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Development and Performance Evaluation of a Groundnut Shelling Machine

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Abstract- The numerous uses of groundnuts have made groundnut shelling a lucrative business for processors. In the past, early researchers developed compact machines, but had no cleaning compartments and has high mechanical damages. These problems need to be solved to an appreciable point for optimum utilization of harvested groundnut with an affordable and more compact machine. For optimum use of harvested groundnuts, a groundnut shelling machine was designed, fabricated and tested. The machine was fabricated with locally available materials and designed to shell and clean the groundnut. The main parts are the hopper, shelling chamber, shelling drum, electric motor, fan chamber, channel and frame. The shelling is done by a metallic shelling drum with rough surfaces rubbing the groundnut on another perforated surface. This perforation allows the shelled groundnut and the chaffs to escape to the inclined channel where the fan blows air to push out the chaffs at the upper end while groundnut flows through the lower end. The channel and hopper are inclined at angle 29o to the horizontal to aid unshelled and shelled groundnut flow. The motor of 1 horsepower was revolving at 170 rpm, provides the shelling drum with a speed of 68 rpm to shell the groundnut. The machine was tested three times to obtain the shelling efficiency, cleaning efficiency and material efficiency which were 97.94%, 56.2% and 90.13% respectively. The shelling capacity and mechanical damage of the machine were 192.86kg/hr. and 9.87% respectively. The cost of the machine is estimated as 330 USD. The machine is highly efficient and can be adopted by farmers and groundnut processing industries for groundnut shelling operation.

Keywords Design, fabrication, groundnut, machine, parameter, shelling, testing.

1. Introduction

Groundnut (*Arachis Hypogaea L)* with other names such as peanut and earthnut is the sixth most important crop in the world [1]. [2] – [3] reported that the oil content from groundnut is within 45% – 55% depending on varieties. This rich oil content makes groundnut a valuable cash crop leading to it cultivation in over 100 countries with 94% production contributed by developing countries [1, 4]. As the invaluable uses of groundnut are discovered, there has been an increase in production. [5] estimated that the global production of groundnut is about 10 million tonnes per year. This production is largely contributed by Asia (68%) and Africa (25%) on a global scale. [6] estimated this growth in production by west African countries to be 53% over the last 25 years. Nigeria contributes 31% to the Africa's supply chain and significantly 51% in west Africa production [7]. A large percentage of the global production is used for oil. This was estimated by to be two-third of the total production, with one-third for food consumption [8].

The usage of groundnut spans from consumer to industrial applications. Some consumer uses include peanut oil, cooking oil, peanut butter and peanut flour, while Industrial applications include lubrication oil, leather dressing, furniture polish, paints etc. It is worthy to note that after oil extraction, the waste is used for animal feeds. These numerous usages implies that more processors, from small scale to large scale, are joining the groundnut processing industries. This connotes that there is an increase in the need of groundnut processing machines such as the shelling machine for optimum usage.

Shelling is usually the first operation in groundnut processing which was usually done manually either by beating or pressing the groundnut kernels out of the shells with sticks or hands, or a manually operated machine used to process a large quantity of the groundnut [9]. These methods proved ineffective due to wastage, groundnut damage and human draught. This led to the development of machines to curb these problems in different countries. Researchers had developed different types of groundnuts shelling machines, addressing the problem of shelling groundnut. Some authors modified past machines to improve efficiency and get the best possible output. A look at the factors affecting the performance of the shelling operation is also considered. These factors include the groundnut size, moisture content, shelling speed, sieve, and concave clearance. These factors were observed based on the operational parameters, including the shelling and cleaning efficiencies, mechanical damage, and throughput capacity. The operating speed of the machines ranged from 150 – 300 rpm; the range of the shelling and cleaning efficiencies were 78 – 98.32% and 50.63 – 91.67% respectively, while the mechanical damage ranged between 5.3 – 17.4% [10] – [30].

