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Design and Fabrication of Hexagonal Drumhoneyextractor

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ABSTRACT
Honey is the natural sweet substance produced by honey bees from the nectar of blossoms or from the selection of living parts of plants or excretions of plant sucking insects on the living parts of plants, which honey bees collects, transformed and combine with specific substances of their own, store and leavein the honey comb to ripen and mature in which all commercially required characteristics of the production are described. Bee is also a winged, flower-feeding insect which have branched body hairs. Indeed, bees are dependent on pollen as a protein source and on flower nectar or oils as an energy source. Bees are the most significant pollinating insects. Their interdependence with green plant makes them an excellent example of the type of symbiosis known as mutualism. Consequently, two parties of an unlike organism's benefits from each other. In this research work, the need to design and fabricatea honey extracting machine is very important. The dimensions of hexagonal drum (702mm x 790mm).also includes shaft ($\theta 30$ mm $\times$ 1.5 m long), pinion shaft ($\theta 40$ mm $\times$ 600 mm long,basket frame 1 mm thickness plate mesh, bearing housing ($\theta 50$ mm $\times 40$ mm wide) and out-let/tap ($\theta 30$ mm $\times$ 1 mm thickness plate). The overall proposed size of the exacting machine would (702 mm $\times$ 790 mm $\times$ 1,026 mm).Design parameters such as torque, bending stress, shaft diameter, and centrifugal force were also stated The results obtained wouldbe require for proper functioning of the machine. Performance test evaluation was determined to arrive at sustainable required efficiency of 86% for optimum performance of the machine compete with international standard of 85%.

I. INTRODUCTION

Honey is the most important primary product of' beekeeping both from a quantitative and an economic point of view. Honey equally has colourful variety of uses. in other products for example in bakery, confectionery and in of cosmetics. Because of these important reasons honey is being. extracted (collected) to meet the demand both in raw form or as valued added to other products using rudimentary methods by the local beekeepers, this method is inefficient and time consuming. Various extractors that are used for honey extraction exist world wide ranging from manual operated to automated honey extractors (Oluka, 2015).Stainless steel material would be used to give optimum best quality of the honey compared to the honey extracted using mild steel and the like.

The poor extraction and filtration processes of honey processing by the existing methods which have led to increased demand for high value: honey in the markets warrants the development of low cost, locally made and portable hexagonal drum honey extractor that can be accessed by the honey farmers. (Onwuamaeze and Joel, 2018). This study therefore aimed at developing of honey processing machine that integrated the processes of honey processing; extraction, filtration, and clarification with heating mechanism. The availability of this machine improves the extraction and filtration processes relief the honey farmers of their drudgery in producing honey, create self-employment for the. jobless and finally increase the economy of Ile-Oluji, Nigeria through exportation of this 'honey and its products. (Akinnuli et al., 2015).

Honey in this research referred to the honey produced by Apis mellifera. Honey is used in moisturing and nourishing cosmetic creams but also in pharmaceutical preparations and also applied directly on open wounds, sorbed sores, ulcers, varicose ulcers and burns. It helps against infections promotes tissue regeneration and reducesscarrig also in its pure, unprocessed form (Biesmeijer, 2003) and (Shrestha, 2018) further emphasized that honey improves food assimilation and is to be used for chronic and infective intestinal problems such as constipation, duiodenal ulcers and liver disturbance. A lot work has been done on honey therapy by (Fatimah, et al, 2013) and (Fasasi, 2012). The tropical applications under controlled conditions have shown underrated wound healing in animals (Assia and Ali2015) and of experimental burn wounds in rats but also of various types of wounds including post operation ones in humans (Orhorhoro etal, 2016).

