mm

L = Clearance between the top and feed roller, mm

2θ = Nip angel

The nip angle is a function of the coefficient of friction, μ, between the roller surface and the sugarcane surface, and the relationship between the nip angle and the coefficient of friction is such that;

$\theta = \tan^{-1}\mu$

where;

μ = coefficient of friction between the roller surface (medium carbon steel) and the sugarcane.

$\mu = 0.45$

$\theta = \tan^{-1} 0.45 \quad \theta = 24.22 \quad \approx 24°$

From equation 1 the formula of clearance is derived below:

$$L = 2(\frac{X_1}{2} + R) \cos\theta - 2R$$

$L_{max} = 2((\frac{60}{2} + 30.5) \cos 24 - 2(30.5)$

$L_{max} = 49.5 \text{ mm} \approx 50mm$

$L_{min} = 2(\frac{33}{2} + 30.5) \cos 24 - 2(30.5)$

$L_{min} = 24.87 \text{ mm} \approx 25mm$

For the design purpose, we select the minimum gap between the two rollers which is 25 mm.

3.413 Weight of crushing rollers

The weight of the crushing roller is estimated from equation (2).

$$W = \rho\, v\, g \quad \text{………...…………………………………} \quad (3.2)$$

Where;

W = weight of crushing roller

ρ= The density of the crushing roller material 7980 kg/m^3

v = Material volume of the roller (m^3)

g = Acceleration due to gravity, 9.8 m/s^2

The volume of the roller is calculated using the following formula,

$$V = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right) l + 2\left(\frac{\pi d^2}{4}\right) t \quad \text{………} \quad (3.3)$$

Where

D=Outer diameter of the roller

d = inner diameter of the roller

l = length of the rollers= 200 mm.

t= thickness of roller taken as 5 mm.

Combining Equation 2 and 3 we can determine the weight of the roller,

$$w = p \times \left[\left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right) l + 2\left(\frac{\pi d^2}{4}\right) t\right] \times g$$

For the upper roller D = 83 mm, d = 78 mm and t = 5 mm

$$W = 7980 \left[\left(\frac{0.083^2\pi}{4} - \frac{0.078^2\pi}{4}\right) 0.200 + 2\left(\frac{0.078^2\pi}{4}\right) 0.005\right] \text{x } 9.8$$

$W = 13.6N$

For the 2 lower rollers D = 65 mm, d = 60 mm and t = 5mm

$$W = 7980 \left[\left(\frac{0.065^2\pi}{4} - \frac{0.060^2\pi}{4}\right) 0.200 + 2\left(\frac{0.060^2\pi}{4}\right) 0.005\right] \text{x } 9.8$$

$W = 9.9N$ each

Total weight of the rollers = 13.6 + 2(9.9) = 33.4N

3.414 Crushing force of rollers

The crushing force on the roller is expressed as given in equation 4.

$F_c = R_f \times F_s$ ....

(3.4)

Where;

R_f =Rapture force of sugarcane = 1,055N

F_s= Factor of safety = 0.7

$F_c = 1{,}055N \times 0.7$

$F_c = 738.5N$

3.415 Crushing torque of roller

The crushing torque on the roller is expressed as given in equation

$T = F_c \times r$ ……………………… (3.5)

Where;

T= Torque on the roller

F_c=Crushing force of sugar cane

r = Radius of the roller

$T = 738.5N \times 0.0325$

$T = 24N\,m$

3.416 Rotating speed of the roller

The choice of roll speed affects the production rate. Low speed is required for large diameter rolls, while for smaller rolls high speed is required. Wills and Napier Munn, indicated that the peripheral speed of rolls ranges from 1m/s for small rolls to 15m/s for the largest rolls. For our design, we select a velocity of m/s.

By converting velocity to rpm and angular velocity the corresponding values can be found.

•Speed of crushing roller

$N(rpm) = \frac{60}{2\pi r} v$ ……………………… (3.6)

$$= \left(\frac{60}{2\pi \times 0.0325}\right) 1m/s$$

$= 293.8 \approx 294\ r\,p\,m$

•Angular velocity crushing roller determine from equation 7,

$\omega = \frac{2\pi N}{60} = \left(\frac{2\pi \times 294}{60}\right) = 31\ rad/s$……..……… (3.7)

3.42 Selection of motor

3.421 Design of motor power

A velocity ratio between the motor and the crushing roller is chosen as 0.9. That will be achieved through the combination of chain and gear train.