However, many of these machines are either large or expensive and not readily available to small and medium scale farmers or enterprises. Peculiar uses of groundnut such as production of *kulikuli*, amongst many others, necessitate the need for affordable groundnut shelling machines that can serve the masses who generates revenue from this business. Hence, the development of a portable and affordable groundnut shelling machine that will be available to the small, medium and large-scale groundnut businesses.

2. Materials and Methods

2.1 Machine Description and Working Principle

The machine is designed for both shelling and cleaning. The shelling is first done as the groundnut flows through the hopper into the shelling chamber where the shelling drum does the shelling by rubbing action. As the groundnut is rubbed on the face of the chamber, the shells breaks and the kernel is released. The kernel and the chaffs pass through the perforated area of the chamber and enter into the channel beneath it. At one end of the channel is the fan blowing out the chaffs out of the groundnut to ensure a clean groundnut is collected. This fan effect blows the chaffs through the other end. Figure 1 shows an exploded view of the conceived machine.

No.	Part	Material	Qty.
1	Frame	Mild steel	1
2	Hopper	Galvanized Sheet	1
3	Shelling shaft	Mild steel	1
4	Shelling Chamber	Mild steel	1
5	Shaft Bearing	Cast Iron	2
6	Fan Blades	Galvanized Sheet	1
7	Shaft Pulley		1
8	Electric Motor 1hp.		1
9	Collector channel	Galvanized Sheet	1
10	Shaft Belt		1
11	Fan Pulley		1
12	Fan Belt		1
13	Fan Cover	Galvanized steel	1
14	Fan Bearing	Cast Iron	2

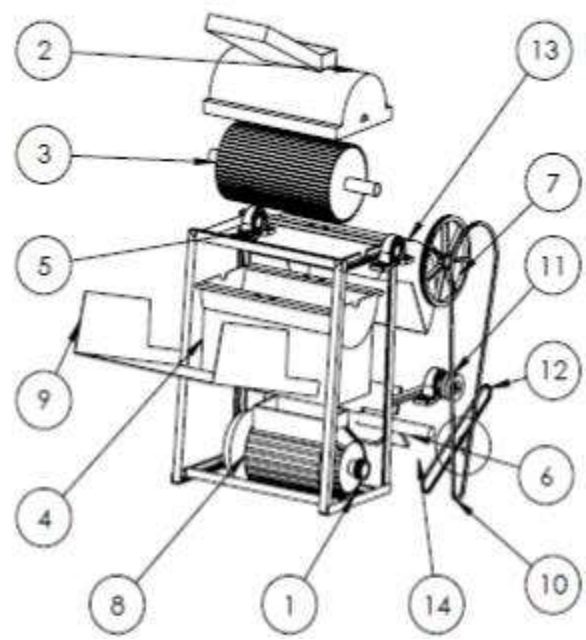

Fig. 1. Exploded view of the groundnut shelling machine.

2.2 Design Considerations

The design considerations adopted during the development of the machine include the use of available materials in the locality to ensure affordability of machine and accessibility to the machine parts and components. Other considerations include, compact design for easy mobility, locally developed fan to offset the cost of a bought-out fan, low shelling speed to ensure lesser mechanical damage and good shelling. The pass-through sieve was perforated and drilled taken into consideration the average size of groundnut kernels. The developed groundnut shelling machine is presented in Figure 2 and Plate 1 respectively.

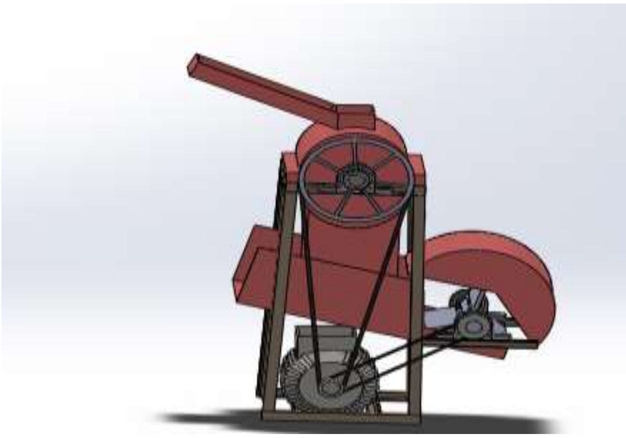

Fig. 2. The isometric drawing of the developed groundnut shelling machine

Plate 1. The developed groundnut shelling machine.