Honey can be made dried or dehydrated by various industrial techniques by including inclusion in some recipes (Maradun, and Sanusi, 2013). According to (Orhorhoro etal, 2016) dried honey described to be hygroscopic and needs to be stabilized by mixing other powders such as starches, flours or other non hygroscopic sugars. This can be made to a powdered honey which can be used in dry mixes for cakes, breads, and drinks or energy health powders and avoids the need to handle any liquid or sticky honey. (Khan et al., 215) discusses theuse of dried honey in baked goods in Germany. (Akinnuli et al., 2016) describes different production techniques used in Turkey to stabilized dry honey powder.(Rahman et al., 2019)reports granular dried honey as reducing shrinkage of meat products by 19% and production of an additive free dried honey powder has been mentioned in the speedy bee (1988).Because of these aforementioned benefits derived in honey, its extraction is very important to make it available for its unlimited demands.

Generally, honey extracted traditionally does not meet up with international market standard; therefore, there is the need to design and fabricate a honey extractor; a mechanical device that extracts honey from the honeycomb without destroying the comb. Honey extractor is a mechanical device used in honey extraction. It extracts the honey from the comb without destroying the comb. Extractors work by a centrifugal force. A drum holds a frame basket which rotates throwing the honey out of the comb. With this method, the wax comb stays intact within the frame and can be reused by the bees. This concept is very important to bee keepers. It is basically a manually operated machine; the different components are made from available and affordable materials. This machine is designed to be used at any time of the day no matter the temperature or weather conditions. Bees cover the filled in cells with wax cap that must be removed. There are different types of electrically operated extracting machine; there is the twenty frame extractors loaded with four frames turning. In this research, extracting machine is either tangential or radial depending on how the frames are put into the basket. The aim of this research work is to design and fabricatea honey extractor to compete with international market standard base on quality.

II. LITERATURE REVIEW

Almost 20 years ago, industrial consumption of honey was only 5 to15% of total honey consumption (Rahman et al., 2019).This proportion has increased in the meantime and is expected to continue increasing considering the advantageous consumer appeal of products with honey as an ingredient. It is possible to enjoy extracted honey without recourse to machine extractor, using basic kitchen implements to cope with one or two supers. It will betime consuming, sticky and inefficient, but if it means that her beekeepers family can obtain some benefits from his or her obsession, it will be worthwhile. Series of extractor have been developed in advance countries e.g. United States, Germany, Australia, Italy and other such extractors as tangential, radial, automatic programmable and electrical driven types (Biesmeijer, 2003).

A fortunate beginner will not be able to buy the types mentioned above because of their costs. In addition to the above, if intending to purchase, the choices faced are tangential or radial? Plastic or Stainless steel, manual or electric driven? Therefore, there is need todevelop in portable hand driven radial type extractor of low cost used for commercial purpose with its material locally sort for and electricity which its supply is irregular was considered. (Friday et al., 2021).

Honey is a traditional medicine or food in nearly all societies and whether sold simply at village level or packaged more sophisticatedly, honey generates income and can create livelihoods for several sectors within a society (Chikamai et al., 2009). Beeswax is also a valuable product from beekeeping, although in some places its value is not appreciated. One of the key challenges faced by local farmers or honeybee keepers is the extraction of honey from the honeycomb. It is therefore imperative that machines be designed that will help the local farmers in not only increasing production to meet the demands but also in extracting honey from honeycomb in a more hygienic process.

The recent increase in the demand of honey is because of its great economic importance which ranged from numerous uses as food to medical relevance. To meet this demand requires extracting honey from the honeycomb in an efficient way different from the obsolete and traditional methods currently used by local beekeepers. To remove the honey from the combs efficiently, there is need for a mechanical device for the removal of honey from the honeycombs without compromising the quality or the natural form of the honey (Shaaban et al., 2019). This can be achieved through the design of an extractor. It has been reported that the microorganisms which affect the quality of honey usually come from the nectar and pollen, but more particularly from the processing method, areas and containers which are usually not hygienic (Adadi and Obeng, 2017). Presently, Nigeria honey is being adulterated and fall short of imports to other countries (Ayansola and Banjo, 2011). This has been attributed to quality issues arising from the traditional method of honey extraction currently used by honeybee keepers, which impacts negatively on the quality of the honey.