$\omega_m = \omega_r \times 0.9 = 31 \times 0.9 = 27.9 rad/s$

The power required is calculated using equation 8

$$P = T \times \quad \text{....................} \qquad (3.8)$$

$$P = 24\text{x } 27.9 \, rad/s = 669.6 \text{ W}$$

$$\text{HP} = \frac{P(w)}{746} = \frac{669.6}{746} = 0.898 \approx 1\text{HP}$$

Therefore, 1 HP and 1450 rev/s motor is selected.

3.43 The Chain Drive

The required chain drive was calculated using equation (9) (Khurmi & Gupta 2010)

$$Design\ power\ per\ strand = \frac{Transmitted\ power \times Service\ Power}{No\ of\ strand} \text{...........} \qquad (3.9)$$

Where

Transmitted Power is 710 kW

Service Power is 1.35

$$Design\ power\ per\ strand = \frac{710 \times 1.35}{1} = 958.5 \text{ kw/Strand}$$

3.431 The Actual Speed of the Roller

The actual speed of the rollers was obtained using equation

$$\frac{D_2}{D_1} = \frac{N_1}{N_2} \text{....................} \qquad (3.10)$$

Where

D_1 =Diameter of the driver = 5.77 mm

D_2= Diameter of the driven = 91.1 mm

N_1=Speed of the driver = 1450 rev/min

N_2= speed of driven pulley =?

$$N_2 = \frac{N_1 \times D_1}{D_2} = \frac{1450 \times 5.77}{91.1} = 91.8 \text{ rev/min}$$

3.432 Power Transmitted by Chain

The power transmitted by the chain basis on breaking load was calculated from equation

$$Sf = \frac{WB \times V}{n \times Ks} \quad \text{……………………….} \quad (3.11)$$

where

W_B is the braking load in Newton, which is 8971 N

V is the velocity of the chain in m/s, which is 0.45 m/s

n is the factor of safety which is 30.7 Ks is the Service factor K_1 x K_2 x K_3

K_1 is the load factor, which is 1.25, K_2 is the lubrication factor, which is 1.5, K_3 is the rating

Factor, which is 1 Sf is the power transmitted by a chain

$$P = \frac{8971 \times 0.45}{30.7 \times 1.875} = \frac{4036.95}{57.5625} = 70.1\, watt$$

3.44 Design of shaft diameter

To design the shaft equation 12 below can be used

$$d^4 = \frac{584 M_t L}{G\theta} \text{…………………………….} \quad (3.12)$$

Where, L = length of shaft (270mm)

G=modulus of rigidity (80 GPa)

θ = angular deflection (0.5)

D= diameter of shaft

$$d^4 = \frac{584 M_t L}{G\theta}$$

$$d^4 = \frac{584 \;\; X \;\; 5 \;\; X \;\; 0.27}{80 \;\; X\, 10^9 X \;\; 0.5}$$

$$d = 0.012\, m$$

$$d = 12\, mm$$

The diameter of the solid Shaft, d is 12 mm

3.45 Design of gear

Assumption

I. Pressure angle of 20^0 is selected,

II. The module of the pinion is 3

III. For 20^0 pressure angles to avoid interference between full depth gear and full depth pinion minimum number of pinion teeth should be 18. Therefore we select the number of teeth of the pinion gear is 26.

- Pitch circle diameter of a pinion (d_p)

$d_p = module \times N$ …………………

(3.13)

$d_p = 3 \times 26 = 78\ mm$

- Pitch radii of a pinion (r_p)

$$r_p = \frac{d_p}{2} \text{………………..……………..….} \qquad (3.14)$$

$$r_p = \frac{78}{2} = 39\,mm$$

- Circular pitch (p_c)

$$P_c = \frac{\pi d}{N} \qquad (3.15)$$

$$p_c = \frac{\pi\,(78)}{26} = 9.426$$

- Base pitch (p_b)

$$p_b = p_c \cos \emptyset \qquad (3.16)$$

$$p_b = 9.426 \cos\ 20^0$$

$$p_b = 8.87\,mm$$

- Diametral pitch (p_d)

$$P_d = \frac{\pi}{P_c} \qquad (3.17)$$

$$p_d = \frac{\pi}{9.426} = 0.333\ mm$$

- The addendum(a)

$$a = \frac{1.0}{p_d} = 2 \qquad (3.18)$$

- The dedendum (b)

$$b = \frac{1.25}{p_d} = 2.5 \qquad (3.19)$$

- The whole depth (h_t)

