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DESIGN AND FABRICATION OF DRIED COCONUT OIL EXPELLER

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ABSTRACT

This paper aims on design and fabrication of dried coconut oil expeller, to check and apply for dried coconut oil process in Nigeria. Segmented - screw, helical ribs with stationary pegs fitted to the screw barrel facilitate forward movement of material without clogging and generating heat. A movable pressure core fitted at the discharge end provides sufficient pressure inside the screw barrel.
Optimum performance of the expeller was at 33.6RPM of the screw shaft and 10 - 12 litres of dried coconut oil in an hour with a 60% oil yield was realized .The machine can be efficient and easy to operate and maintain .The oil extracted has various applications in food, medicine and industry. Since the expeller is operated by a single - phase ZHP motor, it can be used to produce dried quality coconut oil at cottage level as a means of self employment .Due to simplicity of the expeller, it can be fabricated in a medium level workshop .The machine may be applied to milling other types of nuts by using appropriate meshes which this design facilitates.

Key words: Dried coconut oil Expeller, design, constraints, objective functions, Thrust Ball Bearing, worms, Ansys, Pro-E.

Nomenclature

G = Gear ratio; T = main shaft torque; D_1 = motor pulley diameter; D_2 = Gear pulley diameter; P_r= pressure required to expel oil; F_a = Axial or thrust load; F_{amin} = Minimum axial load; A_L = Left side race area; A_r = Right side race area; δ = Principle stress; e = Principle strain; $\frac{\rho\delta 1}{2}$= strain energy; δ_1= Axial deformation or displacement, PTD = Tones per day, Ʈ= shear stress, N =Revolutions per minutes main shaft (RPM), N_I = Revolutions per minute motor shaft (RPM),N_{max}= maximum rotational speed, P_m = motor power, cdyn = dynamic capacity of bearing, M= minimum axial load factor, P = Pressure, d = Main shaft diameter.

INTRODUCTION

Coconut oil (CNO) is one of the important food commodities used for food preparation and for various other applications. CNO is a major kernel product next to desiccated coconut (DC).in 2005, 2576 million nuts were harvested and 2000 million tons of CNO and 36991 tons of DC were produced (Anon, 2005).Coconut oil has been used in ayuroala for various medicinal oil productions and skin ailments. CNO contains about 65% of short and medicine chain fatty acids, which do not contribute to the synthesis of cholesterol in metabolism (peiris ,2005).Approximately 50% of the fatty acids in coconut fat are lauric acid and it is a medium chain fatty acid ,which has an additional beneficial function of being into monolourin within the human body (Enig1996).Therefore ,it is easy to digest and CCNO has the least amount of cholesterol of 0 -14 PPM compared to other oils such as palm oil(18PPM),soy oil (28PPM),CORN OIL(50PPM) and butter(3150PPM) and it's a good source of instant energy . Also, CNO has anti -virus, anti – bacterial and anti - fungal properties (Enig, 1996). Therefore, CNO fetches a superior position among the other edible oil.

Usually CNO is produced from copra and copra oil extraction requires large — scale high pressure, energy intensive equipment and experience. Unhygienic copra means that the resultant oil is normally of low quality with a Free Fatty Acid (FFA) level of 3% or more. Therefore ,various quality improvements like ,refining ,bleaching and deodorizing are required to convert CNO into a commercially acceptable products .Due to high pressure in the expeller and friction against the metal parts, generation of heat is unavoidable and therefore, most of the nutrients are destroyed and also due to the carramalizzation of sugar and protein, oil has a yellowish color.

Hitton & Ethering, 1997 have introduced a process of direct micro expelling (DME), in which fresh grated coconut is dried to 10% - 12% (wb) moisture content, packed into a cylinder and heated in and over to 60 - 80 C for about 30 min. The cylinder is then placed in a press and oil is extracted by applying sufficient pressure for 10 minutes. NERD centre has developed a similar method of drying grated coconut in the sun for 2 hours, until oil is visible; when the coconut is pressed between thumb and forefinger (moisture is 10%wb). Then it is pressed in a specially modified string hopper mould (Ranatunge, 2000).

The extracted oil is a transparent liquid with high quality, conforming to virgin quality standards. Since this mould has the holding capacity of a nut, the capacity of the mould was increased to about 3-4 nuts and now it is popular as a cottage industry. The third version of this type has a 10 - 12 nuts holding capacity press in which partially dried coconut is pressed by a hydraulic jack (santha, 2001).

