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Design and Development of Manually Operated Roasted Groundnut Seeds Peeling Machine

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***Abstract*— This work focused on the design and development of a manually operated roasted groundnut seeds peeling machine. The machine comprises a specially designed peeling chamber which greatly reduces the amount of breakages during peeling and a transmission mechanism which greatly reduces the required effort to drive the system. It has a peeling efficiency of about 85% which is an improvement over previously fabricated designs. The machine is easy to operate and has a capacity of 5.4kg/hr of roasted groundnut seeds. With such capacity, the machine can be used both in medium scale industries and also for domestic needs of peeled roasted groundnut seeds.**

***Keywords*—Design and development, manually operated, roasted groundnut, peeling machine.**

I. Introduction

Peanut or groundnut is one of the major oilseed crops of the tropics and subtropics, although it is also cultivated in the warm areas of the temperate regions. It is a valuable source of edible oil (43-55%) and protein (25-28%) for human beings, and of fodder for livestock. About two thirds of world production is crushed for oil and the remaining one third is consumed as food. Several works have been carried out on the design of machineries for groundnut processing [1-8]. Included in these designs is a recent work on roasted groundnut decorticating machine by Ogunwole [1] which showed that the efficiency of the manual part of the machine was an average of 52.3%. Also included is the design of hand-operated decorticator for Jatropha fruits [2]. This particular design considered in this work is expected to have an improved efficiency over previous designs. It is also expected to have a specially designed peeling chamber which will greatly minimize breakages during the process of peeling.

II. Design Analysis And Calculations

Determination of Volume of Peeling Chamber

Volume of peeling chamber (V_{PC}) may be determined using the following equation:

$$V_{PC} = V_H - V_{FL} - V_{BH} - V_P \qquad (1)$$

Where,
V_H = Volume of housing
V_{FL} = Volume of foam lagging
V_{BH} = Volume of bearing housing
V_P = Volume of Paddle

Volume of Housing

Volume of housing may be determined using the following equation:

$$V_H = \pi \times r_H{}^2 \times h_H \qquad (2)$$

Where,
r_H = Radius of housing = 0.12m
h_H = Height of housing = 0.20m

From equation (2), we get

$$V_H = \pi \times 0.12^2 \times 0.20 = 9.05 \times 10^{-3} m^3$$

Volume of Foam Lagging

Volume of foam lagging may be determined using the following equation:

$$V_{FL} = \pi \times \left(R_{FL}{}^2 - r_{FL}{}^2\right) \times h_{FL} \qquad (3)$$

Where,
R_{FL} = Outer radius of foam lagging = 0.12mm
r_{FL} = Inner radius of foam lagging = 0.08mm
h_{FL} = Height of foam lagging = 0.20m
From equation (3), we get

$$V_{FL} = \pi \times \left(0.12^2 - 0.08^2\right) \times 0.2 = 5.03 \times 10^{-3} m^3$$

Volume of Bearing Housing

Volume of bearing housing may be determined from the following equation:

$$V_{BH} = \pi \times r_{BH}{}^2 \times h_{BH} \qquad (4)$$

Where,
r_{BH} =Radius of bearing housing = 0.075m

h_{BH} = Height of bearing housing = 0.085m

From equation (4), we get

$$V_{BH} = \pi \times 0.075^2 \times 0.085 = 1.50 \times 10^{-3} m^3$$

Volume of Paddle

Volume of paddle may be determined from the following equation:

$$V_P = 2 \times (l_P \times b_P \times h_P) \quad (5)$$

Where,

l_P = Length of paddle = 0.15m

b_P = Breadth of paddle = 0.040m

h_P = Height of paddle = 0.080m

From equation (5), we get

$$V_P = 2 \times (0.15 \times 0.040 \times 0.080) = 9.60 \times 10^{-4} m^3$$

Therefore from equation (1), we get

$$V_{PC} = 9.05 \times 10^{-3} - 5.03 \times 10^{-3} - 1.50 \times 10^{-3} - 9.60 \times 10^{-4} = 1.56 \times 10^{-3} m^3$$

Determination of Weight of Groundnut Seeds

The weight of groundnut seeds (W_{GS}) may be determined from the following equation:

$$W_{GS} = M_{GS} \times g = \rho_{GS} \times V_{PC} \times g \quad (6)$$

Where,

M_{GS} = Mass of groundnut seeds

ρ_{GS} = Density of groundnut seeds = 490kg/m^3

g = Acceleration due to gravity = 9.81m/s^2

From equation (6), we get

$$W_{GS} = 490 \times 1.56 \times 10^{-3} \times 9.81 = 7.50N$$

Determination of Twisting Moment acting on the Horizontal Transmission Shaft

The twisting moment acting on the horizontal transmission shaft may be determined from the following equation:

$$M_{tH} = F_A \times r \quad (7)$$

Where,

F_A = Applied arm force = 87N

r = Perpendicular distance = 0.18m

From equation (7), we get

$$M_{tH} = 87 \times 0.18 = 15.66Nm$$

Determination of Horizontal Transmission Shaft Diameter

Neglecting the effect of bending moment, the diameter of the horizontal transmission shaft may be determined using the following torsion equation [9]:

$$\frac{M_{tH}}{J} = \frac{\tau}{r} \Rightarrow d_V{}^3 = \frac{16 \times M_{tH}}{\pi \times \tau} \quad (8)$$

Where:

$J = \frac{\pi \times d_H{}^4}{32}$ = Polar moment of inertia of the shaft about the axis of rotation

τ = Permissible Torsional shear stress = 42MPa

$r = \frac{d_H}{2}$ = Distance from neutral axis to the outermost fiber

From equation (8), we get

$$d_H = \left[\frac{16 \times 15.66}{\pi \times 42 \times 10^6}\right]^{\frac{1}{3}} = 12.4mm$$

