Development and Evaluation of a Motorized Peanut Shelling Machine

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***Abstract: -* This research was carried out to design, construction and evaluate a peanut shelling machine. The machine comprised of feeding hopper, shelling cylinder, chaff discharge chute, blower fan, frame and 2.5 kw electric motor. A sensitive Electric balance of 30Kg by 5g(Model no: ACS-J2C) was used to measure the weight of the peanut sample. A Digital Tachometer of Contact/Surface Speed (Model no: DT-2235B) Was used to measure the speed of the blower speed of the machine which was 155rpm. The shelling machine developed was tested with a three (3) different samples of peanut of 6.5 Kg each. The samples were soaked at room temperature for 2hrs, filtered and dried on concrete floor for 3hrs and returns to bags for 20hrs, 21hrs and 22hrs and then shelled. A multi-level factorial experiment was used to analyzed the data generated. It was found that the machine has 98% shelling efficiency, 5.3% mechanical damage, 89% cleaning efficiency and a throughput capacity of 160kg/hr.**

***Keywords:* Peanut, Development, Evaluation, Shelling efficiency and Mechanical damage.**

I. INTRODUCTION

Groundnut, or peanut, is commonly called the poor man's nut, is an important oilseed and food crop. This plant is native to South America and has never been found uncultivated[1]. Groundnut, (*Arachis hypogaea Linn*.), is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning below ground, referring to the formation of its pods in the soil. Groundnut or Peanut is an upright or prostrate annual plant. It is generally cultivated in the tropical, sub-tropical and warm temperate zones. China and India together are the world's leading groundnut producers accounting for nearly60 percent of the production and 52 percent of the crop area[1]. India cultivates about 7.74million hectares and produces 7.61 million tones of groundnut with the productivity level of 991.8 kg ha-1. South Africa is the major producer in Africa, while in Latin America almost one half of the total groundnut produced in that region may be credited to Argentina[2]

In most of the developing countries, the productivity levels are lower than in the United States of America, mainly due to a number of production constraints outlined as follow: i.) The cultivation of the crop on marginal lands under rainfed conditions; ii.) Occurrence of frequent drought stress due to vagaries of monsoon; iii.) higher incidence of disease and pestattacks; iv.) low input-use and v.) factors related to socio-economic infrastructure. In the developing countries, groundnut plays, an important role both as oil and food crop. For example, in India about 10 kg groundnut per capita are available fordomestic consumption. Groundnuts are important component of Nigerian diet and about 5 percent of the estimated 58.9 g of crude protein available per head per day, is contributed by groundnut [3].

The shelling method of peanut has remained traditional, Shelling is usually done by breaking the shell by hand pressure under the thumb[4]. Though a mechanized peanut shelling has been developed, but due to high cost of the machine, its subsequent maintenance, availability of spare parts, low efficiency, high percentage of breakage and high cost of shipping[5]traditional methods of shelling peanut is still predominant. The development of peanut shelling machine is therefore, necessary to reduce the burden, reduced pod breakage and drudgery associated with traditional hand shelling.

This research was therefore aimed to developed and evaluate the performance of a motorized peanut shelling machine. with a view to solved the problems of seed damage during peanut shelling and secondary significance is its economic importance to farmers. The machine is also aimed to encourage large scale producers and entrepreneurs. It is believed that the peanut shelling machine will be available to the market at affordable price that majority of small-scale farmers can afford, and maintained easily, hence by its operators and subsequently replace the traditional methods of shelling peanut.

II. MATERIALS AND METHODS

Materials used for the construction of the peanut shelling machine are 2mm mild steel plate, and 25mm x 25mm angle iron. The choice of these materials was based on their unique properties that are adoptable to a particular component of the machine and also, their availability in the market. Such properties include light weight, and malleability. The machine comprises the following: the shelling cylinder, bearings, sieve, hopper, outlet hopper, chaff outlet, blower fan and electric motor.