The above three presses are used on batch operation and have limited oil extraction capacities. Since there is a great demand for coconut oil of virgin quality in local and export market, it creates a requirement for a large - scale extractor. This study aims at investigating and exploring the possibility of designing and the fabrication of a continuous type expeller which can extract oil from grated coconut without generating heat to produce virgin quality coconut oil. (Adhikarinayake, 2007)

The oil extraction process system was developed as a means to convert coconuts into their main items of commerce, namely oil and cake, right where the coconut comes from the coconut plantation.

Because of this objective, the oil extraction machines were also designed so they can be owned and operated by the people who planted and make their living out of the coconut tree. Even seeds of various varieties can be used to produce oil, certain tests have been proved that our machine produces

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adequate amount of oil. It is constrained to make the system simple to operate and maintain, reasonably acceptable to the community and the environment, relatively inexpensive to own and suited to household applications. The design and tested towards achieving the following, high oil yield, high extraction efficiency, high oil yield and low cost of construction of oil expeller. Consideration was also given for a strong main frame to ensure structural stability and strong support for the machine. (Anon, 2002).

Screw specification is the making part of the expeller. It consists of helical threads that push the particle further inside the chamber or barrel till the pressure increases and oil is released. It is placed inside a cylindrical barrel and its outer shaft is connected to the gearbox via coupling. The seeds are continuously fed to the expeller, which grinds, crushes and presses the oil out as it passes through the machine. The pressure exerted from the screw crushes and ruptures the oil cells in the product and oil flows through the opening in the casing and is collected in a way underneath. A stainless steel screw is used for the oil extraction machine with screw length is 100mm and with diameter 20mm. (Aremu and Ogunlade, 2013).

Dried coconut oil expellers are power — driven, and are able to process 8 to 300kg per hour of product or even more depending upon the type of expeller used. Bigger units processing greater qualities of oil are available for use in larger mills. The percentage of oil expressed by expellers is nearly 90% depending upon the type and kind of products as well as the expeller being employed. Dried coconut oil expellers use a horizontally rotating metal screw, which feeds oil — bearing seeds into a barrel shaped outer casing with perforated walls. The residue of the materials from which oil has been expressed exists from the units, and it’s known as the cake. With some types of expellers takes place. This allows for greater oil expression and reduces wear and tear on the machine. (Bamgboye and Adejumo, 2007).

An oil expeller is a screw - type machine that processes oil seeds through a caged barrel - like cavity. Expeller processing (also called oil pressing) is a mechanical method for extracting oil from raw materials. The raw materials are squeezed under high pressure in a single step. (Idris Noriqman Hakimi, 2010).

Screw type dried coconut oil presses are advanced oil processing machinery, characterized by their high output rate with good quality, simple design, easy to use and continuous operation. They can be use for various raw materials, such as peanuts, beans, grape seeds, cotton seeds, sunflower seeds, copra etc. (Mangesh and Pawan, 2013)

MATERIAL AND METHOD

Formulation of the objective function

The main objective of this work is to design and fabricate a dried coconut oil expeller using screw type oil press. Also carryout analytical and software analysis of thrust ball bearing used in machine. The resulting equations is given as;

$$G_1 = \frac{T_3}{T_2} = \frac{D_3}{D_2} \text{------------------------------(1)}$$

$$G_2 = \frac{T_5}{T_4} = \frac{D_5}{D_4} \text{------------------------------ (2)}$$

Gear ratio G = G_1*G_2--------------------- (3)

Design Constraints
The following are the constraints used in the design method.

Pressure required to expel oil

$$P_r = \frac{F}{A} = \frac{F}{\pi * dh * L} or \frac{F}{A} = \frac{F}{\pi * D * (D - dh)}$$

Minimum axial load required

$$F_{amin} = M(N_{max}/1000)^2 \text{ [KN]}$$

Thrust load

$$F_a = \frac{\pi * D^2 * P}{4 * 1000} \text{ [KN]}$$

left Side Race Area

$$A_L = \frac{\pi}{4}(d_1^2 - d^2)$$

Right Side Race Area

$$A_r = \frac{\pi}{4}(D^2 - D_1^2)$$

Principle stress

$$\delta = \frac{P}{A}$$

Principle strain

$$e = \frac{\delta t}{L}$$

Strain energy = $\frac{P\delta_1}{2}$

Axial Deformation or Displacement

$$\delta_1 = \frac{P * I}{A * E}$$

Design example

Table 1: show the bearing life recommendation for the design and fabrication of coconut oil expeller.

