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Design and Fabrication of Groundnut Shell Remover

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ABSTRACT

Groundnut product demand is on the increase and the application is largely dependent on the cleanness of the nuts. The separation process is usually an energy sapping task that requires a lot of time. In order to separate the nuts from its shell effectively a shelling machine was developed. The machine employs an auger screw as a means of breaking the groundnut pod. The machine basically comprises of shelling chamber, separating chamber and a motor (1HP). The arrangement of these parts is connected by a compound belt of type B standard V-belt of pitch length 1694mm. With the Von-mises equation, the material for the shelling shaft is taken to be mild steel. The materials used in the fabrication of the machine are sourced locally so as to ensure that it is cheap, affordable and easily maintained by the peasant farmers. The shelling efficiency and material damage are 84% and 14% respectively for groundnut seeds of 86.5% dry.

Keywords: Blow Air , Separating Chamber, Fan ,Calculation And Analysis.

I. INTRODUCTION

Groundnut (Arachis Hypogea) originated from latin America (Brazil) and was introduced into West Africa by Portuguese traders in the 16th century. Its actual origin dates back to 350BC (Komolafe*et al.*, 1985 and Hommons, 1994). It is botanically a member of the papilionaceae and is the largest and most important member of the leguminosae (Shankarappa, Robert and Virginia, 2003). This crop is considered to have great potential for both food and industrial purposes in the tropical regions of Africa (Milner, 1973). In some parts of Nigeria like Kano, Sokoto, Kaduna, Bauchi and Borno States, it is used as a source of revenue generation to support rural development (Maduako*et al.,* 2006).

One of the important processes involved in the production of groundnut is shelling and separation. Shelling is the removal of the groundnut seed from its pod by impact action, compression and shearing or combination of two/more of these methods. The shelling operation is majorly divided into two, namely: traditional and mechanical methods. The traditional shelling could be by stick beating, animal trampling or pod pressing by hand. Pod pressing is mostly practiced in Nigeria and it has low efficiency, high energy requirement, time wastage, high labour and fatigue.

Several shelling machines based on different techniques have been developed over the years. Among these machines are hand-operated groundnut sheller, baby groundnut sheller, powered rubber groundnut sheller to mention but few (Rodriquez, 1985). Due to custom charges, these machines are very expensive and are not affordable by the small-scale producers and farmers.

Maduako and Hamman (2004) determined some physical properties of three groundnut varieties. The materials used were ICGV-SM-93523, RMP-9 and RMP-12. Some of the physical properties considered were weight, bulk density, moisture content etc. Anova was used for analysis at 0.5 probability level.

Okegbile*et al.,* (2014) designed and fabricated groundnut shelling and separating machine. With 1hp motor, the machine has shelling capacity of 400kg/hour and shelling efficiency of 78% and material damage is 17.25%. The materials used were sought locally. The machine used spike to crush the pods.

This research aimed at using anger shaft in the crushing of the pod to replace the existing design. Also, to improve on the shelling capacity at low cost by using locally – available materials. Then, the machine is evaluated based on shelling efficiency and percentage material.

The purpose of this paperis to understand the knowledge of design andfabrication mechanism of groundnut Sheller machine.The design is an environment friendly and uses simple mechanism properties such as shelling system, blowering mechanism and automation separating system etc. In this, some crushing force is needed to crush the groundnut. The design is so done that the knowledge of designing, mechanism and forces are increased. This project consists of designing and fabrication of an automatic groundnut Sheller machine considering various important parameters. In this project, designing & development of a machine to crush or shell groundnut so the farmers can gain high profit by selling groundnut direct in market. As well as the study of manufacturing was very important in order to carry out this project to ensure that what are needs to do. This project involves the process of designing and fabrication of different parts of this shelling machine considering forces and ergonomic factor for people to use. This project is mainly about generating a new concept of groundnut shell (crush) that would make easier to bring anywhere and easier to crush groundnut. After the design has completed, it was transformed to its real product where the design is used for guideline.