2.3 Design Calculations

2.3.1 Hopper design

The hopper volume (V_h) and depth (h) were determined using equations 1 and 2 respectively, as recommended by [4], [19].

$$V_h = L_h x\, W_h\, x\, B_h \quad (1)$$

$$Sin\,\theta = \frac{h}{L_h} \quad (2)$$

Where L_h is the length of hopper in mm , W_h is the width of hopper in mm and B_h is the depth of hopper in mm. Substituting L_h= 340 mm, W_h =220 mm, B_h =50 mm and $\theta = 29^o$. Therefore, V_h *and* h are 3.74 x 10^6 mm^3 and 193.92 mm respectively.

2.3.2 Pulley design

2.3.2.1 Determination of pulley diameter

The pulley diameter was determined using equation 3 as recommended by [4].

$$d_1 = \frac{N_m\, d_m}{N_1} \quad (3)$$

where N_m is the speed of motor pulley in rpm, d_m is the diameter of motor pulley in mm and N_1 is the speed of shaft pulley in mm. Substituting N_m= 170 rpm , d_m = 70 mm and N_1= 68 rpm, therefore d_1 is 175 mm.

2.3.2.2 Determination of pulley weight

The weight of the pulley was determined using equations 4 and 5 as recommended by [31] – [32].

$$W_p = \rho\, x\, V_p\, x\, g \quad (4)$$

$$V_p = \frac{\pi d_p^2\, t_p}{4} \quad (5)$$

Where W_p is the weight of the pulley in kg, ρ is the density of steel in kg/m^3, g is the acceleration due to gravity in m/s^2 and V_p is the volume of pulley in mm^3. Substituting ρ= 7850 kg/m^3, g= 9.81 m/s^2, t_p= 12.5 mm, d_1= 175 mm and d_2= 80 mm. Therefore, V_1 and V_2 are 1.203 x 10^6 mm^3 and 6.28 x 10^4 mm^3 respectively and W_1 and W_2 are 92.64 N and 4.84 N respectively.

2.3.3 Belt Design

2.3.3.1 Length of belt

[31] reported the formulae for calculating the length of the belt (open) using equation 6.

$$L = \frac{\pi(d_m + d_1)}{2} + 2C_1 + \frac{(d_m - d_1)^2}{4C_1} \quad (6)$$

L is the length of belt in mm, d_m is the diameter of motor pulley in mm, d_1 is the diameter of front shaft pulley in mm, C_1 is the center between motor pulley and shaft pulley in mm. Substituting d_m= 70 mm, d_1 =175 mm and C_1= 600 mm. Therefore, a belt of length 1590 mm was chosen.

2.3.3.2 Angle of contact of belt

[11] reported the formulae for calculating the angle of wrap and contact as suggested using equations 7 and 8 respectively.

$$Sin\,\alpha_1 = \frac{r_1 - r_m}{C_1} \quad (7)$$

$$\theta_1 = (180^o - 2\alpha_1)\frac{\pi}{180} \quad (8)$$

Where, α_1 is the angle of wrap in ^{o}, r_1 is the radius of shaft larger pulley in mm , r_m is the radius of motor pulley in mm, c_1 is the distance between motor and shaft pulleys in mm.

Θ_1 is the angle of contact, r_m = 35 mm, r_1 = 87.5 mm and C_1 = 600mm. Therefore α_1 and θ_1 are 5.02° and 2.97 rad respectively.

2.3.3.3 *Velocity of the belt*

The linear velocity of the belt pulley was determined using equation 9 as recommended by [33].

$$v_1 = \frac{\pi\, d_1 N_1}{60} \tag{9}$$

where v_1 is the linear velocity of pulley in m/s, d_1 is the diameter of the pulley in mm and N_1 is the speed of pulley in rpm. Substituting d_1=175 mm and N_1=68 rpm, the velocity is 0.62 m/s.