Where,

d_H = Diameter of the horizontal transmission shaft

Determination of Power Required to Drive Machine

The power required to drive the machine may be determined from the following equation:

$$P = M_{tH} \times \left(\frac{\pi \times N}{30}\right) \quad (9)$$

Where,

N = Average speed of rotation = 60rpm

From equation (9), we get

$$P = 15.66 \times \left(\frac{\pi \times 60}{30}\right) = 98.39W$$

Determination of the Speed of the Driven Sprocket

The speed of the driven (big) sprocket may be determined from the following equation:

$$\frac{N_S}{N_B} = \frac{D_B}{D_S} \Rightarrow N_B = \frac{N_S \times D_S}{D_B} \quad (10)$$

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Where,

N_S = Speed of driver (small) sprocket

N_B = Speed of big sprocket

D_S = Diameter of small sprocket = 65mm

D_B = Diameter of big sprocket = 160mm

From equation (10), we get

$$N_B = \frac{60 \times 65}{160} = 24.38rpm$$

Determination of the Twisting Moment acting on the Vertical Transmission Shaft

The twisting moment transmitted acting upon the vertical transmission shaft carrying the big sprocket may be determined using the following equation [9]:

$$M_{tV} = \frac{30 \times P}{\pi \times N_B} = \frac{30 \times 98.39}{\pi \times 24.38} = 38.54Nm \qquad (11)$$

Where,

M_{tV} = Twisting moment (or torque) acting upon the vertical transmission shaft

Determination of Vertical Transmission Shaft Diameter

The diameter of the vertical transmission shaft may be determined as follows:

$$d_V = \left[\frac{16 \times 38.54}{\pi \times 42 \times 10^6}\right]^{\frac{1}{3}} = 16.7mm$$

Where,

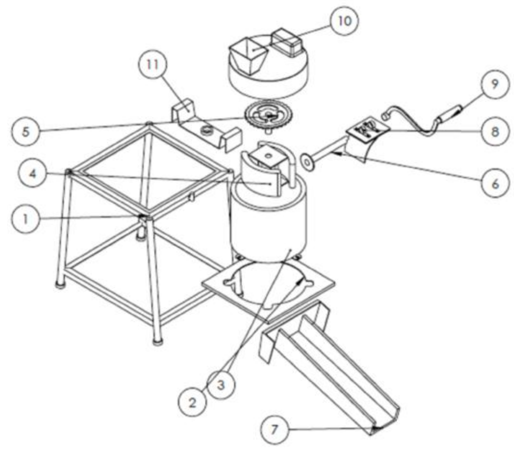
d_V = Diameter of the vertical transmission shaft

III. Testing

Figure 1 shows the exploded view of the various sub-assemblies of the manually operated roasted groundnut seeds peeling machine. Testing was carried out to ascertain the efficiency of the machine shown in Figure 2. The following is the procedure for testing:

1) Roasted groundnut seeds of known weight were fed into the peeling chamber through the hopper, the handle was then rotated and while it rotated, power was transmitted through the various transmission mechanisms to the paddle.
2) The paddle rotated in a clockwise direction in response to the movement of the main shaft, and as it rotates, it strips the chaff from the roasted groundnut seeds.
3) The chaffs and the roasted groundnuts (peeled, unpeeled and damaged seeds) were then released to the trough through the chute.
4) The time taken to complete the peeling was noted using the stopwatch and also recorded

The peeled roasted groundnut seeds were then weighed on the weighing balance. The unpeeled and damaged seeds were also collected and weighed.



Item	Name	Item	Name
1	Stand	7	Discharge chute
2	Clamp	8	Bearing
3	Peeling chamber	9	Handle
4	Paddle	10	Hopper
5	Big sprocket	11	Main bearing shoulder plate
6	Small sprocket shaft		

Figure 1: Exploded view of various sub-assemblies

Figure 2: Roasted groundnut seeds peeling machine

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Calculations

Weight of roasted groundnut seeds (W_T) = 1250g
Weight of peeled seeds (W_P) = 1062.5g
Weight of unpeeled seeds (W_{UP}) = 187.5g
Weight of broken seeds (W_B) = 0.27kg
Weight of good seeds (W_G) = 0.79kg

$$Efficiency = \frac{W_p}{W_T} \times 100 = \frac{1062.5}{1250} \times 100 = 85\%$$

The time taken to peel 1.25kg of roasted groundnut seeds was 14 minutes (0.23hrs). The capacity of the machine is therefore:

$$Capacity = \frac{Weight}{Time} = \frac{1.25}{0.23} = 5.4kg/hr$$

$$\%Breakage = \frac{W_B}{W_G + W_B} \times 100 = \frac{0.27}{0.79 + 0.27} \times 100 = 25.5\%$$

IV. Conclusion

This work designed and developed a machine for peeling roasted groundnut seeds. The machine was fabricated using readily available materials and it is applicable for local production of peeled roasted groundnut seeds. The machine is easy to use, safe to operate, easy to repair and easy to maintain. The technology is affordable and less expensive when compared to imported peeling machines. It has low operating cost; it is small in size, has low weight, low noise and it is vibration free. The time taken to the peel 2.5kg of groundnut using hands is about 4-5 hours while the time taken to peel same quantity of groundnut using this machine is about 30-40 minutes. This clearly shows that it is more advantageous to peel roasted groundnut seeds using this machine than using bare hands.

The efficiency of the machine is 85% and therefore exceeds the efficiency of previously produced manually operated roasted groundnut peeling machines. It also has % breakage of 25.5% which is relatively small when compared to others.

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