Groundnut is grown on small scale by farmers in developing countries like India. Lack of groundnut processing machines at affordable cost, especially groundnut Sheller, is a major problem of groundnut production. Numbers of groundnut Sheller machines are available in the market but they are large in size, costly and not suitable for domestic applications, they are best suitable for industrial applications where mass production is required. Hence it is essential to design and fabricate a portable groundnut sheller machine for domestic application. This paper describes about the design of various components of groundnut Sheller machine. Hence in this design of various parts are necessary, and design of various parts due to which the design quality of those parts will be improved. Overall, this project involves processes like design, fabrication and assembling of different components etc

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The performance of the machine was evaluated in terms of throughput capacity, shelling efficiency, material efficiency and mechanical damage. Regression models that could be used to express the relationship existing between the Sheller performance indices, pod moisture content and feed rate were establish. This paper describes about the design and fabrication of various components of groundnut Sheller machine. Hence in this design of various parts are necessary, and design of various parts due to which the design quality of those parts will be improved. Overall, this project involves processes like design, fabrication and assembling of different components etc.

II. LITERATURE REVIEW

Knauft&Ozias – Akins, 1995 : The uses of groundnut are diverse; all parts of the plant can be used. The nut (kernel) is a rich source of edible oil, containing 36 to 54% oil and 25 to 32% protein (Knauft&Ozias-Akins, 1995). About two thirds of world production is crushed for oil, which makes it an important oilseed crop (Woodroof, 1983). The oil is used primarily for cooking, manufacture of margarine, shortening and soaps. Seeds are consumed directly either raw or roasted, chopped in confectioneries, or ground into peanut butter.

III. MATERIALS AND COMPONENTS

The materials used were locally obtained from a town called Ado-Ekiti which is the capital of Ekiti State in Nigeria. The selection of these materials was based on durability, cost and availability, strength and rigidity, weight and friction

Various components were put together in the fabrication of this machine

- Frame
- Electric motor
- Roller
- V-Belt
- Pulley
- Hopper
- Fan

Working Principle

Groundnut SHELLER is operated on the shearing action blowering action and separating action. Firstly the inputs i.e. the groundnut are fed to the machine through the hopper. Then groundnuts come in contact with the two members, one is semicircular net and another is roll shaft. Semicircular net is a stationary member while the roll shaft is rotating member. When the groundnut comes in contact with these two members then the shearing action takes place here. Due to shearing action (crushing) the groundnuts gets shelled and divided into two parts. i.e. in the peanut and outer shell of the groundnuts. There clearance is provided between the net and roll shaft. The clearance provided is depends upon the size of the groundnuts which is to be decocted. After shelleing the groundnut the peanut and shells of the groundnut gets dropped from the semicircular net, downward direction then a centrifugal force is applied by a fan on the peanut and shell of the groundnut. Due to more weight, the peanuts gets moved downward and collected in the separator. But due to lighter weight the shell of the groundnuts are thrown outside the machine and which are collected from the backside of the machine. From the shelling chamber the unshelled groundnuts also gets dropped in the tray (7% to 10%). This groundnut gets dropped from the clearance made among the grill. The three kinds of the nets can be used with different size of capsule slots, size vise small, medium and large for various size of groundnuts. In this way the "GROUNDNUT SHELLER" works.

IV. RESULTS AND DISCUSSION

The data collected for the shelling efficiency of the machine.the calculated average shelling efficiency. The result of test conducted on the percentage dryness is presented . It was deduced from the test data that the groundnut seeds used are 86.5% dry. The machine is having a shelling efficiency of 84% and material damage of 14%.Sample is selected according to the research work done in previous chapter . The sample is brought from market (mandi). It is sun dried for one day to remove moisture contend. Sample contains unshelled groundnut and some soil adhered to shell. As we discussed about the working principle and experimental set up of testing

Machine in the previous chapter, accordingly research we decide one sample & testing can done five times. After taking reading, calculating total sample reading and this total reading give mean reading. This mean reading help us to calculating result of Sheller machine. As the experimental set up of machine shown in the previous chapter regarding this, the sample reading are tabulated in the following table. In testing table following parameters are mention like,of sample, of shelled nuts and time required to shelled groundnut.

DESIGN AND CALCUTATION

1.Determination of Crushing Power to Break the Pod

The crushing power (P) to break the pod as computed by Okegbile*et al.,* (2014):

Power = CLWF ---------------------- (1)

Where,

C =Convey or Capacity (m^2/s),

L =Convey or Length (w),

W = bulk material weight (N/m^3),

F = material factor.