$h_t = a + b$ ………………………………………… (3.20)

$h_t = 2 + 2.5 = 4.5$

- Clearance (c)

$c = b - a$ …………………………………………

(3.21)

c= 2.5 − 2 = 0.5

- The outside diameter (D_{op}) of each gear

$Dop = dp + 2a$ ……………… (3.22)

$Dop = 78 + 2\ (2) = 82mm$

3.5 FABRICATION METHOD

Fabrication methods or processes are the steps through which raw materials are transformed into a final product. In the previous chapter raw materials have been selected for each part. And then the machine parts are designed using material properties, material specification, a different theory of failure, and some parameters taken from the previous design. Then dimension from the design is used to fabricate the workshop part. But all parts are not fabricated in the workshop, so they can be purchased from the market using dimensions gated from the design. There are different fabrication processes in mechanical engineering like shaping, machining, surface finish, joining, and processes affecting changes in properties. Now in this topic, we will see how to fabricate the sugar cane machine parts in a workshop by using different machines and machining operation through a step-by-step procedure.

3.51 Fabrication of roller

In the fabrication of roller different machining processes are performed. The main machining process used to fabricate the rollers is turning, facing, drilling, boring, and knurling which are called turning operations. These operations are performed by using a lathe machine. Steps for fabrication of the roller are listed below: -

- The first medium carbon steel rod with a dimension larger than the desired size is prepared by cutting using a machine tool power hacksaw.
- A small hole more like an indent is created on one face to align the shaft at the center by using tailstock.
- The turning process comes next; during the turning process cutting tool removes material from the outer diameter of the rotating work piece. There are two turning operations rough and finish. First, we roughly turn the part to decrease within a short time disregarding the accuracy and surface finish. Then finishing turning produces a smooth surface finish with accurate dimension.
- Drilling operation performs which remove material from the inside of the workpiece. It will give a hole with a diameter equal to the size of the utilized drill bit.
- After drilling boring operation is following, in boring operation, the tool enters the workpiece axially and removes material along the internal surface to enlarge the existing hole to the desire diameter
- Then in order to increase gripping friction between the roller and the sugar cane a knurling operation is performed on the roller. This operation produces serrated patterns on the surface of a part. And we use the most common pattern which is the diamond pattern.

- Lastly, facing operation is performed. It is used to decrease the length of the roller to the final size and smooth face surface by removing the thin layer of the material.

3.52 Fabrication of Shaft

The shaft fabrication process is almost the same as the roller. The machining process includes turning, step turning, facing, and milling. The turning operations are done by the lathe machine. There is a keyway on the shaft to do this feature we use a milling machine. The procedure followed to fabricate the shaft is listed below.

- A high carbon steel(50C4) rod is first prepared by cutting with a dimension greater than the required one. The size is increased to have a comfortable machining process and a good surface finish.
- The workpiece is then fixed to chuck on the lathe machine then turning operation is performed. The shaft has a step to produce these feature multiple passes at a small radial depth of cut is necessary. Step turning creates two surfaces with an abrupt change in diameter between them. The final future resembles a step.
- The length of the workpiece is slightly longer than the final part so it should be faced. During the facing, the tool moves along the radius of the workpiece to produce the desire part length.
- Then keyway on the shaft is done by a keyway milling operation. This operation can be done either on a specialized keyway milling machine or ordinary mills. The workpiece is clamped by the fixture, and the keyway milling cutter is used to mill it layer by layer.

3.53 Fabrication of key

Sunk keys have been chosen for our design. They have a rectangular shape. A plain carbon steels (50C4) rectangular bar is used for the fabrication of key. The sunk key is fabricate using a milling machine. The step for fabrication this key is very simple it is listed below: -

- First rectangular steel rod is cut to a desired shape.
- The workpieces were fixed on the fixture of the milling machine.
- The machining operation facing is performed on the rectangular bar to give the final shape and smooth surface finish.