Shaaban et al. (2019) believed that if beekeeping is being promoted and encouraged, then it must be wholly sustainable, using equipment, which is available locally. He further stated that although equipment can be imported to serve as a prototype, small-scale beekeeping can only be economical in the long-term with equipment, which can be serviced and manufactured locally. Research work of (Assefa, 2009) and Abera et al. (2016) reported that one of the major problems facing the profitability of beekeeping for honey production in developing countries, particularly in among African countries is the lack of appropriate equipment for honey extraction.

Assefa also (Assefa, 2009) in his study reported that apart from the known basic hive tools, many of the materials needed for honey extraction are either non-existent or kept by quite a few. The honey extractor was reserved at the centre of the Pyrrolizidine Alkaloids (PAs) for demonstration purpose. All equipment for low technology beekeeping must be made locally as reported by Martin et al. (2011). They noted that beekeeping equipment should not be used unless the infrastructure exists for manufacturing it locally. Most of the equipment or honey extractors used in developed or industrialized countries are non-existence in Nigeria as well as in many other African countries (Assefa, 2009). Due to their costs and maintenance requirements is usually well above farm household possibilities. It is therefore expedient that honey extractor is fabricated locally using available local materials and designed and developed for the extraction of honey from honeycombs in developing countries, particularly in Nigeria.

III. MATERIALS AND METHOD

3.1 Framework for Honey Extracting Process

Factors that hindered extracting of Honey in terms of quality in design process were identified using questionnaire administration and oral interviews of manufacturing experts. These extracting challenges were caused by both external (outside production system) and internal (within production system) factors, individually and collectively. The identified internally factors are manpower, money, machine, management, information /communication, material and marketing while external factors are Quality / Reliability / Quantity. The propose block diagram that shows the relationship among the internal, external onextracting system effectively is given in Figure 1.