2.3.3.4 *Tension on the belt*

The tension on shaft belt was estimated with equations 10 and equation 11 [31].

$$\frac{T_1}{T_2} = e^{\mu\theta_1} \tag{10}$$

$$T_1 - T_2 = {}^{P}/_{v_m} \tag{11}$$

where T_1 is the tension on the tight side in N, T_2 is the tension on the slack side in N, µ is the coefficient of friction, P is the power transmitted in W and v_m is the velocity of motor in m/s. Substituting µ and P given by [11], [9] as 0.25 and 40.83W respectively and $\theta_1 = 2.97$ rad, T_1 *and* T_2 are 119.63 N and 59.81 N respectively.

2.3.4 *Fan design*

2.3.4.1 *Determination of fan speed*

The fan speed was determined using equation 12 as given by [4].

$$N_3 = \frac{N_2\, d_2}{d_3} \tag{12}$$

Where N_3 is the speed of shaft smaller pulley in rpm, d_2 is the diameter of shaft smaller pulley in mm, d_3 is the diameter of fan pulley in mm. Substituting N_2= 68 rpm, d_2 = 80 mm and d_3= 70 mm. Therefore, speed of fan pulley is 77.71 rpm.

2.3.4.2 *Determination of fan pulley weight*

The weight of the fan pulley, W_{fp} was estimated using equations 13 and 14 as given by [31] – [32].

$$W_{fp} = \rho\ x\ V_{fp}\ x\ g \tag{13}$$

$$V_{fp} = \frac{\pi d_{fp}^2\, t_{fp}}{4} \tag{14}$$

Where W_{fp} is the weight of fan pulley in kg, ρ is the density of steel in $\mathrm{kg/m^3}$, V_{fp} is the volume of fan pulley in m^3, t_{fp} is the thickness of fan pulley in mm, g acceleration due to gravity in $\mathrm{m/s^2}$ and d_{fp} diameter of fan pulley in mm. Substituting $\rho = 7850\ \mathrm{kg/m^3}$, $g = 9.81\ \mathrm{m/s^2}$, $t_{fp} = 12.5\ mm$ and $d_{fp} = 70\ mm$. Therefore, volume of fan pulley and weight of fan pulley are $4.81\ x\ 10^{-5} m^3$ and 3.7 N respectively.

2.3.4.3 *Length of fan belt*

The length of fan belt was estimated by equation 15 as given by [31].

$$L_2 = \frac{\pi(d_2+d_3)}{2} + 2C_2 + \frac{(d_2-d_3)^2}{4C_2} \tag{15}$$

Where, L_2 is the belt length in mm, d_2 is the diameter of shaft smaller pulley in mm = 70 mm, d_3 is the diameter of fan pulley in mm = 175 mm, C_2 is the distance between shaft pulley and fan pulley in mm = 600 mm. Therefore, a belt of length 1200 mm is chosen.

2.3.4.4 *Angle of contact of fan belt*

The angle of wrap and contact were estimated using equations 16 and 17 as reported by [31].

$$Sin\ \alpha_2 = \frac{r_2 - r_3}{C_2} \tag{16}$$

$$\theta_2 = (180^{\circ} - 2\alpha_2)\frac{\pi}{180} \tag{17}$$

Where, α_2 is the angle of wrap in °, r_2 is the radius of shaft smaller pulley in mm, r_3 is the radius of fan pulley in mm, c_2 is the centre distance between the pulleys in mm and θ_2 is the angle of contact in rad. Substituting r_2 = 40 mm, r_3 = 35 mm and c_2 = 480 mm. Therefore α_2 and θ_2 are 0.597° and 3.12 rad respectively.

2.3.4.5 *Tension on shaft front belt*

The tension on the shelling belt was estimated with equations 18 and 19 as recommended by [31].

$$\frac{T_3}{T_4} = e^{\mu\theta_2} \tag{18}$$

$$T_3 - T_4 = {}^{P}/_{v_2} \tag{19}$$

where T_3 is the tension on the tight side in N, T_4 is the tension on the slack side in N, µ is the coefficient of friction, θ_2 is the angle of contact in rad, P is the power transmitted in W and v_2 is the velocity of fan belt in m/s. Substituting µ and P given by equations (11, 9) as 0.25 and 40.83 W respectively and θ_2 = 3.12 rad. The tension of the tight and slack sides of the fan belt are 145.82 N and 123.57 N respectively.

