**Improvement in the Design, Construction and Performance Evaluation of a Screw Press Extractor for Oil Seeds**

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**ABSTRACT**

Palm kernel (*Eliaeisguinensis*) and Soybean (*Glycemhzalepidita*) oil have gained popularity in food, cosmetic, soap, pharmaceutical and medical industries for the production of cooking oil, margarine, pomade, toilet soaps, drugs, and medical ointments. This research work involve improvement in the design, construction and testing of a small scale screw press extractor for palm kernel and soybean oil extraction. The design improvements made are in clearance reduction between the worm shaft and the cylindrical barrel for effective compression to achieve increased extraction capacity and efficiency per batch. Design components included cylindrical barrel, worm shaft, gear reduction box, prime mover, hopper, pulley, bearing, and transmission belt. Parts like oil outlet, cake outlet, supporting frame were fabricated based on machine load function demand. The operational principle of the oil extraction is that the worm shaft is at an increasing diameter while, the screw system is at a decreasing pitch. This process gradually build-up pressure along the worm shaft as it moves along cylindrical barrel thus, crushing, grinding, pressing and squeezes the oil out of the seeds. The screw press was fabricated using materials sourced locally at affordable cost. Performance evaluation using test result for palm kernel and soybeans shows improved average oil yield, extraction efficiency and reduction in system oil extraction loss over previous versions. From the study, it is recommended that low initial capital cost, optimum operational procedure and effectiveness in promoting hygienic oil extraction should be fundamental in the development of oil extraction devices.

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**Keywords:** Improvement, oil screw extractor, development, hygienic oil, extraction efficiency

**1.0 Introduction**

Extraction of oil from seed obtained from plants or tress are of immense economic value to man. Palm kernel oil, is an ingredient for soap making, margarine, bio-fuel coating and other specialty fats is derived from milling of cracked palm kernel nuts, while palm kernel cake obtained as a by-product form a vital part of animal feed. Soybeans which has the highest protein content of all food crops and is second only to groundnut in term of oil content amongst food legume and is used producing edible oil, milk, animal feed and as an industrial raw material for paint manufacturing, varnish, cosmetics, linoleum and rubber fabrics (Okafor, 2002). Some applications of oil seeds are found applications for energy generation, automotive industries as biodiesel, in the engineering industry as cooling fluids in machining process as well as lubricants for machine components (Bachman, 2001). This research work improved on an existing design by reducing the clearance between the worm shaft and the cylindrical barrel from 2.0 mm to 1.5mm for increased compression effect to enhance extraction efficiency and reduce extraction losses. System batch capacity was also increased to facilitate its deployment for small business enterprises. Introduction of dampers was to minimize the device vibration. These improvements will save manual labour, increase yield output, increase farmer’s income and, make available these oils at affordable prices.

**2.0 Methodology**

 The oil extracting machine consist of hopper for feeding the raw material, transmission belt, central shaft, gear box, coupling, cylindrical barrel, cake outlet, cake-tray, oil tray, pulley, and supporting frame. The components are design based on established theories and principles, considering the leading of each member as some are presented below (Table 1).

**2.1 Power requirement of the extractor**

The power requirement of the extractor is calculated using a modified Equation from Onwualu *et al*., (2006)

 … (1)

Where;

 is the power required to drive extractor

 is the volumetric capacity of the worm shaft

 is the length of worm shaft

Ρ is the bulk density of palm kernel

 is the acceleration due to gravity

F is material factor.

**2.2 Power of the electric motor**

The power of the electric motor for driving the extractor is estimated using Equation 2 given by Onwualu *et al.,* (2006):

 … (2)

Where;

Pm is the power of electric motor

η is the drive efficiency.

**2.3 Capacity of the extractor**

The theoretical capacity of the extractor is determined using a modified form of Equation 3 given by Onwualu *et al.,* (2006):

 … (3)

Where;

 is the theoretical capacity of the extractor

 is the diameter of the thread

 is the base diameter of screw shaft

 is the screw pitch

 is the rotational speed of screw shaft

 is the filling factor

 is the bulk density of palm kernel.

**2.4 Design of the worm shaft of the extractor**

The worm shaft is design to safeguard against bending and torsional stresses as reported by and Khurmi and Gupta (1998):

 … (4)

Where;

 is the diameter of screw shaft

 is the torque transmitted by shaft

is the yield stress of mild steel.

**2.5 Pressure of the barrel**

The pressure that can be withstood by the barrel is determined by Equation 5 given by Khurmi and Gupta (1998):

 … (5)

Where;

 is the pressure withstand by the barrel

 is the thickness of the barrel

 is the available stress

 is the inside diameter of the barrel.

**2.6 Screw Load**

The load is determined from Equation 6 as reported by Okafor **(**2002):

 … (6)

 … (7)

Where;

 is the load to be lifted by the screw

 is the torque transmitted by screw

 is the mean thread diameter

 is the coefficient of friction

 is the thread (lift) angle.

**2.7 Oil yield, extraction efficiency and loss**

The oil yield with extraction and losses efficiencies were computed using Equations 8, 9 and 10 respectively given by Adesoji *et al.*, (2013).

Oil yield, (%) = … (8)

Oil extraction, (%) = … (9)

Extraction loss, (%) = … (10)

Where;

is the oil yield

 is the extraction efficiency

 is the extraction loss

 is the weight of oil extracted

is the residual cake

is the feed sample

is the oil content of seed in decimal.

**Table 1: Result of design calculation**

|  |  |  |
| --- | --- | --- |
| **S/No** | **Variables** | **Output**  |
| 1 | Extractor power, kW | 8.37 |
| 2 | Electric motor power, kW  | 11.16 |
| 3 | Extraction capacity, kg/h | 948.24 |
| 4 | Extractor worm shaft, mm | 44.41 |
| 5 | Barrel pressure, Mpa | 16.20 |
| 6 | Screw load, KN | 72.88 |

**3.0 Fabrication and cost estimation**

Functionality, economic consideration and ease of operation were fundamental for the machine development. Dimensioned mild steel sheet of 1.5 mm was welded to form the hopper, while a mild steel rod of 100 mm was used to form the worm shaft. Screw thread machined at a decreasing screw depth formed a tapered screw conveyor of nine screw turns. Mild steel formed the cylindrical barred of 500mm in length with 20 narrow slots made on the lower portion which served as drainage for the extracted oil. Angle iron of 50 mm × 50 mm × 4 mm welded together served as the machine structural supporting frame. Components such as bolts and nuts, bearings, pulley, couplings, belt were bought off shelf. For enhanced beauty, resistance to corrosion and economic life elongation; proper finishing was done.

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Plate I**:** Developed machine, palm kernel seeds and extracted oil.

**4.0 Performance evaluation**

Known weights of clean sun dried palm kernel seeds were fed into the machine through the hopper, conveyed by the worm shaft, crushed, squeezed and oil extracted. The extracted oil was weighed as well as the residual cake (palm kernel cake, PKC). The tests were carried out in triplicates. Computations using Equations 8, 9 and 10 indicates that the oil yield, oil extraction and extraction loss were 17.4%, 28.5% and 0.49% respectively and found to be slightly higher compared to those reported by Adesoji *et al.*, (2013) and thus, demonstrates an improvement in the design.

**5.0 Conclusion**

An improved multi-oil screw extractor is developed at a low initial capital cost with optimum operational procedure and effectiveness in promoting the production of hygienic oil. It will boost small businesses and thus, stimulate the economy. It is recommended that fabrication of this device be encourage by government agencies in charge of small and medium scale businesses.

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