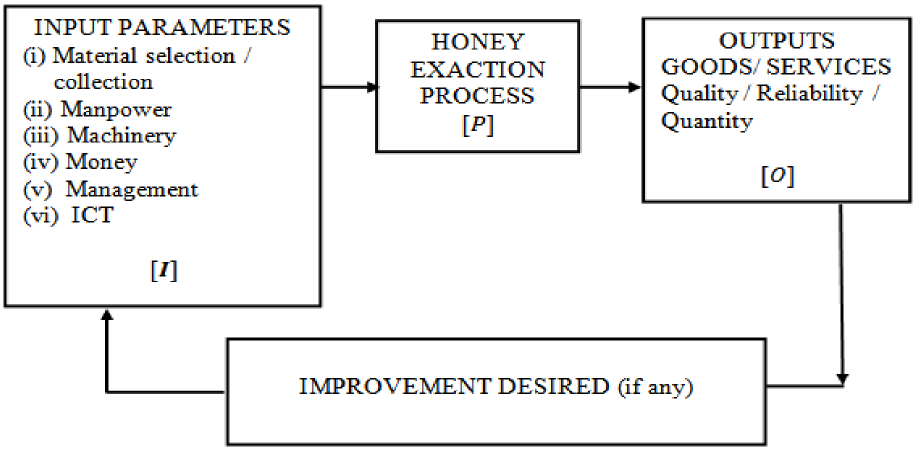

Figure 1: Block Diagram of Hexagonal Drum Honey Exacting Process

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3.2 Material Selection

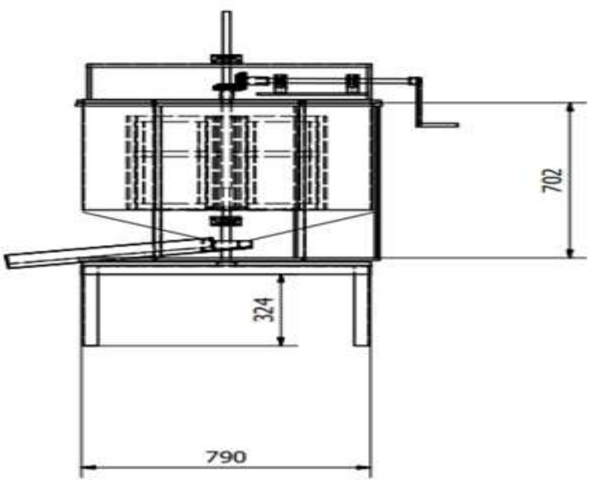
The shaft, bearing housing out-let steel and electrode were stainless steel. used The basket frame as well as the hexagonal cylindrical drum container was also made of stainless metals respectively. These decisions would betaken to avoid rust and to give optimum quality of the honey.

Table 1: List of Material Required

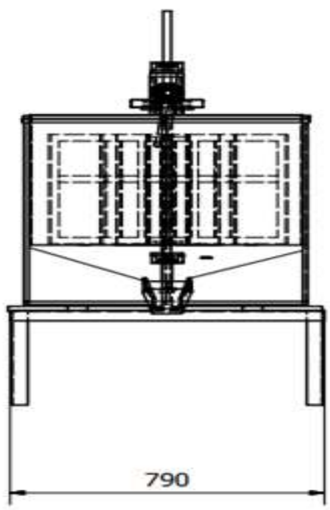
S/n	Items	Qty
1	Stand	1 piece
2	Base shaft	1 piece
3	Hexagonal Drum(1.2mm thick stainless steel	1 piece
4	Pillar frame (θ16m rods)	1 piece
5	Bearing Housing (θ80mm × 40mm) Stainless steel	2 pieces
6	Shaft θ30mm × 1.5mm long)Stainless steel	1 piece
7	Flange	2 pieces
8	Basket frame	1 piece
9	Top support	1 piece
10	Bevel Gear (Wheel and Pinion)	2 pieces
11	Bevel Gear shaft	1 piece
12	Pillow Bearing housing (P205)	2 piece
13	Handle	1 piece
14	Drum base	1 piece
15	Electrode: (Stainless electrode, gauge 12)	3 packets

3.3 Construction Details

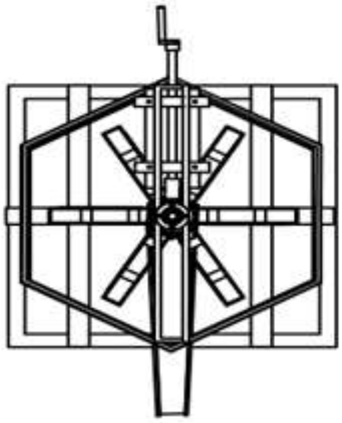
All produced parts was coupled together or fixed together to their position. Operations carried out include riveting, bolting, press-fitting of bearings, keying of pulleys and welding. The conceptual design selected for detained designs is the combined honey extractor and processor assembly, which will also act as a settling and filtering tank. All the operations of honey extraction, processing, settling and filtering that was usually carried out via four different equipment was carried out in this one-unit equipment (the combined honey extractor and processor assembly). The equipment designed and constructed will extract honey from honey combs in frames by a centrifugal force, and process it by indirect heating through a heat transfer medium and settling and filtering in the same unit for packaging. The dimensioned, orthgraphic and isometric views as well as assemble drawing were shown in figures 2, 3, 4 and 5 respectively.