Taken Cc = 800kg/min

→$c_c = \frac{800x10}{60}$ = 116.66N/s.

But, C = $\frac{c_c}{w} = \frac{116.66}{199.3} = 0.59m^3/s$

By substitution,

P = 40.83W.

Base on specification, 1hp motor was selected.

2.Determination of the Pulley Diameters

The diameter, D of the auger pulley may be determined from the relation:

$$N_1N_2 = N_1N_2 \text{ ----------------------(2)}$$

Where,

N_1= speed of prime mover (1400rpm),

N_2= speed of driven pulley (auger),

D_1 = diameter of prime mover pulley = 0.125m,

D_2= diameter of the driven pulley (auger).

By substitution,

$$D_2 = \frac{N_1}{N_2}xD_1 = \frac{1440 \; x \; 0.125}{1800} = 0.1m$$

The diameter, D of the fan pulley may be determined from the relation:

$$N_3D_3 = N_4D_4 \quad \text{--------------- (3)}$$

Where,

N_3 = speed of auger pulley,

D_3 =diameter of auger pulley,

N_4 =speed of fan pulley,

D_4 =diameter of fan pulley.

$D_4 \frac{N_3}{N_4} xN_3 = \frac{1800 \; x \; 0.1}{900}$ = 0.2m

3.Determination of the length of the belt

The length, $L_1$of thebelt between auger and motoris determined from the equation as given by Khurmi Gupta

$$L_1 = 2c_1 + \frac{\pi(D_1 + D_2)}{2} + \frac{(D_2{}^2 - D_1{}^2)}{4c} \quad \text{------- (4)}$$

Where

L_1= length of,

c = distance between centres of pulley of motor and auger,

D_1 = diameter of the motor pulley,

D_2 = diameter of the auger pulley.

L_1 = 1640.47mm

The length, $L_2$of the belt between auger and fan is determined from the relation:

$$L_2 = 2c_{min} + \frac{\pi(D_3 + D_4)}{2} + \frac{(D_4{}^2 - D_3{}^2)}{4c} \quad \text{-------(5)}$$

Where,

c_{min} =distance between centres of pulleys of fan and auger,

$$= 2(D_4 + D_3) = 600mm$$

D_3 =Diameter of the auger pulley,

D_4 =Diameter of the fan pulley.

L_2 =1671.3mm.

Hence, a type B – standard V-belt of 1694mmpitch length was selected for each of the belts, $L_1$and L_2 for maximum power transmission.

4.Determination of Tension in the Belt

The tensions, T in the belt of length L_1 is shown below:

The belt speed V_b is estimated as given by Khurmin and Gupta (2005) and Akerele and Ejiko (2015)

$$V_b = \pi \frac{DxN}{60} \text{ --------------------- } (6)$$

Where,

N =Angular speed of motor (rpm),

D =Diameter of motor pulley $V_b = 9.426m/s$.

The angle of contact,ø1for the belt around auger and motor (Hall *et al.,* 1983):

$$ø1 = (180^0 - 2sin^{-1}(\frac{r_2 - r_1}{c})x\frac{\pi}{180} \text{ --------- } (7)$$

Where,

r_2 = radius of motor pulley,

r_1 = radius of auger pulley,

c = centre to centre distance between auger and motor,

$$ø1 = 3.103rad$$

For a v-belt, the relationship between the tensions T_1 and T_2 in the belt is given by (Khurmi and Gupta, 2005):

$$2.3log\frac{T_1}{T_2} = \mu\emptyset_1 cosec\beta \text{ ------------ } (8)$$

Whereμ= coefficient of friction = 0.3,

$\emptyset_1$ = angle of contact on smaller pulley,

β = half of groove angle = 19^0.

By substitution,

$$T_1 = 17.507T_2 \text{ ----------- } (9)$$

Recall,

power, $P = (T_1 - T_2)V_b$,

where$P = 3.7285KW$,

V_b =belt velocity = 9.426.