Type of Application	Life, Kh
Instruments and apparatus for infrequent use	up to 0.5
Aircraft engines	0.5 - 2
Machines for short or intermittent operation where service interruption is of minor importance	4 - 8
machine for intermittent service where reliable operation is of great importance	8 - 14
Machine for 8 — h service which are not always fully utilized	14 - 20
Machines for 8— h service which are fully utilized	20 - 30
Machine for continuous 24 — h service	50 - 60
Machine for continuous 24 — h service where reliability is of extreme importance	100 - 200

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Table 2: Show the comparison of results obtained by Ansys and Pro-E for old and new bearing

Property	Analytical		Software Analysis				Units
	Old Bearing 51326M	New Bearing 51426M	ANSYS Old Bearing	ANSYS New Bearing	Pro-E Old Bearing	Pro-E New Bearing	
Left side Race							
Maximum principle stress	1, or9.301 1.11796-03	5.4945 9.7738E-04	7.7204 00015071	4.3734 0.0014808	13.89 0.0016399	11.26 0.0016318	MPa
Displacement (X Axes) Maximum principle strain	4.478E-05	2.6145E-05	0.00004532	.000026626	6.134E-05	0.00005011	1 or radian
Strain energy	0.01039	2.6851E-03	0.57292	0.58714	0.0167	0.03325	Joule
Right side Race							
Maximum principle stress	8.9686	5.33259	5.4319	3.5906	11.50	5.282	MPa
Displacement(X Axes) Maximum principle strain	1.07795E-03 4.3118E-05	9.48586-04 2.5637E-05	0.0014456 0.000038212	0.0012903 1.1491E-07	0.0013962 0.00006191	0.0012552 6.911E-07	1 or radian
Strain energy	4.833856-03	2.52919E-03	0.77479	0.73595	0.001648	0.0004533	Joule
Ball							
Maximum principle stress Displacement(X Axes) Maximum principle strain	172.959 5.7496E-3 3.28548E-4	203.46 5.634E-3 7.076E-E	171.18 0.0056303 0.0011577	128.34 0.0057205 0.0007779	91.22 5.6152E-3 1.802E-3	1.066E2 5.7257E-3 1.442E-3	MPa 1 or radian
Strain energy	0.0284	1.7996	0.26988	0.6978	6.207	3.966	Joule

RESULTS AND DISCUSSION

In figures 1 and 2 below shows the feeding hopper with wide bottom and conceptual design of the screw type dried coconut oil expeller. The bottom of the feeding hopper has to be designed to avoid any bridging of the material just over the screw. Therefore, the section just over the screw was widened in order to drop the material on the wider exposed screw.

A screw shaft with a uniform pitch is easy to fabricate than the other types. In order to avoid building up of material within the screw rib space by rotating it with the screw, a few pegs are welded to the barrel as shown in figure 2.

The special features of the proposed expeller is that the screw shaft is made in segments leaving space to pass the stationary pegs, which are fitted to the barrel and these pegs act as obstacles to prevent rotating the material with the screw shaft. This arrangement is a new concept and it is easy to fabricate compared to the other screws of variable pitch, increasing diameters and twin screw. The pressure inside the barrel is created by adjusting the pressure core or using a die head fitted to the barrel.

Matured coconut was grated and dried in the sun to the required moisture level. Moisture content was determined by the infra - red moisture analyzer M X 50 of accuracy i0.01%.Preliminary testing was carried out by the expeller with samples dried to different levels to determine the optimum moisture content of the sample for the expeller to be tested.

The result of the design calculation and the resulting specification for the production of the designed work is shown in Table 1, the bearing life recommendation for the design and fabrication. The property comparison of results obtained by Analysis and Pro - E for old and new bearing with the S.I unit also shown in Table 2.

The various test carried out and the results obtained demonstrate that the dried coconut oil expeller machine achieved its design and fabrication aims. The system worked accordingly to specification and quite satisfactory. The performance of the expeller was evaluated at different revolutions of screw shaft by changing the sprocket wheels purchased in the market. Input capacity of raw materials oil yield were measured by operating the expeller for a known period with samples dried to predetermined levels. Optimum revolution was selected considering the input capacity and oil yield. Temperatures at the screw barrel and of oil samples were measured using a digital thermometer, Digitron 2000T of accuracy 0.1°C.

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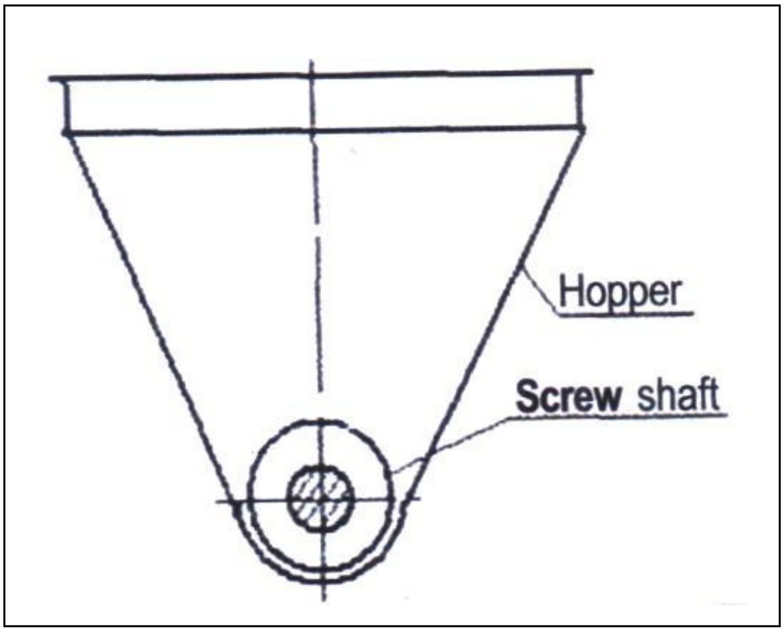