3.54 Fabrication of spur gear

Spur gear is fabricated with the help of cutting. Yet there are many other forming processes like casting, rolling and forging. We can use either of the processes but for our design, we use a gear cutting process. Gear cutting is a machining process for creating gear. The most common gear-cutting processes include hobbing, broaching, milling, and grinding. Hobbing is the most common method that is utilized in the cutting process due to its versatility and efficiency. A step-by-step procedure of fabrication spur gear using a hobbing process.

- Raw material is brought from a market which is a circular rod within the desired diameter.
- In sawing process, the material is cut to the size.
- Using a lathe machine, a turning process proceed. In this process, a cut work piece is shaped into a gear blank.
- Gear cutting is done with a hobbling machine. The hobbling usually leaves burrs on the teeth.
- Burrs on the teeth have been removed with a deburring machine to give a clean and polished look.
- Lastly for gear to have a long lifespan finishing is crucial. Black oxide finish is performed on the gear in preventing the rust on the spur gear.

Spur gears can be cut or ground by a milling machine or jig grinder utilizing a numbered gear cutter, and any indexing head or rotary table. The number of the gear is determined by the tooth count of the gear to be cut. The most common method of cutting the spur gears on a milling machine is by form cutting. This is done by taking a blank gear and rotating a cutter, with the desired tooth pattern, around its periphery. This ensures that the gear will fit when the operation is finished.

Steps for fabrication of gear on a milling machine.

- The cutter is formed according to the shape of the tooth.
- The space to be removed between two adjacent teeth by a form milling cutter.
- The cutter is attached to the mandrel and connected to the dividing head.
- The selection of cutter is depending upon the size of the gear tooth and no of teeth.
- Finally, the cutter cut the gear teeth to the desire shape.

3.55 Fabrication of frame and cover

The fabrication method of frame and cover is made by casting which requires preparing a pattern that has the same shape as the frame and cover but is constructed from simple material such as wood, metal, or plastic with slight dimension difference to compensate for contraction of molten metal during solidification. Then the pattern is placed on sand to create mold and the gating system is prepared on the mold for the entry of molten metal. The pattern is removed and molten metal is filled into a molten cavity. After some time, the molten is cooled then the frame and cover are removed from the mold by destroying the sand mold.

3.56 Fabrication of bolt and nuts

In the fabrication of bolts and nuts, there is two fabrication processes. Those are forming process without cutting and machining process. Informing process, it includes cold forming (cold extrusion) and hot forming.

- Forming process
- Cold forming

In modern fastening technology, the majority of fasteners are made using the cold forming procedure. In this procedure, the fastener is formed, usually in multistage processes, by pressure forging, cold extrusion and reducing, or a combination of these procedures. The term solid or cold forming was coined for this type of production. This procedure is usually used for large quantities, because, from an economic aspect, it is the most rational method. Hot forming

This production method is used mainly to fabricate large diameters starting with approx. M27, and longer pieces starting from approx. 300 mm. Besides, there are parts cannot be produced using cold forming because of the very small volumes, or because of a very high degree of forming. With this procedure, the input material (usually bars) is heated wholly or partially to forging temperature. This heating up enables even complicated geometries or very high degrees of forming to be realized.

- Machining

Machining is usually understood as processing steps such as turning, milling, grinding, or reaming. The most common method concerning fasteners is turning. During turning, the required contour of the component is cut from the input material using a turning tool. The diameter of the input material depends on the largest diameter of the component. Usually, bars with a length of up to 6 m are used.

3.57 Bearing

In ball and roller bearings, the rolling elements and the races are subjected to high local stresses of varying magnitude with each revolution of the bearing; therefore the material of the rolling element (i.e., Steel) should be of high quality. The balls are generally made of high carbon chromium steel. The material of both the balls and races are heat-treated to give extra hardness and toughness. The rollers are fabricate by hot forging on hammers from steel rods. They are then heat-treated, ground, and polished. The races are also formed by forging and then heat-treated, ground, and polished.

3.6 ASSEMBLY METHOD

Sugar cane juice extraction machine is a combination of different parts. These parts should have to be assembled to function properly. The assembly processes of the sugarcane extractor machine start with the assembly of bearing in the frame by a press-fit after that the shaft is assembled in the bearing on one half of the frame. Then the key assembled on the shaft keyway and rollers which are a hollow shaft are assembled on the solid shaft and the key. Then the other half of the frame is assembled to the first half including shaft, key roller, and bearing. All the gears assembled with the key and shaft in their appropriate position. The first gear assembled on the driving shaft. The second two gear assembled on the first driven shaft. The fourth gear assembled on the second driven shaft. A key is assembled between the gear hub and the shaft.