Then,

$$T_1 - T_2 = 395.55N \text{ ----------}(10)$$

By simplifying the equation2 9 and 10:

$$T_1 = 419.506N$$

and

$$T_2 = 23.9621N$$

Initial tension in the belt,

$$T_1 = (T_2 + T_1)/2 = 221.73N$$

The tensions, T in the belt of length L_1 is shown below:

The angle of contact,ø2 for the belt around auger and fan is given in equation 11 by Hall *et al.,* (1983) andAkerele and Ejiko, (2015)

$$ø1 = (180^0 - 2sin^{-1}(\frac{r_4 - r_3}{c})x\frac{\pi}{180} \text{ ------- } (11)$$

Where

r_4 = radius of fan pulley,

r_3 = radius of anger pulley,

c_2 = centre distance of fan and auger pulleys.

$$\emptyset 2 = 2.9751rad.$$

$$2.3log\frac{T_3}{T_4} = \mu\emptyset_2 cosec\beta \text{ ---------------- } (12)$$

$$T_3 = 15.5574T_4 \; 13$$

Also,

$$power = (T_3 - T_4)\, V_b \text{ ------------}(13)$$

$$\rightarrow T_3 - T_4 = 395.55 \text{ ---------------}(14)$$

By simplifying equations 13 and 14:

$$T_3 = 422.7217N$$

And

$$T_4 = 27.1717N$$

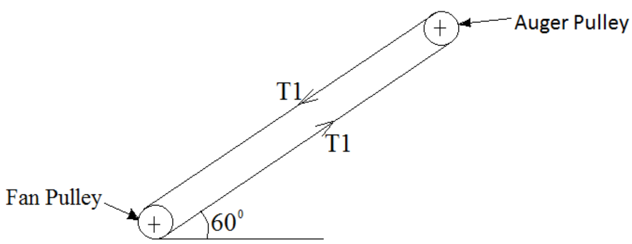
Initial tension in the belt,

$$T_1 = (T_3 + T_4)/2 = 224.95N.$$

5. Determination of the bending moments acting on the shaft:

The resultant of the tensions on belt 1,F_{r1};

$$F_{r1} = T_1 + T_2 = 419.506 + 23.9621$$
$$= 443.4681N$$



By resolving the forces into its vertical and horizontal components;

$$F_{v2} = F_r 2sinø = 449.8934sin600 = 389.6191N$$

F_{H2}Vertical weight of the pulley, $wp = 9.81N$.

So, resultant vertical head of the pulley is given as:

$$F_{r1} + F_{v2} + Wp = 443.4681 + 389.6191 + 9.81$$
$$= 842.8972N$$

Wt. of auger, $w_1 = 0.15KN/m$,

Vol. capacity of hopper,

$$V = 0.5(a+b)hl$$
$$= (0.25 + 0.15)0.25 \times 0.42 = 0.021m^3$$

By experiment, the specific weight of dry groundnut is 199.3N/m³.

Therefore the hopper capacity $= 0.021 \times 199.3 = 4.1853N$.

Weight of the handle disc = volume of disc x specific weight of steel

$= \frac{\pi x D^2 x h x 75}{4} = 0.003142 \times 75 = 236N$

6.Determination of the shaft material

The selection of suitable material for the auger shaft is done as computed by Benham*et al.,* (1998):

$$\text{Bending stress, } \sigma_b = \frac{My}{I} \quad \text{-------------- (14)}$$

Where

M = bending moment,

y = centroid of the shaft,

I = moment of initial.

The critical part of the shaft is at

$$E.M = 0.1307KNm, y = 0.05m,$$

$I = \frac{\pi d^4}{64} = 4.909 \times 10^{-6} m^4$.

Then,

σ_b= 1331.2kpa

$$\text{Torsional stress, } \tau_s = \frac{Tr}{j} \quad \text{--------------- (15)}$$

Where

T = torque,

r = radius of shaft,

j = polar moment of inertia.

T = 19.77Nm,

r = 0.05,

$j = \frac{\pi d^4}{32} = 100.67kpa$

$$\text{The shear stress, } \tau_v = \frac{4V}{3A} \text{ ------------- } (16)$$

(Where v = shear force, A = area of the shaft).

$$v = 0.842^2 + 0.224^2$$

$$\rightarrow v = 0.8713KN.$$

So, $\tau_v = \left(\frac{4x0.8713}{3x7.855x10^{-6}}\right) = 147.9kpa.$

In order to estimate the principal stresses, we use the relation:

$$\sigma_{1,2} = \frac{\sigma_x+\sigma_y}{2} \pm \left(\frac{\sigma_x-\sigma_y}{2} + \tau_{xy}{}^2\right)^{0.5} \text{ ------------ (17)}$$