2.3.5 Shaft design

Autodesk Inventor Pro was used in analyzing the shear force and bending moments of the shelling drum shaft. The analysis results were compared with manually calculated values to ensure accuracy and the shear force and bending moment diagram plotted (Figures 3 to 8). Figure 3 presents the vertical and the horizontal bending moment of the shaft. The vertical and the horizontal bending moment of the shaft were obtained using the equations 20 to 23 as recommended by [31].

2.3.5.1 Vertical bending moment

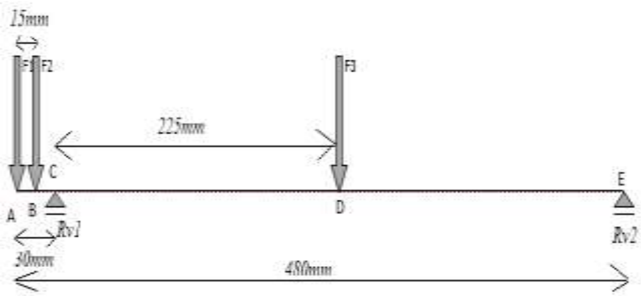

Fig. 3. Vertical forces and reactions on shelling shaft.

$$F_1 = Wsp + (T_3 + T_4)\, Sin45^o \quad (20)$$

$$F_2 = Wp + (T_1 + T_2) \quad (21)$$

$$F_3 = W_{SD} \quad (22)$$

Substituting Wsp = 4.84 N, T_3 = 145.82 N, T_4 = 123.57 N, Wp = 92.64 N, T_1 =119.63 N and T_2 = 59.81 N, $F_1, F_2, and\ F_3$ are 195.33 N, 272.08 N and 130.91 N respectively. The vertical shear force and bending moment diagrams are shown in Figures 4 and 5.

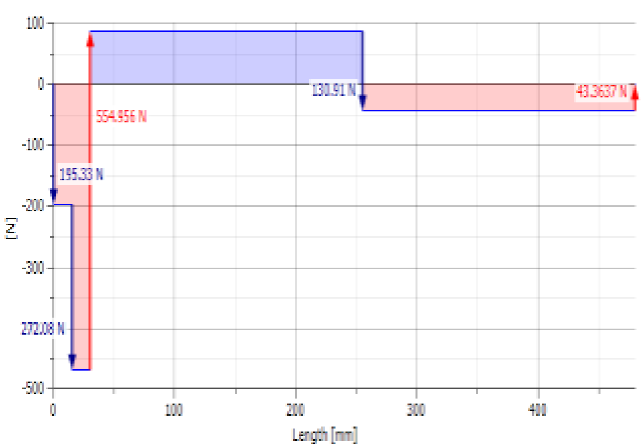

Fig. 4. Vertical shear force diagram.

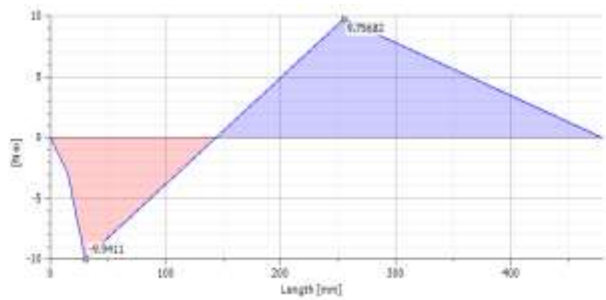

Fig. 5. Vertical bending moment diagram.

The shear force diagram in Figure 4 shows the vertical forces and reactions acting at each point from A to B. The bending moment diagram in Figure 5 reveals the vertical bending moments at each point from A to E due to the forces acting at the points.

