

MODIFICATION OF AN ENGINE POWERED KNEADER FOR GROUNDNUT OIL EXTRACTION

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ABSTRACT

An engine powered groundnut oil kneader was modified and fabricated to address the challenges of the traditional method of oil extraction. The working principle was based on a rotational viscometer, in which the viscous flow drag of rotating a body immersed in a fluid is measured as a function of speed. The machine was fabricated and evaluated for its performance in terms of its kneading time and throughput capacity. In addition to reducing the drudgery involved in the existing manual machines, grinding unit and kneading cylinder were incorporated. Test result shows a substantial savings in kneading time. Kneading time was reduced by 85% and the throughput capacity of the machine in terms of weight of oil extracted per unit time was found to be 78.98kg/hr, as compared to the existing one that kneaded 35.2kg/hr and 46.3kg/hr.

Keywords: Groundnut, Kneading, Paste, Oil, Extraction

1 INTRODUCTION

Groundnut is a leguminous crop with seed rich in oil and high protein contents. It is one of the most valuable crops of the tropical and subtropical countries that are used as food for both human and livestock. Groundnut is used in the production of biscuits, soup and in making vegetable oil. The oil is mainly used for the production of margarine and many other products in industries [1]. During the process of extracting the oil, the by – products obtained are used to produce animal feeds and also serve as raw materials in manufacturing textured vegetable proteins used for human consumption. In the traditional method, shelling and oil extraction from groundnut is mostly done by rural women, using time and labour consuming methods. Yield obtained is mostly below 50% of what is obtained using improved machinery and equipment [2].

In Nigeria, a survey conducted in some northern states (Kano, Kaduna, Adamawa, Niger, Bauchi and Taraba) showed that traditional groundnut oil extraction is a profitable business, and is mostly done by women. It was also found that out of the 439 processors of groundnut oil in three of the states (Kano Niger and Kaduna), 74% of the sample population said that they were processing for income generation [3]. A survey study conducted on how women process and extract oil from groundnut traditionally revealed the following sequence of operations; shelling, winnowing, sorting, roasting, skinning, grinding to paste, primary oil extractions (kneading), secondary oil extraction, frying the formed meal to cake locally called Kuli-Kuli [4]. A study showed that groundnut seed contain 42% to 62% oil, and most of the world groundnut processing is done for its oil. The oil is desirable for cooking and salad, it is

of high quality, containing about 80% unsaturated fatty acids, such as oleic and linoneic acids and so much protein [5].

The traditional use of mortar and pestle to process groundnut seed for oil is a serious problem to women that are engaged in the groundnut oil extraction business. The method is very tedious and time consuming to the women. Kneading was identified as the most tasking and energy consuming among these operations which underscores the need to develop an engine powered machine. The Institute for Agricultural Research (IAR) at Ahmadu Bello University Zaria developed a traditional model for groundnut oil extraction in 1995. The model was operated manually, but the mortar was installed and cemented to the ground for stability, and the pestle was clamped on the mortar such that it could pivot on the casing as it knead the groundnut paste in the mortar. Another work done at National Agricultural Extension and Research liaison services (NAERLS) Ahmadu Bello University, Zaria attempted to replace the traditional mortar and pestle with manually operated drum chamber and a stirring shaft and finger mechanism.

Another motorized model of groundnut oil extractor was designed constructed and tested at Agricultural Engineering Department ABU Zaria. The main features of the oil extractor includes, kneading head, the conventional mortar, transmission unit and the supporting frame. The intended quantity of paste was poured in to the mortar and the machine is set up for kneading. Once the electric motor is switched on, rotary power is transmitted to the kneading shaft through the intermediate shaft to the input shaft on which the kneading shaft is hooked. Kneading was accomplished by the centrifugal effect of the rotating fingers on the oil molecules in the paste, with water added gradually as the process progresses until it is completed. The capacity of the machine was 35.2kg/hr as it kneads 6.6 kg of groundnut paste in 11.25mins. It also saved 54%-76% time when compared to the manual kneading tools [6].

Another motorized model of groundnut oil kneader was designed, fabricated and tested at Agricultural and Environmental Engineering Department Federal University of Technology, Yola. The main features of the oil kneader include the conventional mortar, kneading head, transmission unit, power unit and supporting frame. The paste quantity of known weight was poured in to the motor and the machine is set up for operation. Once the electric motor is switched on, rotary power is transmitted to kneading shaft through the V-belt. Kneading was accomplished by the centrifugal effect of the rotating fingers on the oil molecules in the paste, with hot clean water added gradually as the process progresses until the kneading process is completed. The kneading time was reduced by 80% and the throughput capacity of the machine in terms of weight of oil extracted per unit time was found to be 46.3kg/hr [7].