FRONT VIEW



END VIEW



PLAN VIEW
Figure 2: Orthographic view of Hexagonal Drum Honey Extractor

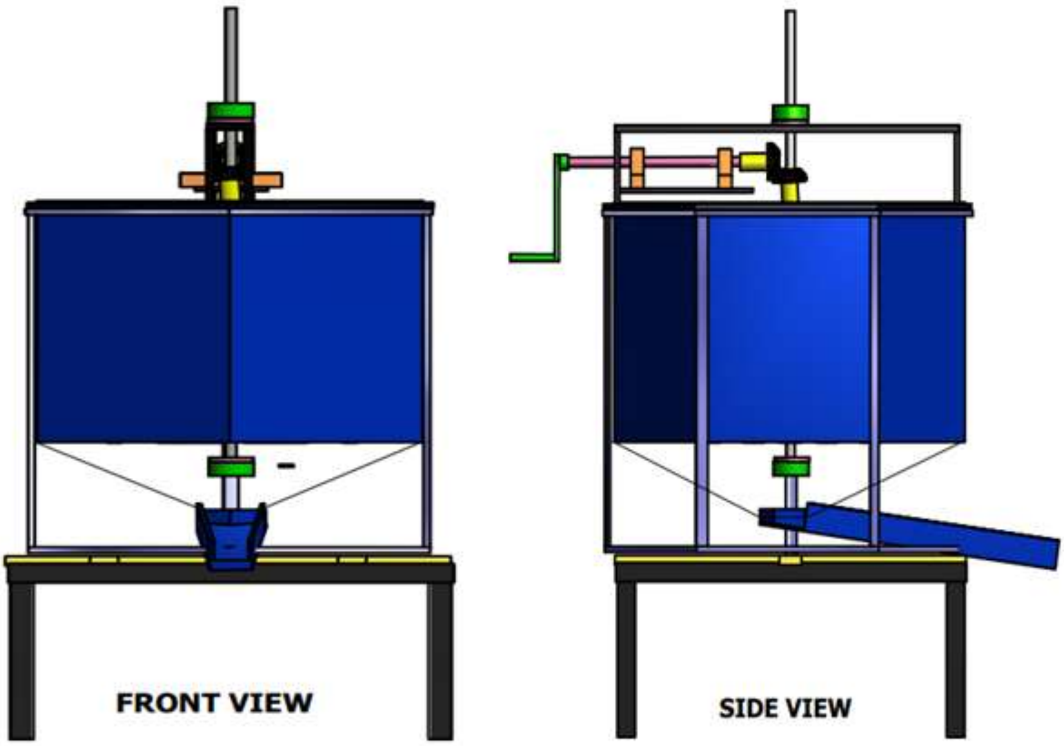


Figure 3: Front and Side view