2.3.5.2 Horizontal bending moment

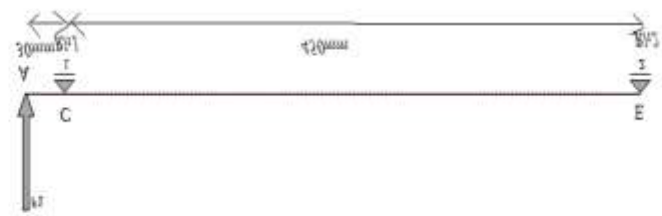

Fig. 6. Horizontal forces and reactions on shelling shaft.

$$F_1 = Wsp + (T_3 + T_4)Cos45^o \quad (23)$$

Substituting Wsp= 4.84 N, T_3 = 145.82 N and T_4= 123.57 N, therefore F_1 = 195.33 N. The horizontal shear force and bending moment diagram are shown in Figures 7 and 8 respectively.

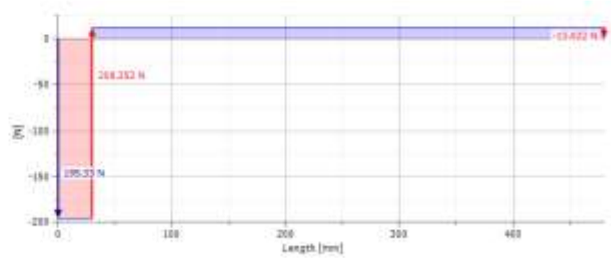

Fig. 7. Horizontal shear force diagram.

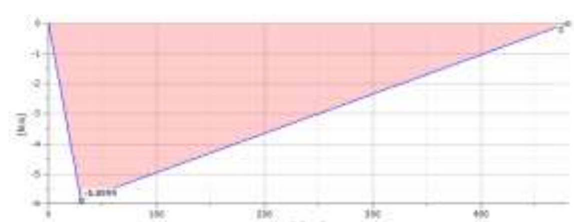

Fig. 8. Horizontal Bending Moment diagram.

The shear force diagram in Figure 7 shows the horizontal forces and reactions acting at each point from A to B. The bending moment diagram in Figure 8 shows the horizontal bending moments to each point from A to E due to the forces acting at the points. From the bending moment diagrams, the resultant bending moment diagram can be computed. The Table 1 shows the corresponding vertical and horizontal bending moments as well as the resultant bending moment. From Table 1, the maximum bending moment is 11341.78 Nmm.

Table 1. Resultant Bending Moment

Points	**Vertical (Nmm)**	**Horizontal (Nmm)**	**Resultant (Nmm)**
A	0	0	0
B	-2929.95	0	-2929.95
C	-9941.1	5859.9	11341.78
D	9756.8	0	9756.8
E	0	0	0

2.3.5.3 Torsional moment

The torsional moment is presented in equation 24 [31].

$$T_e = \sqrt{(K_m.Mb)^2 + (K_t.Mt)^2} \quad (24)$$

Where, Mb is the maximum bending moment, Mt is the tortional moment and K_m and K_t are combined shock and fatigue factors for bending and torsional moment respectively. Substituting K_m = 2.0 and K_t = 1.5 as given by [4]. Therefore, T_e = 2.404 x 10^4 Nmm.

2.3.5.4 Determination of shaft diameter

The shaft diameter was estimated using equation 25 as recommended by [31].

$$T_e = \frac{\pi \,.\, \tau \,.\, d^3}{16} \quad (25)$$

Where τ is the permissible shear stress. Substituting T_e= 2.404 x 10^4 Nmm and τ = 42MPa. A shaft of 15 mm diameter was chosen.

2.4 Cost of production for the groundnut shelling machine

The cost of production for the groundnut shelling machine is presented in Table 2.