2.1 Determination of Pulley Dimension

The dimension of the pulley was determined using the following expression

$N_1D_1 = N_2D_2$ -[6] - - - - - - - - - - (1)

Where: N_1= Speed of drive Pulley = 155rpm

D_1 = Diameter of drive pulley = 70mm

N_2 = Speed of thresher pulley = 700rpm

D_2 = Diameter of thresher pulley = 200

2.2 Estimation of belt lengths

The belt length was estimated using the expression established by Hannah and Stephen in 1984

$$L=2c+1.57(D-d)+\frac{(D-d)2}{4c} \quad \text{- [6] - - -} \quad (2)$$

Where:

L = effective length of belt (mm)

C = center distance from drive to driven pulley (mm)

D = Outside diameter of drive pulley (mm)

d = diameter of driven pulley (mm)

2.3 Calculation of belt Speeds

The belt speeds were calculated using the equation:

$$N = \frac{V}{\pi d} \quad \text{[6]- - - - - - - -} \quad (3)$$

Where:

V = Belt speed (m/s)

N = Drive speed (rpm) = 1600rpm

D = Diameter of drive pulley (m) = 70mm

2.4 Determination of the Shaft Diameter

The construction of shaft involves determination of the minimum diameter of the shaft material that can withstand certain loading conditions. Shaft may be subjected to torsion, to bending, to axial, tension or compression or to a combination of any or all of these actions. Therefore, all of the above were taken into consideration to avoid shaft failure. The selected material used for the shaft in this machine is medium carbon steel (C1040).To get the shaft diameter (d) using the relationship

$$d^3 = \frac{16}{\pi Sa}\sqrt{(KbMb)^2 + (KtMt)^2} \quad \text{[7] - - -} \quad (4)$$

Where

S_a = allowable shear stress = 90.3 x 10^3KN/M^2

K_b = constant of bending moment = 1.5

K_t = constant of torsion = 1.0

M_b = bending moment = 0.17KNM

M_t = moment of torsion = 0.031KNM

III. DESCRIPTION OF THE PEANUT SHELLER

The Peanut shelling machine were made up of inlet hopper, Chaff out let, blower housing from 2mm mild carbon steel sheet. 25mm x 25mm angle iron frame which support the assembly. Threshing housing, Pulley and Blower Pulley with their belts. The machine was powered by 2.5 hp electric motor. The 3D model was design using solid work 2016 software. The complete fabricated machine and itsthree-dimensional orthographic drawing presented in Figure 1.0 and Figure 2.0. Table 1.0 is the machine part components and their quantities to make up the complete machine assembly.

Table 1.0 Component/Parts of the Machine Assembly and their quantities

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	frame 1		6
2	frame 4		6
3	frame 2		4
4	frame 3		4
5	frame5		2
6	prime mover base		1
7	prime mover stand		4
8	Assem2		1
9	threshing unit assembly		1