Assemble of Hexagonal Drum Honey Extractor

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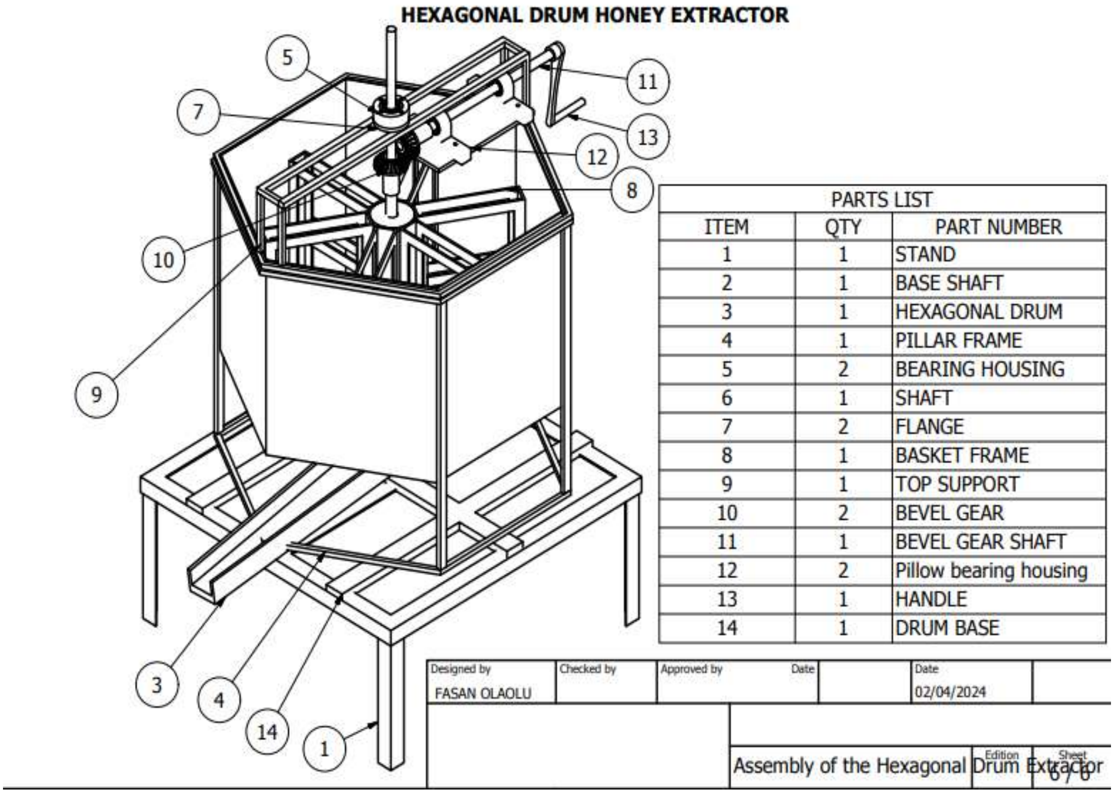
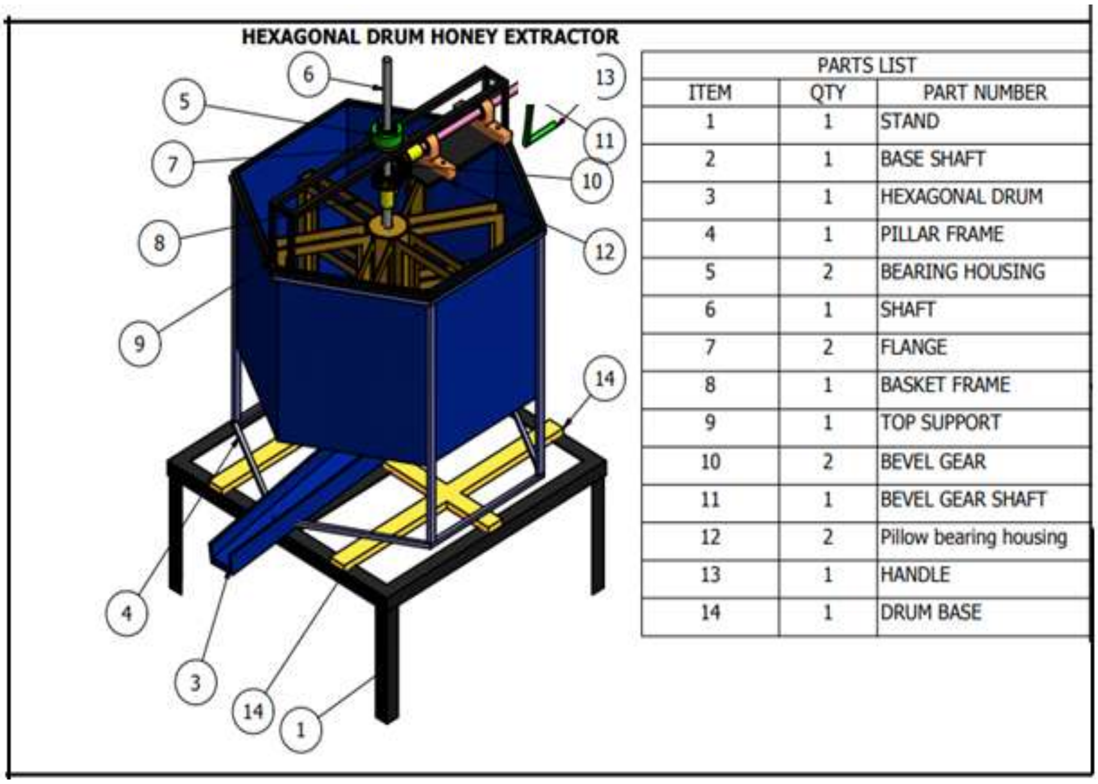


PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	STAND
2	1	BASE SHAFT
3	1	HEXAGONAL DRUM
4	1	PILLAR FRAME
5	2	BEARING HOUSING
6	1	SHAFT
7	2	FLANGE
8	1	BASKET FRAME
9	1	TOP SUPPORT
10	2	BEVEL GEAR
11	1	BEVEL GEAR SHAFT
12	2	Pillow bearing housing
13	1	HANDLE
14	1	DRUM BASE

Figure 4: Isometric view of Hexagonal Drum Honey Extractor



PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	STAND
2	1	BASE SHAFT
3	1	HEXAGONAL DRUM
4	1	PILLAR FRAME
5	2	BEARING HOUSING
6	1	SHAFT
7	2	FLANGE
8	1	BASKET FRAME
9	1	TOP SUPPORT
10	2	BEVEL GEAR
11	1	BEVEL GEAR SHAFT
12	2	Pillow bearing housing
13	1	HANDLE
14	1	DRUM BASE

Figure 5: Assemble view of Hexagonal Drum Honey Extractor

3.4 Design goals/considerations

Before the design of the honey extracting machine, some goals were set which were seen as sustainable design strategies. These design goals includes:

a) To design the machine such that it maintains and protects the cleanliness of the honey.

b) Materials which are food-safe and honey-safe should be used where appropriate.

c) The design should be such that the machine is easy to use, maintain and repair by the users who may have little or no formal education.

d) To increase the overall efficiency of the honey extraction process while maintaining its quality.

e) To use existing pre-made components where possible, and materials and components that are readily available; and

f) To minimize the use of direct human energy as much as possible in honey extraction with a design that is less complex in mechanism, fabrication, and operationof the machine.

3.5 Design Analysis

These major components would be designed: chain drive, power transmitted, load on the shaft, force required and diameter of the axial shaft.

(a) Weight of rotating cylinder (W_r)

The rotating cylinder is made of stainless steel with density. To obtain the volume of thebasket as per calculating for the weight we obtain an equivalent value of the rod used in fabrication the rotating cylinder.

$$Volume\ of\ rotating\ cylinder = \pi r^2 h \quad (1)$$

But,

$$h = 2\pi r \quad (2)$$

where;

h = Perimeter of rotating cylinder which represent the height

r = Radius of rotating cylinder

$$Mass = Density\ x\ volume \quad (3)$$

Also,

$$W_r = mg \quad (4)$$

where;

$W_r = Weight\ of\ rotating\ cylinder$

g = Acceleration due to gravity = 9.81

$Volume\ of\ column = \pi r^2 h$

(b) Weight of honey (W_H)

Weight of honey = Volume of total net x Density of honey x Gravity

$$W_H = \rho v g \quad (5)$$

$V = Volume\ of\ net$

$g = acceleration\ due\ to\ gravity = 9.81 m/s^2$

To obtain the power to drive the weight of the system;

Power = T x ω (6)

where,

T = Torque

Ω = Angular velocity in rpm

But,

Torque = Force (weight) x r (7)

where,

r = radius of the driven system

To obtain Power (W)

$$\omega = \frac{\pi DN}{60} \quad (8)$$

(c) Centrifugal Force

To obtain the centrifugal force at which the system will rotate about its center we apply the formula:

$$F_C = \frac{mv^2}{r} \quad (9)$$

also

$$V = \omega r \quad (10)$$

where

ω = Angular velocity of rotating part

m = mass of the rotating system

v = velocity of the rotating system

r = radius of the rotating system

Mass = Total weight of the system / gravity

(d) Angle of Twist of the Shaft

Consider the free body diagram below in other to get the angle of twist and also the bending moment and twisting moment of the shaft;

$$\frac{T}{l} = \frac{\tau}{R} = \frac{\omega}{L} \quad (11)$$

where,

T = Torque (T) on shaft = 115.2NM

R = Modulus of Rigidity of mild steel shaft (C) = 80GN/m^2

L = Length of shaft (L)