2 MATERIALS AND METHODS

2.1 Material Selection

Galvanized metal sheet was chosen for kneading cylinder construction because of its resistance to corrosion even under damp conditions. The angle iron and U-channel iron that was used for frame were both selected because of their durability, availability, thermal conductivity, low cost and strengths to hold other components. The grooved pulleys and the v-

belts were selected together to produce a tight fit for transmission of power from the drive to the driven side. The choice of materials used for shafts and stirrer fingers were based on thermal conductivity, availability, low costs and strengths. Other materials such as bearings and grinding plates were both selected due to their durability, availability, low cost, low corrosion and resistance to wear.

2.2 Design Analysis

The design method of the machine was based on the principle of rotational viscometer. In which the viscous flow drag of a rotating body immersed in a liquid is measured as a function of speed as reported by [8]. In this design, the shear stress, shear diagram and other related relationships were established. Using the rotational concentric cylinder viscometer principle in particular and applying it to the kneading cylinder, stirrer shaft and stirrer fingers as shown in figure (1), the following parameters were calculated: -

Angular velocity; (ω)

Radius of the stirrer fingers; (R_s)

Radius of kneading cylinder; (R_c)

Height of groundnut paste inside the cylinder; (H)

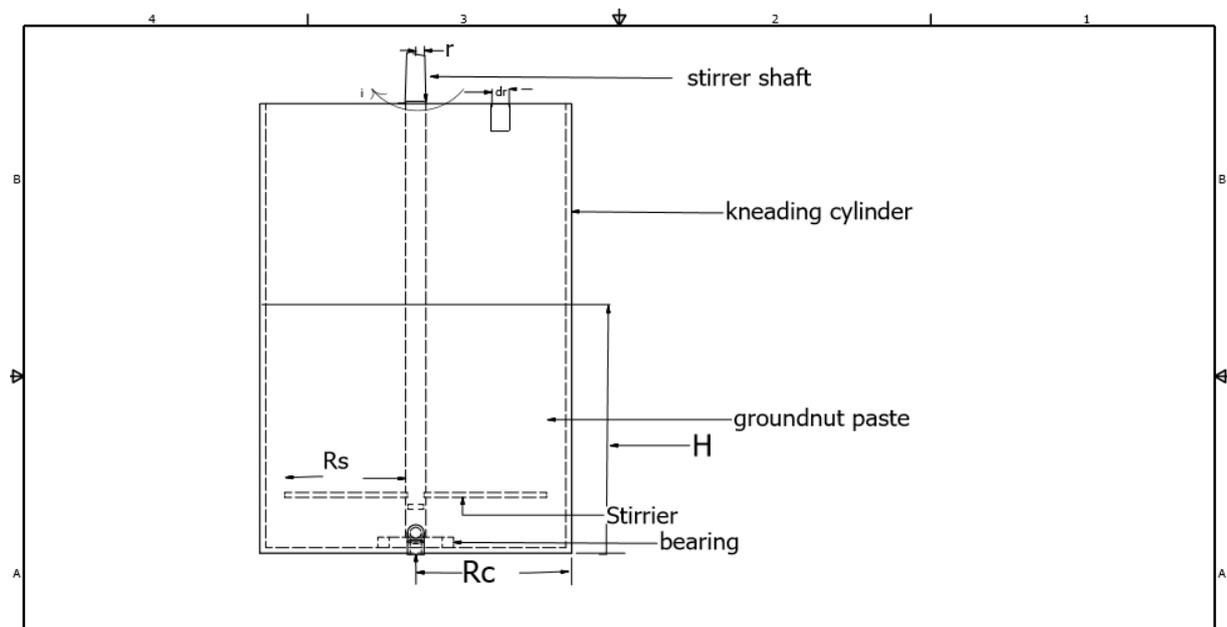


Figure 1. sectional view of the kneading cylinder

For an incompressible fluid exhibiting Bingham characteristics such as groundnut paste, and assuming there is no slippage between the paste and the kneading cylinder. In a steady state flow, the external torque equals the opposing torque in the paste, such that the following general expressions are valid [8].

$$T = 2\pi RH\tau \quad (1)$$

Where T = External torque (Nm); R = Radius of the shaft (M); τ = shear stress which tends to turn the shaft (N/M^2); H = paste surface with respect to the kneading cylinder (M)