Figure 1. *Feeding hooper with wide bottom*

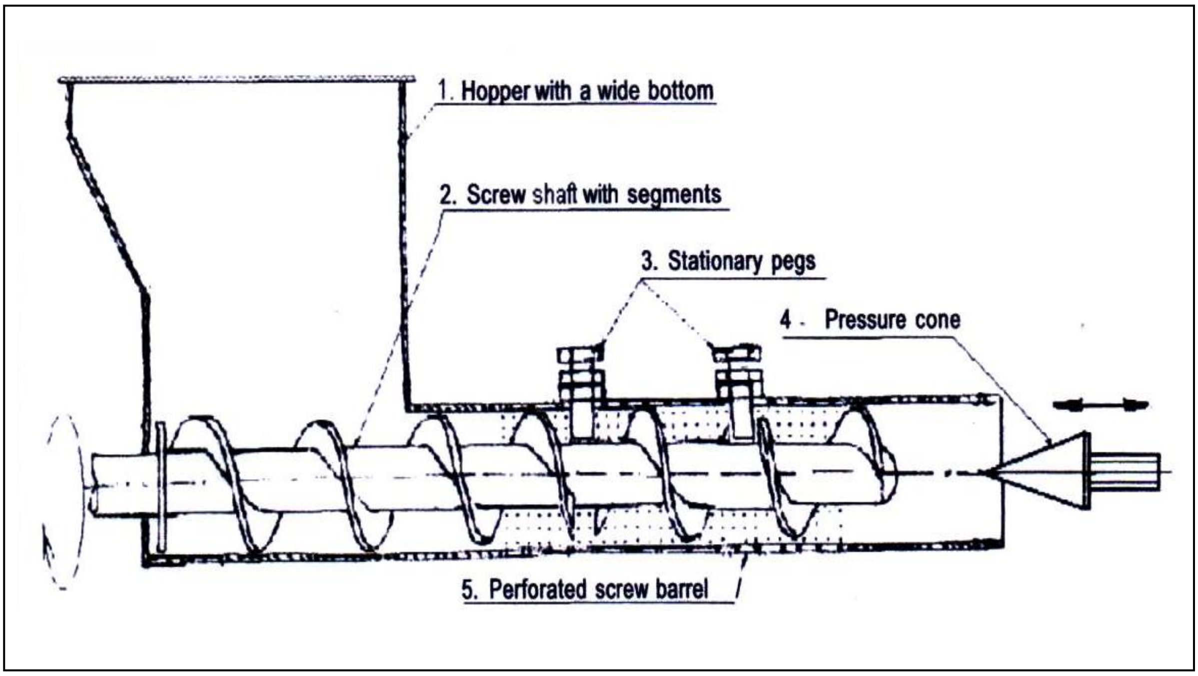

Figure 2 *Conceptual design of the screw type virgin dried coconut oil expeller*

The invented segmented - screw type expeller performed satisfactory oil extraction without generating heat with smooth movement of material through the screw barrel. Dried coconut was subjected to a shear and compression process, which leads to increase in oil produced by the expeller, conformed to virgin quality grade.

Oil extraction machine was designed, constructed, using locally available and easily accessible materials, and tested for oil extraction. The expeller was simple enough for local fabrication, operation, repair and maintenance .The oil produced will be at affordable costs for consumers and also provide cake for livestock mill.

In the fabrication work, we designed some of the components of dried coconut oil expeller such as gear ratio, main shaft rpm, main shaft diameter and crushing chamber dimensions. Design of all these components matches with the components actually used in oil expeller machine. Therefore, we can say that the design components used is safe.
We also carryout static analysis of the part of bearing on Pro-E wild fire 4 and Ansys work bench

In analysis results the principle stress, principle strain and axial deformation is reduced.
Further, the results obtained by different software are approximately matching the results obtained by the analytical solutions. From the comparison of the result data, we found that results obtained by the Ansys workbench are closer to the analytical results.

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