(e) Bending moment

The maximum bending moment will occur at the mid-point, which is half of the length

Bending moment at mid-point; (M) = load (F) x length (L)

$$M = F_C \times L \quad (12)$$

Also for the bending stress;

$$\sigma_b = \frac{32M}{\pi d^2} \quad (13)$$

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Also for equivalent twisting moment T_e which is the twisting moment which when acting alone, produces the same shear stress as the actual twisting moment.

$$T_e = \sqrt{M^2 + T^2}$$

For equivalent bending moment M_e which is the moment that acts alone produces the sametensile or compressive stress as the actual bending moment.
Using,

$$M_e = \frac{1}{2}[M + T_e] \quad (14)$$

(f) Bearing Design

The bearing is an already made component. Choice of selection will be dependent on the diameter of the shaft. The internal diameter of the bearings has to correspond to the diameter of the shaft.

Equation (15)and (16) would be used to calculate the machine throughput capacity and efficiency of the machine.

$$\text{MTC} = \frac{M_1}{T_m} \quad (15)$$

$$\text{Efficiency} = \frac{M_1}{M_2} \quad (16)$$

IV. RESULT AND DISCUSSION

This study identified the sources of honey, production methods that can be used, its physical characteristics, thermal properties and areas of honey applications which was highly unlimited. This made the need for honey extractor obvious. This extractor was designed, constructed and tested for performance evaluation. The results of the experiment in table 1shows that as the number of turns increases the quantity by mass of honey extracted increases which shows that as the number of turns increases by spinning the filled basket, the centrifugal force also increases which made the quantity by mass of honey collected to increase between 25 to 202 turns of the basket per minute but the mass of honey collected from the honey combs became constant at 9.5 litres between202 to 239 turns. This shows that optimum numbers of turns required for optimum mass of honey production is 202 turns going beyond this resulted to energy and time waste. Comparing the output of the locally fabricated extractor to the imported extractor, the mass of honey collected when fed with same mass of honey comb(15kg) and operated at 202 turns per minute gave11.00 kg of honey. This made the relative efficiency of the locally fabricated extractor to be 86% (9.5/11 x100) = 86.36%

Table 2:

Designed Parameter	Values Obtained
Volume of rotating cylinder (m3) 1	3.9E-5 m3
Density of mild steel (kgm-3)	7850
Mass of rotating cylinder (kg)	1.1
Weight of rotating cylinder (N)	10.8
Weight of rotating column (N)	207.6
Mass of rotating column (kg)	5.29kg
Volume of net (m3)	0.00327
Weight of honey (N)	273.3
Torque (Nm)	115.2
Required speed (rpm)	850
Required power (hp)	2.5
Centrifugal force (kN)	4.5
Load on shaft (kN)	4.5
Angle of twist	0.03
Bending moment (KNm)	0.248
Bending stress (GN/m2)	11.2
Bending moment (KN)	57.7

V. CONCLUSION

The locally required honey extractor of total local content has been designed and fabricated with designed capacity of a litre per minute when spinned the basket 202 turns per minute. This gave this extractor relative efficiency of 86%. When compared with imported extractor. The production cost can easily be afforded by the small and medium scale honey product. It required no electricity s source of power so it can be installed in both rural and urban community for optimum use.

This study is limited to the design, fabrication of a honey extractor excluding the extraction of heather honey which is different from other honeys. Heather honey is thixotropic or jelly-like and must be pressed out of the combs or heated, causing the honey to become temporarily fluid, so that it can be extracted in a conventional extractor. The limitation of this study does not involve the study of the physicochemical properties of honey.

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