Since under the steady conditions, the movement of the fluid at any two radii in the gap are equal for the two boundaries; hence,

$$T = 2\pi R_s^2 H \tau_s = 2\pi R_c^2 H \tau_c \quad (2)$$

Where R_s = Radius of stirrer fingers; R_c = Radius of the cylinder; τ = Shear stress due to cylinder

2.3 Description of the Kneader

The main features of an engine powered groundnut kneading machine include; the grinding unit, the power unit, the supporting frame, the kneading cylinder and the transmission unit as shown in fig.3. The grinding unit consists of hopper, auger rolled grinding shaft, two grinding plates, one fixed on a round frame and the other rotating with the grinding shaft which will grind the oil bearing seeds. It also contains two bearings which support the grinding shaft and a housing that protrude to form the outlet which releases the groundnut paste into the kneading cylinder. The power unit comprise of a gasoline engine with capacity of 6.5Hp which generate the rotary motion to the grinding unit and the kneading cylinder. It was coupled on the supporting frame (angle iron) at the lower part of the frame. The supporting frame consists of 4 x 50mm angle iron and 5 x 50mm U-channel iron. The irons were cut at specified sizes of 820mm heights 940mm width and 640mm depths. They were welded together to form a rectangular shape, on which all the components were coupled.

The kneading cylinder which serves as the paste chamber has an internal diameter of 560mm and internal depth of 600mm. It was formed from 2mm galvanized iron sheet, and at the bottom an oil drain tap was provided to drain the extracted oil into the oil container. The kneading process was carried out in this cylinder. The transmission system consists of three v-belts, five pulleys and four shafts. The v-belts obtain their drives from gasoline engine and pass the drives to the pulleys, one upwards to the grinding pulley and the other downwards to the kneading pulley. The upper lateral pulley passes the drive to the enclosed bevel gear and finally to the vertical kneading shaft inside the kneading cylinder supported by a bearing at the base. On the central kneading shaft are four lateral iron bars welded at the base known as stirrer fingers. The stirrer fingers derive its rotational power from the central kneading shaft and rotate the content of the kneading cylinder partly or completely immersed in the fluid (paste)

2.4 Operating Mechanism of the Machine

Some measured quantity of skinned groundnuts was fed gradually into the hopper, and conveyed to the grinding chamber by the rotating auger on the grinding shaft. In the grinding chamber, the skinned groundnut is grinded into paste as a result of robbing of the two circular plates, one stationary and the other fixed at one point. The grinded paste was released into the kneading cylinder beneath it through the outlet point.

In the kneading cylinder, the rotary power is transmitted to the kneading shaft through the v-belts in conjunction with the bevel sprocket above it. Kneading was accomplished by the centrifugal effect of the rotating stirrer fingers on oil molecules in the paste, with hot clean water added gradually as the process progresses until the kneading was completed. When the molecules of the oil have been separated from the residue, the oil drain tap was opened to collect the extracted oil. The residue was further pressed manually and in some cases deep-fried to extract the residual oil. The formulae used for computing the yield of oil (Y_o), and throughput capacity (T_c) are expressed in equations (3) and (4) respectively;

$$Y_o = \frac{W_o}{W_p} \times 100 \tag{3}$$

$$T_c = \frac{W_p}{T_k} \tag{4}$$

Where Y_o = Yield of oil extracted from groundnut paste in each kneading operation (%)

W_o = Weight of oil obtained after each kneading operation (kg)

W_p = Weight of groundnut paste kneaded in each operation (kg)

T_c = Throughput capacity (kg/hr)

T_k = kneading time in each operation (hr)

Fig. 2 and 3 shows the orthographic and exploded view of the kneader.