Table 2. Cost of production for the groundnut shelling machine

S/N	Components	Description	Cost ($)
1	Hopper	1/2 unit of 3 mm galvanized sheet	20
2	Frame	3 units of 42 mm by 42 mm of mild steel angle iron	15
3	Shelling drum	2 units of shelling drum	20
4	Shelling chamber	1/2 unit of 3 mm galvanized steel	20
5	Shaft	2 units of 15 mm diameter mild steel	10
6	Blower fan	1 unit of 3 mm mild steel and 1 unit of 3 galvanized steel	20
7	Channel	1 unit of 3 galvanized steel	15
8	Bearing	4 units of cast iron bearing	10
9	Bolt and nuts	15 units of dimension of 10 mm by 15 mm	5
10	Pulley	3 units of 170mm, 70mm x 2, 80mm	15
11	Belt	2 units of rubber v-belt class A, 1200mm, 1590mm	2
12	Electric motor	1 unit of 1 hp single phase low speed electric motor	60
13	Machining job	Cutting, grinding, drilling, and welding	28
14	Non-machining job	Painting, folding and bending	10

15	Other jobs	Cost of developing the machining	80
	Total		330

2.5 Experimental Procedure of the Shelling Machine

The developed groundnut shelling machine was tested to shell groundnut of 15% moisture content wet basis. This work was carried out at the Department of Agricultural and Environmental engineering workshop, Obakekere, Federal University of Technology Akure. The test was carried out with an electric motor of power rating 1hp. The machine was tested first to observe the machine behavior using an unspecified quantity of groundnut, after which three test were carried out on the groundnut. A total 400 g of groundnut at 15% moisture content wet basis was used to evaluate the performance evaluation of the groundnut shelling machine using equations 26 to 30 as recommended by [34] – [35].

2.5.1 Performance Evaluation Parameters of the Shelling Machine

The shelling efficiency, mechanical damage, material efficiency, and shelling capacity were determined using equations 26 to 29 as recommended by [34]. Cleaning efficiency involves the separation of the dehulled seeds from the pod/chaff. [35] recommends using equation 30 to estimate the cleaning efficiency.

$$Shelling\ efficiency\ (\%) = \left(\frac{Q_s}{Q_t}\right) \times \frac{100}{1} \quad (26)$$

$$Mechanical\ damage\ (\%) = \left(\frac{Q_d}{Q_u + Q_d}\right) \times \frac{100}{1} \quad (27)$$

$$Material\ efficiency\ (\%) = \left(\frac{Q_u}{Q_u + Q_d}\right) \times \frac{100}{1} \quad (28)$$

$$Throughput\ capacity\ \left(\frac{kg}{h}\right) = \left(\frac{Q_s}{T_m}\right) \times \frac{100}{1} \quad (29)$$

$$Cleaning\ efficiency\ (\%) = \frac{Wd}{W_{wp}}\ x\ \frac{100}{1} \quad (30)$$

Where Q_s is the total weight of shelled groundnut, Q_t is the total weight of groundnut, Q_u is the total weight of undamaged groundnut, Q_d is the total weight of damaged groundnut, and T_m is the time to shell the groundnuts, W_d is the weight of dirt included in kernels and W_{wp} is weight of total dirt from shelled groundnut.

2.6 Statistical Analysis

Microsoft Office Excel 2016 was used to compute the performance evaluation parameters of the shelling machine.

3. Results and Discussion

The results obtained from testing the groundnut shelling machine three times are shown in Table 2. These results show that the machine was effective in shelling groundnut with minimal damage.

3.1 The Shelling Efficiency of the Peanut Machine

The shelling efficiency of 97.94% obtained is higher than the ones obtained by [4], [9], [15]. However, the shelling efficiency is lower than that of [32]. [14] predicted that shelling efficiency increased as moisture content decreased for all groundnut cultivars studied. [15] also reported that when moisture content increased, shelling efficiency decreased and seed damage increased. [16] found that increasing the moisture content results in an increase in the axial dimensions of the kernel. [16] found that when moisture content increases, shelling efficiency decreases. The reason for this is because the imparted pods become friable, allowing them to flex rather than fracture. As a result, only a small portion of the peanut is shelled. To achieve the best shelling outcomes, researchers suggested a moisture level of 10-15% wet base [17]. The increased shelling efficiency could be attributed to the machine's shelling drum, concave clearance, material, sieve, and greater types of peanuts. Larger types of peanuts provided a higher shelling efficiency, according to [19]. Shelling efficiency also decreased as clearance increased [22]. A decrease in concave clearance was found to boost shelling efficiency, according to a number of researchers. [24], the wire mesh sieve performed better in their study than the slotted grate sieve.