The bigger pulley is mounted on the load shaft with a key in between them. The smaller pulley is assembled on the motor shaft which is used as a power transmission medium between the motor and the bigger pulley. The motor and the driving shaft are connected by using a V-belt which is mounted on the bigger and smaller pulley. The cover is assembled to the hole part of the machine for protective measure and bolted with the frame. Finally, the Filter is placed underneath the rollers to clarify the juice.

3.7 PERFORMANCE EVALUATION OF SUGARCANE JUICE EXTRACTION MACHINE

Preliminary machine testing was carried out to assess the effective performance of the machine components and to examine the machine's efficiency. Stalks of sugarcane were bought from the market, weighed, and fed into the machine through the feed pipe and the extracted juice was collected through the extraction unit. For each extracting process, the time taken from the start of each crushing/juice extraction process was recorded.

The bagasse remains and the juice extracted were collected to determine the extraction efficiency of the machine.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter contains the result obtained, safety precautions, performance evaluation and discussion of result.

4.2 Performance Evaluation

The machine was evaluated using the following indicators and the results of the test are tabulated below

$$J_E = \frac{W_{JE}}{W_r - W_{db}} \times 100\%$$

J_E = Extraction efficiency (%)

W_{JE} = weight of juice extracted

W_r= Weight of raw sugarcane

W_{db} = Weight of dry bagasse

T = Time used for extraction

$$C_J = \frac{W_{JE}}{T} \; (Throughput\ capacity\ of\ the\ machine - KhurmiandGupta2008)$$

C_J = Throughput capacity of the machine (Kg/h)