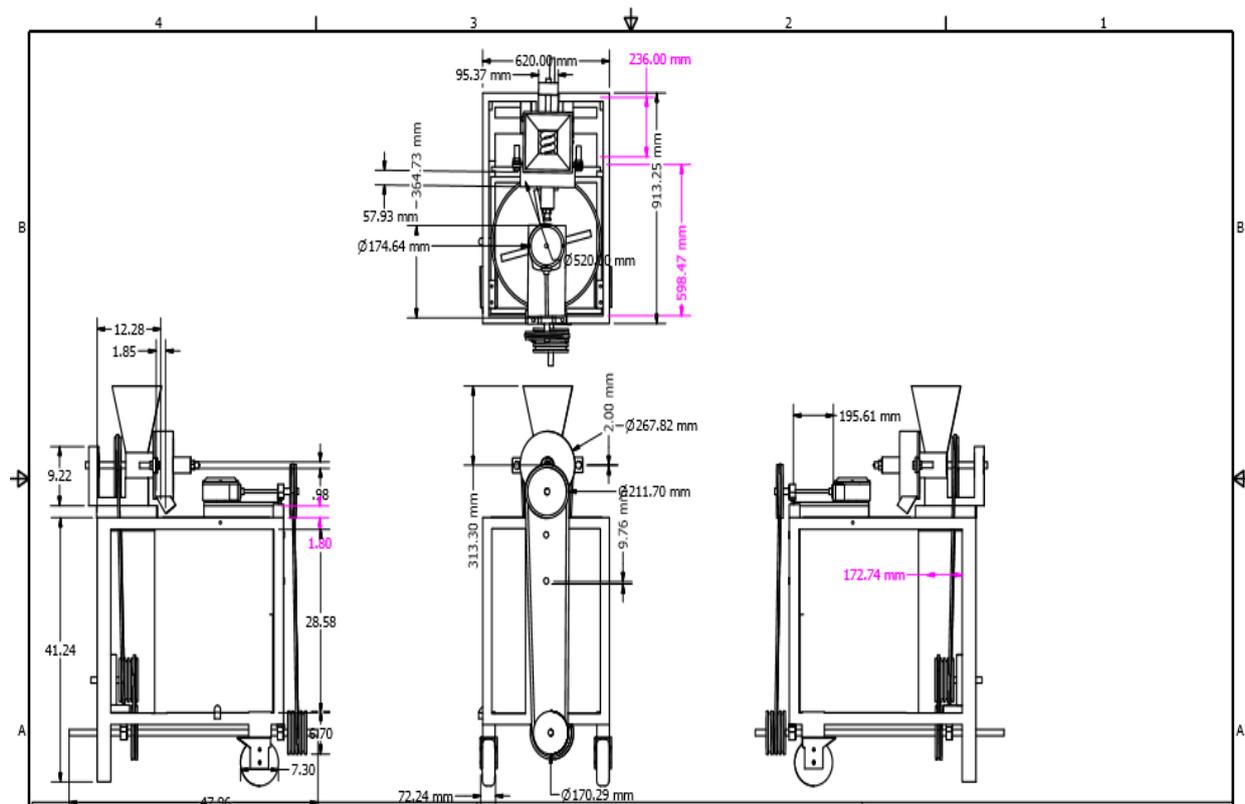


Figure 2. Orthographic view of the Kneader

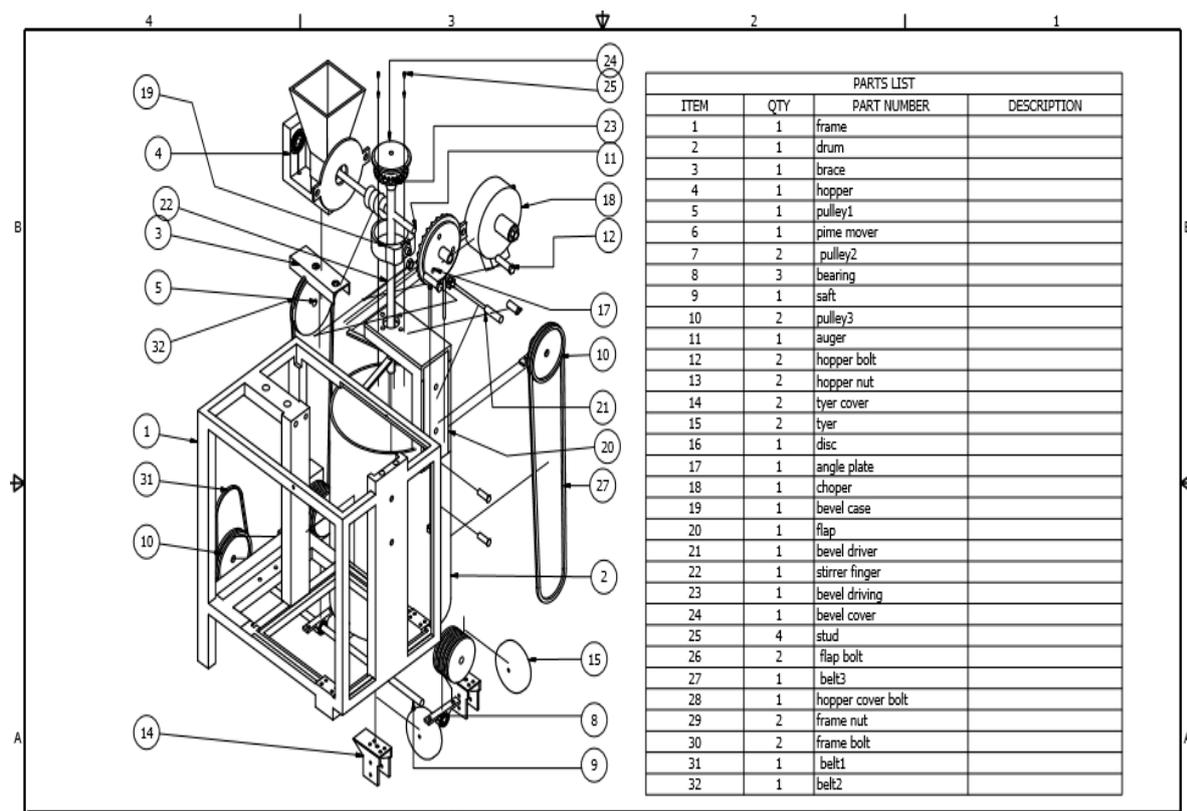


Figure 3. Exploded view of the Kneader

3 RESULTS AND DISCUSSION

3.1 Results

The results of the test carried out is presented in table 1 below in which 16.00kg of groundnut paste (W_p) was used as a constant capacity of the machine for each kneading operation. The operation was repeated for five times and weight of oil obtained (W_o) as well as yield of oil (Y_o) for each operation was recorded. The time taken for each successful operation (T_k) was also recorded and was used to determine the throughput capacities of the machine for each operation in kg/hr.

Table 1. Results of Kneading Operations and Throughput Capacities

S/N	Paste quantity W_p (kg)	Kneading time T_k (min)	Weight of oil W_o (kg)	Yield of oil Y_o (%)	Throughput capacity (kg/hr)
1	16.00	12.00	6.20	38.75	80.00
2	16.00	13.00	6.40	40.00	73.85
3	16.00	11.30	6.50	40.63	84.96
4	16.00	12.20	6.80	42.50	78.69
5	16.00	12.40	6.50	40.63	77.42
\bar{X}	16.00	12.18	6.48	40.50	79.10

Note: \bar{X} =Mean value of samples.

3.2 Discussions

The oil yield obtained from the Manipinta variety of groundnuts used in testing the kneading machine ranged from 38.75% to 42.50% with the mean value of 40.50% as shown in table 1. The significance of the yield of oil lies mainly in using it to estimate the quantity of oil expected from kneading a specified quantity of groundnut paste. In this case, the mean value 6.48kg of oil was obtained from 16.00 kg of groundnut paste. Table 1 also shows a range of 11.30-13.00 mins of kneading time for 16.00kg of groundnut paste. The mean value kneading time of 12.18 mins for 16.00 kg of groundnut paste compares favourably with