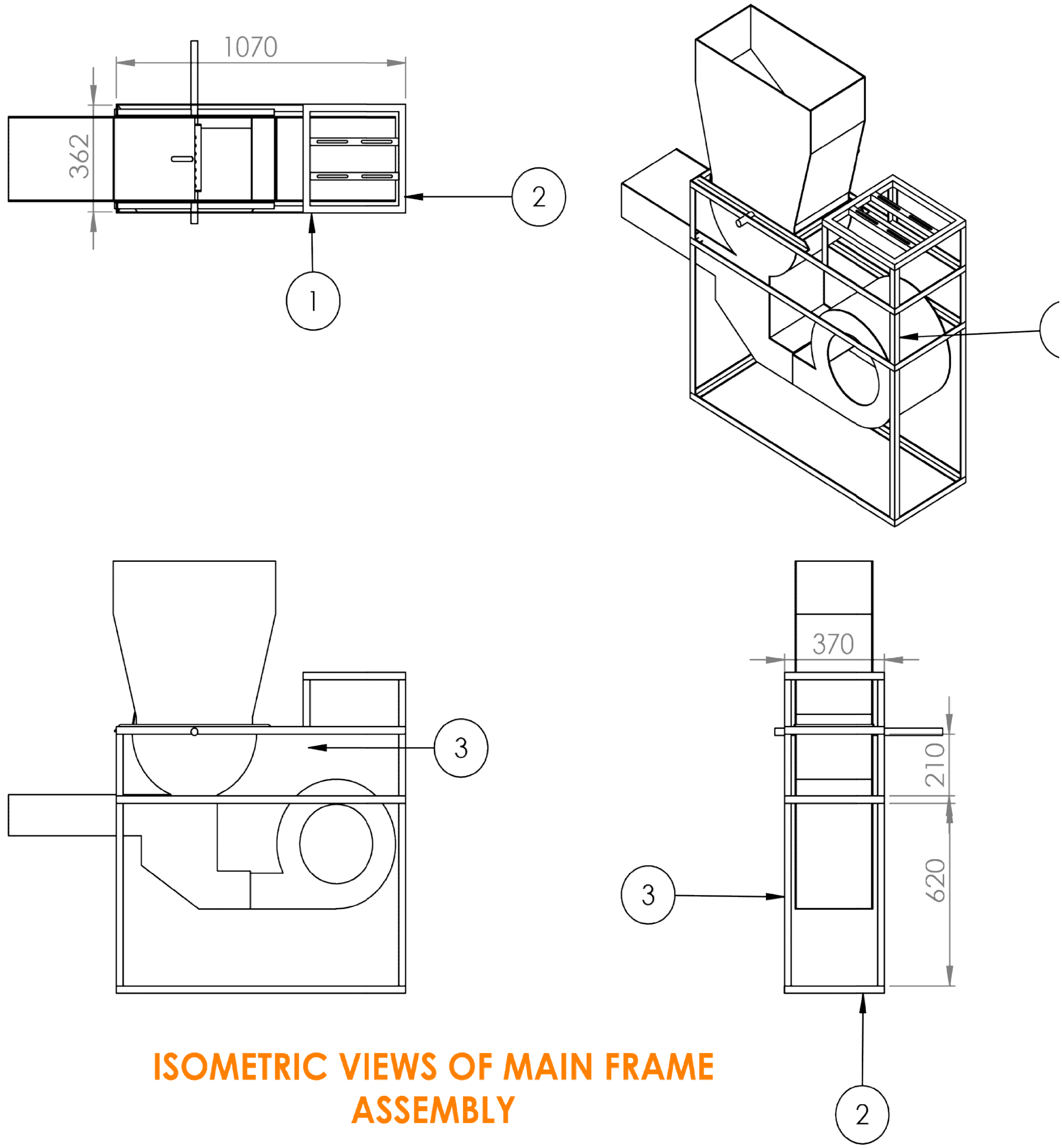

Figure 1: Isometric views of the Peanut Shelling Machine.

Figure 2.0Complete Constructed Peanut Shelling Machine.

3.1Working

The machine is powered with the help of a 2.5kw single-phase Electric Motor which is connected to the external power supply. The motor connected to the shelling unit shaft operates the unit. Peanut are supplied in shelling chamber through hopper at a controlled feed rate for efficient shelling. Shelling is achieved in the shelling unit via impact of spike (beaters) attached to the shelling drum. Cleaning is achieved by the blower fan. Clean seeds are collected at the grain outlet, while the chaff blown out through the chaff outlet.

IV. EVALUATION PROCEDURE

4.1. Experimental Design

Unshelled peanut samples were obtained from Girei market in Girei Local Government Area of Adamawa State. A container was weight using Sensitive Electric Balance (Model: ACS-J2C) and recorded. Three sample of peanut was weight and recorded. The three-sample were soaked with water for 2 hrs and filtered to remove the water. The samples were shed dried on the ground floor for 3hrs and later returned to the bags for 20hrs, 21hrs and 22hrs, before shelling.