Where, $\sigma_x = \sigma_b$, $\tau_{xy} = \tau_v + \tau_s$. Then, σ_1 = 1639.07kpa, σ_2 = 0 kpa and σ_3= -307.95kpa

Von mises equation is used to design against material failure as shown below (Rajput, 2006):

$$s_y = \sqrt[2]{\frac{((\sigma_1-\sigma_2)^2)+((\sigma_2-\sigma_3)^2)+((\sigma_1-\sigma_3)^2)}{2}}$$

By substitution, Sy = 1.8128Mpa. A standard shaft made from mild steel is selected.

7.Determination of the size of power to drive the fan

The required power, P (watt) is obtained from the relation below:

$$\text{Efficiency, } e = \frac{\text{power output } (P_o)}{\text{power input } (P_i)} \text{ --------------(18)}$$

Where p_o= fan flow rate (Q) x static pressure (P_s). Taken Q = 0.59m³/s, P_s= 400N/m², e= 0.80

Then,

Power input, $p_i = \frac{0.59x400}{0.80}$= 295W

8.Determination of auger capacity

The auger capacity, c is determined as given in the equation (Olumide, 1991)

$$C_1 = \frac{\pi x (D^2-d^2) x P x N x P_b}{4} \text{ ------------ (19)}$$

Where

D = screw auger diameter,

d = shaft diameter (m),

p = Screw pitch diameter (m),

N = angular, speed (rod/s),

P_b = bulk density of the material. C = 0.1m³/s. So, the auger can contain about 420g of groundnut at a time.

9. Determination of a size of the key

The size of the key is determined from the relation as computed by Akerele and Ejiko, (2015):

Width, $b = \frac{3D}{16} + \frac{25.4}{8}$

Thickness, $t = \frac{3D}{32} + \frac{25.4}{8}$

Where$D$ =diameter of the shaft (mm).the width and thickness are 7.86mm and 5.52mmrespectively.

OPERATION OF THE SHELLING MACHINE

The dried nuts were fed into the machine through the hopper. A prime mover (electric motor) is connected to the shelling and separating chambers with the aid of compound pulley. As it supplies the power, the auger shaft rotates and breaks the pods against the shelling chamber wall and stationary sieve. The air produced by the action of the fan (or blower) sweeps the seeds and shell fragment out of the shelling zone into the inclined outlet unit. The fan passage serves as the separation chamber such that the seeds are collected at the discharge outlet while the pods are collected at the shaft outlet0

V. CONCLUSION

A groundnut shelling machine has been designed, fabricated and tested in this research. A preliminary test evaluation in terms of shelling efficiency and material damaged has indicated that it has a higher potential in substituting manual methods. Also, the machine exceeded the previously designed and fabricated shelling machine in terms of efficiency and time. This is because the design involves material strength and rigidity. The following recommendations are required for effective utilization of the machine; these include making sure the groundnut moisture content is not more than 16%, running the machine for a maximum of 10 hours daily, installing the machine in a well ventilated area, using engine grade lubrication oil and running daily maintenance after operation to prolong the machine life span.Proper evaluation of the design will be performed and created something even better instead of simply manually operated operations. Finally we conclude that atomize machine is better option to use farmer instead of manually operated. The demands atomize shelling machine of farmer & other customers will be also considered while designing machine. Purpose of fabrication of the Sheller was to determine the suitability of machine for farmer‟s use. Five experiments were performed with peanuts. Since this machine is made for small businessman or for farmers, therefore the work carried out by this machine is less. The capital required for purchasing the bigger size groundnut decorticator is very high or the cost required for decorticating the groundnut on the job work is also more. In comparison these “Groundnut Sheller” is very cheap. We have selected the “GROUNDNUT SHELLER REMOVER MACHINE” as our project work. The “GROUNDNUT SHELLER RENOVER MACHINE” is the ideal equipment for decocting process. In the process of completion of the project work our ideas and thought are development towards the mechanisms and technologies of the equipment. We also visualized that this “GROUNDNUT SHELLER REMOVER MACHINE” is the most critical equipment for the future growth and development of cottage sector projects.

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