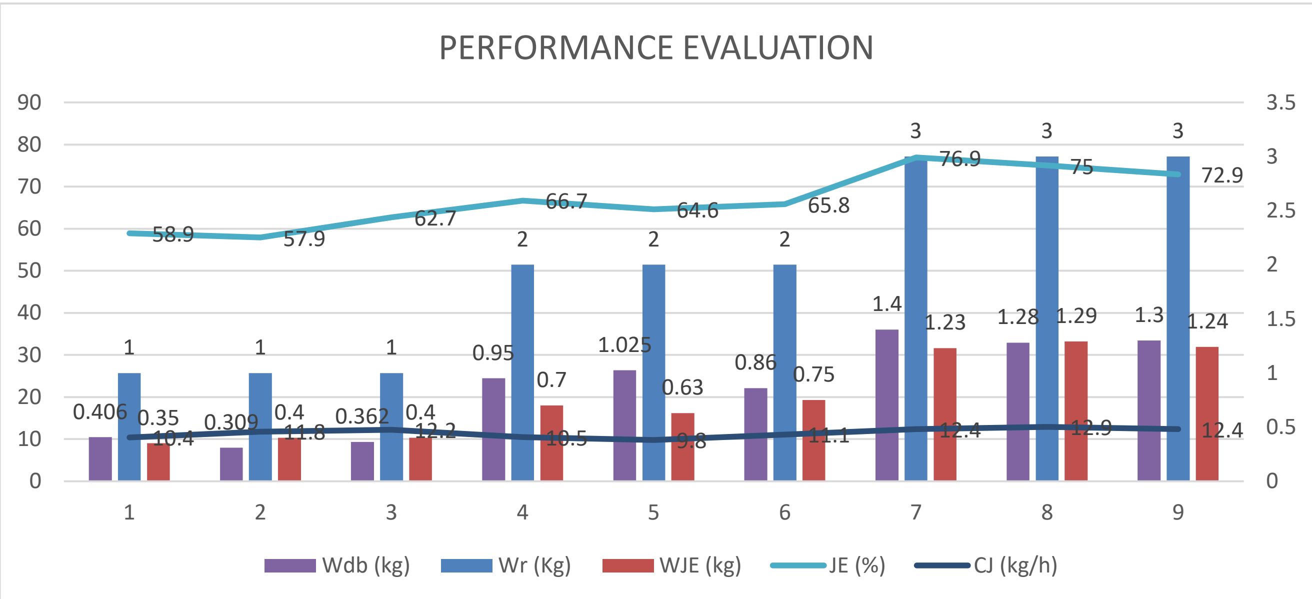
W_{wb} = Weight of wet bagasse

4.3 DISCUSSION OF RESULT

The performance evaluation of the sugarcane juice extractor was conducted using varying quantities of sugarcane, and the results are summarized in Table 4.1. The extraction efficiency was measured for three different quantities of sugarcane: 1 kg, 2 kg, and 3 kg, with each weight being processed three times. When more sugarcane is processed, the extraction efficiency improves. For 1 kg of sugarcane, the average extraction efficiency was 59.8%. This efficiency increased to 65.7% for 2 kg and further to 74.9% for 3 kg. The machine can exert greater force on larger quantities of sugarcane, allowing for more juice to be extracted, which explains the increase in efficiency. Additionally, the throughput capacity (measured in kg/h) was recorded for each process. For 1 kg of sugarcane, the throughput ranged from 10.4 kg/h to 12.4 kg/h, while for 2 kg and 3 kg, the throughput capacities ranged from 9.8 kg/h to 12.9 kg/h. Although there is a slight fluctuation in throughput capacity, these values indicate that the machine operates efficiently across different loads. *Olaoye (2011)* worked on the development of sugarcane juice extractor for small scale industries which the efficiencies ranges between 40% and 61%, depending on the operating speed and cane size. *Dauda et al*. reported to have an average extraction efficiencies for two varieties of sugarcane tested were 64.97% and 56.90%. The two reports indicate that a significant portion of the juice remains in the sugarcane bagasse after extraction.The machine demonstrated an impressive 76.9% extraction efficiency in the 3 kg trial, showcasing optimal performance when handling larger quantities. This finding is significant as it suggests that the machine could prove particularly valuable in small-scale industries where maximizing juice yield is crucial. Considering its operating speed of 1450 rpm, the machine's overall performance is noteworthy. It’s simple and robust design allows it to consistently process different sugarcane loads with minimal variations in efficiency and throughput. This consistent performance highlights the machine’s potential as a cost-effective and efficient tool for small and medium-scale juice extraction businesses.

Table 4.1: Table containing results obtained

S/N	Wr (Kg)	WJE (kg)	Wwb (kg)	Wdb (kg)	JE (%)	T (h)	CJ (kg/h)
1	1	0.35	0.571	0.406	58.9	0.0336	10.4
2	1	0.4	0.4	0.309	57.9	0.0339	11.8
3	1	0.4	0.5	0.362	62.7	0.0328	12.2
4	2	0.7	1.2	0.95	66.7	0.0669	10.5
5	2	0.63	1.4	1.025	64.6	0.0641	9.8
6	2	0.75	1.2	0.86	65.8	0.0675	11.1
7	3	1.23	1.9	1.4	76.9	0.0992	12.4
8	3	1.29	1.83	1.28	75.0	0.0997	12.9
9	3	1.24	1.91	1.3	72.9	0.1003	12.4



CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The design, fabrication, and testing of the sugarcane juice extractor were completed. The machine demonstrated an average extraction efficiency ranging from **59.8% to 74.9%**, depending on the quantity of sugarcane processed. The highest efficiency was recorded when 3 kg of sugarcane was processed, showing that the machine can handle larger loads effectively. The throughput capacity, ranging from **9.8 kg/h to 12.9 kg/h**, demonstrates that the machine is capable of consistent performance across different load sizes. The machine's simple design, ease of operation, and cost-effectiveness make it a valuable asset for small-scale farmers and juice extraction businesses.

Furthermore, the machine’s components, such as the stainless-steel rollers, ensure durability and hygiene, which are essential for food processing. The machine has proven to be a reliable solution for sugarcane juice extraction, particularly in rural or small-scale industrial settings.

5.2 RECOMMENDATIONS

Based on the successful outcomes of the project, the following recommendations are proposed:

1. **Automation Enhancements**: To reduce manual labour and improve operational efficiency, it is recommended to integrate an automatic feeding mechanism. This could be especially beneficial for larger-scale applications where continuous operation is required.
2. Regular Maintenance: Establish a regular maintenance schedule to ensure long-term performance. Inspect and lubricate rollers and shafts to prevent wear and tear.
3. **Scaling for Larger Operations**: The machine's efficiency clearly warrants further research to scale up the design for larger industrial applications. This will involve increasing motor capacity, adding more rollers, and enhancing throughput to meet higher demand.

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