The evaluation of the machine prototype was based on multi-level full factorial experimental design. The experimental design ware are the variables and their observed levels:

Concave clearance 2 levels, Blower speed 2 levels, Drying time3 levels Soaking time3 levels and three replications. Thus, we have 2x2x3x3x3, resulting in 108 experimental units.

V. RESULTS AND DISCUSSIONS

5.1 Effect of Concave Clearance Soaking Time and Drying Time on Cleaning Efficiency

The analysis of variance table 2.0 for the effect of factors (concave clearance, soaking time and drying time) on responses (cleaning efficiency) revealed that, concave clearance and drying time were highly significant on the cleaning efficiency of the machine at P≥0.05 level of significance. This result reveals that, the machine developed have a very good cleaning efficiency(89%) and is also similar (92%) to G. Karthik, D. Balashankar,et al.[8]

Table 2.0 Analysis of Variance for concave clearance soaking, blower speed and drying time on cleaning efficiency

Source	DF	Seq ss	Adj ss	Adj ms	F	P
Soaking time	2	293.7	293.7	146.8	1.90	0.156
Drying time	2	3568.1	3568.1	1784.1	23.03	0.000
Concave clearance	1	15004.9	15004.9	15004.9	193.70	0.000
Blower speed	1	140.1	140.1	140.1	1.81	0.182
Error	101	7824.0	7824.0	77.5		
Total	107	26830.8				

5.2 Effect of Concave Clearance and Drying Time on % Breakage.

The analysis of variance for the effect of factors on responses revealed that, concave clearance and drying time were highly significant on the % breakage of the machine at P≥0.05 level of significance. This results revealed that this shelling machine developed have (5.3%) mechanical damage which is far better than the work of Ashish S. Raghtate et.al [9] which was (20.07%). A great improvement on the machine have a capacity of 160kg/hr. which is the work of Ashish S. Raghtate et.al[9] of 130.5 kg/hr.

Table 3.0 Analysis of Variance for concave clearance Soaking Time, Blower Speed and drying time on percentage breakage

Source	DF	Seq ss	Adj ss	Adj ms	F	P
Soaking time	2	171.7	171.7	85.9	2.18	0.119
Drying time	2	890.3	890.3	445.1	11.29	0.000
Concave clearance	1	5767.0	5767.0	5767.0	146.29	0.000
Blower speed	1	90.8	90.8	90.8	2.30	0.132
Error	101	3981.5	3981.5	39.4		
Total	107	10901.3				

5.3 Effect of Concave Clearance Drying Time, Blower Speed on Shelling Efficiency.

The analysis of variance for the effect of factors on responses revealed that, concave clearance and drying time were highly significant on the shelling efficiency of the machine at P≥0.05 level of significance. This result reveals that, the machine developed have higher shelling efficiency(98%), when compared the results with what is obtained by G. Karthik, D. Balashankar,et.al[8] in there design which was (95.25%) and Ashish S. Raghtate et.al[9] which was (81.2%)

Table 4.0 Analysis of Variance for concave clearance, drying time and blower speed on shelling efficiency

Source	DF	Seq ss	Adj ss	Adj ms	F	P
Soaking time	2	0.9074	0.9074	0.4537	3.91	0.023
Drying time	2	1.2407	1.2407	0.6204	5.35	0.006
Concave clearance	1	1.5648	1.5648	1.5648	13.49	0.000
Blower speed	1	0.4537	0.4537	0.4537	3.91	0.051
Error	101	11.7130	11.7130	0.1160		
Total	107	15.8796				

VI. CONCLUSION

A Peanut Shelling Machine was developed which can shell peanut efficiently at 2hrs soaking time, 3hrs shed drying on concrete floor and returning to bags for 20 to 22hrs. From the evaluation carried-out we can conclude that a shelling machine was developed with a great improvement over [8], is affordable, portable, efficient, with minimal damage when compare with the conventional machines and subsequently will replaced the traditional means of shelling.

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