the 11.25mins used for 6.6kg of groundnut paste, as earlier reported [6]. Now, we have about 85% savings in kneading time for 16.00 kg of groundnut paste with this engine powered kneader, which compares favourably with the 54%-76% recorded by [6]. The throughput capacity of an engine kneader was found to range from 73.85kg/hr to 84.96kg/hr, with mean value 79.10kg/hr, as shown in table 1. This is certainly better than a situation where 6.6kg of groundnut paste kneaded in 11.25mins (i.e 35.2kg/hr) as of one [6]. The throughput capacity (T_c) of the machine in terms of oil extracted can be calculated from table 1. The average throughput capacities for the five operations were calculated as shown below;

$$T_c = \frac{80.00+73.85+84.69+78.69+77.42}{5} \text{ kg/hr}$$

$$= 78.98 \text{ kg/hr}$$

Thus, the machine extracted 78.98kg of groundnut oil per hour.

4 CONCLUSION

The performance of an engine powered groundnut oil kneading machine was very satisfactory. Apart from making use of the traditional concept, the operation of the machine reduces the drudgery involved in the existing manual kneading tools. Test results also revealed substantial savings in kneading time over the other kneading tools. The operation of the kneading machine is simple and can therefore be used in place of the traditional tools. It can be used in rural areas where there is no electricity, since the source of its power is gasoline engine. The grinding unit was incorporated to avoid duplication of machine when processing groundnut for oil purpose. Wheels and tires were also added for easy movement of the machine within short distance. Thus, the machine is reliable, and has achieved its designed objectives.

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