Table 3. The shelling machine performance evaluation parameters

R	SE (%)	MD (%)	ME (%)	SC (kg/hr.)	CE (%)
I	97.61%	8.77%	91.23%	193.50	52.16%
II	97.92%	12.57%	87.43%	192.85	55.71%
III	98.29%	8.25%	91.75%	192.50	60.72%
M	97.94%	9.87%	90.13%	192.95	56.20%

Where R is the run, SE is the shelling efficiency in %, MD is the mechanical damage in %, ME is the material efficiency in %, SC is the shelling capacity in kg/hr., CE is the cleaning efficiency in %, and M is the mean.

3.2 The mechanical damage of the Peanut Machine

The mechanical damage of 9.87% obtained is lower than the ones obtained by [4], [9], [15]. The mechanical damage is higher than that of [32]. This is consistent with the research carried out by other researcher who found that when moisture content increased, shelling efficiency decreased and seed damage increased [15]. [14], the number of blades, material used for the blades, and design all have an impact on how well a machine does in shelling peanuts. It was found that bigger clearances resulted in less damage and decreased shelling effectiveness. Similar results were reached by other researchers, who discovered that raising the concave clearance from 20 mm to 30 mm increased the machine's shelling efficiency from 73.6 percent to 79.8 percent and decreasing it to 73.2 percent when they increased the clearance to 40 mm [17] [21] reported that damage decreased significantly as clearance increased from 8 to 12 mm and gradually as clearance increased from 12 to 20 mm. When working on a variable speed motor spinning at 180–220 rpm. [22] suggests a concave clearance of 16–18 mm.

3.3 The Material Efficiency of the Peanut Machine

The material efficiency of the machine was estimated as 90.13%. This was lesser than the material efficiency of 91.15% obtained by [8]. Many researchers get their material efficiency from their mechanical damage. This results in the summation of mechanical damage and material efficiency to be 100%.

3.4 The Shelling Capacity of the Peanut Machine

The machine capacity is lower than that of 210.5kg/hr, 233.81kg/hr, 400kg/hr.and 400kg/hr. [37], [32], [4] and [36] respectively. The shelling machine has a higher shelling capacity of 192.95 kg/hr compared to the shelling capacities of 110 and 115 kg/h for the two varieties of groundnut [29].

3.5 The Cleaning Efficiency of the Peanut Machine

The cleaning efficiency of 56.20% obtained is higher than the ones obtained by [32]. Moreover, the cleaning efficiency is lower than that of [4], [15]. However, the cleaning efficiency was low because of the lower fan speed as a result of lower speed transferred from the motor operating the shelling drum and the cleaning fan. Because terminal velocity has a considerable impact on a shelling machine's cleaning efficiency, the value of cleaning efficiency that was obtained may be related to the terminal velocity employed for the experiment. The highest speed that grains can reach as they fall through air is called terminal velocity. It occurs when the drag force plus the buoyancy force are equivalent to the downward force of gravity acting on the grains [38].

For different kinds of pods, the terminal velocity ranged from 7.7 to 12.9 m s-1. Therefore, these factors could be taken into consideration when developing devices for the separation of peanut sections. For the purpose of removing lighter material from the peanut pods, the air stream's velocity cannot be greater than 7.7 m s-1 [39]. For peanuts, the moisture content went from 4.85 to 32.00 percent d.b., while the terminal velocity increased from 7.25 to 7.93 m/s. With rising moisture content, a linear increase in terminal velocity was observed [40].

4. Conclusions

A portable groundnut shelling machine was designed and fabricated with a production cost of 330USD.The machine can shell 192.95 kg/hr of groundnut every hour while separating the shafts from the kernels. The machine eliminates the cost of installing an industrial fan by incorporating a local fan for the cleaning process. This makes the machine cost effective and affordable for small or medium scale farmers.

5. References

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