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# Design, Fabrication and Testing of A (Manually and Electrically Operated) Roasted Groundnut Decorticating Machine

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**Abstract**

This work entails the design and fabrication of a manually and electrically operated roasted groundnut decorticating machine. The decorticating machine which is powered manually or by 0.161 Hp, 1500rpm electric motor comprises of the hopper which contains the unpeeled groundnut seeds and is opened directly to the decorticating unit. The body of work is made with galvanize steel of thickness 1mm. The dimension of the body inside the frame is 580mm x 180mm x 580mm. The frame of the work is made with mild steel square bar of thickness 20mm. The frame is of size 600mm x 200mmx 600mm. The decorticating unit comprises of rotating inner drum of length 550mm and a diameter of 60mm with brush like projections and a shaft of 68mm passing through its centers and a fixed cylindrical drum of length 600mm and diameter 120mm. The inner drum with a rotation speed of 150rpm is attached with the help of a v-belt and two pulleys to the electric motor which drives it in an anticlockwise direction to peel the groundnut seeds. The peeled groundnut seeds and the chaffs fall directly into the cleaning unit where an installed fan blow away the chaff and the seeds are collected directly through an opening below the decorticating unit. The machine was made from locally sourced materials and it can be used in both urban and rural areas even where there is no electric power supply. The percentage of roasted groundnut seeds been peeled in manual and electrical operation in three successive runs was found to be 52% and 61% respectively.

**Keywords:** Decorticating, Hopper, Galvanize Steel, Electric Motor, Speed, Projection.

## 1 Introduction

Large quantities of groundnuts are lost annually due to lack of storage facilities and simple mode of processing the groundnuts. In order to improve on various ways in which the husk or rind of a roasted groundnuts are removed, there is need to develop a simple mechanisms to address this problem and this brought about the design and fabrication of a (manually and electrically operated) roasted groundnut decorticating (peeling) machine, whose mode of operation is of course manually and electrically. The designing and fabricating of the machine was done in order to solve problems such as blowing air through roasted groundnuts in order to remove the chaff, reducing the waste of groundnut through winnowing, to reduce the stress and time involved in peeling the chaffs of roasted groundnut through winnowing and to improve the cleanness of the roasted groundnut.

Generally speaking, there are dry groundnut peeling machine types and wet groundnut peeling machine types. Dry peanut peeling machine is highly effective and an ideal decorticating equipment which is used to take off the red skin of peanut in a dry manor. Machine helves, air fan and cleaning skin equipment are the three parts. It is composed of vertical type hoisting machine, storage box, decorticating machine and sieving strap. The dry peeling machine adopts to roll and rubbed for separating seed from the skin. It has steady performance, long time life, high peeling rate, high output rate, very low imperfect seeds, good quality of product, and processing a lot goods by combination several units. It is suitable for processing various types and sizes blanched groundnut seeds.

## 2.Theoretical Analysis

To design equipment for shelling and decorticating the groundnuts, their physical properties must be known. Oje and Ugbor (1991), Oje (1993), koya and Adekoya (1994), Oje et al. (1997), Alonge and Adigun (1999), Adigun and Alonge (2000), Oje et al . (2001), Alonge (2003) all carried out studies on physical and mechanical properties of some agricultural product. But little is known of the physical properties of groundnut.

Since the roasted groundnut peeling machine will be employed to peel roasted groundnut, some relevant physical and mechanical properties of groundnut need to be understood. Properties of an average groundnut include: length - 8.54mm, width – 3.55mm, thickness – 6.9mm, sphericity – 0.76g/cm$^3$, density – 1.01g/cm$^3$ (Olajide and Igbeka 2003).

**3. Design Analysis**

*3.1 Design calculations*

*3.1.1 Determination of outer and inner drum of peeling chamber*

Volume of drum = $\pi \times r^2 \times h$ (1)

Where h = Length/Height of drum

r = radius of drum

Volume of outer drum – volume of inner drum (2)

*3.1.2 Determination of groundnut quantity (mass)*

$\rho = \frac{m}{v}$ (Kundu and cohen 2002) (3)

Where ρ = density of an average groundnut

V = Volume of groundnut

M = mass of groundnut

*3.1.3 Determination of Power Required to Peel Roasted Groundnut Seed*

Total power required is calculated using equations as specified by Akintunde et al, 2005

$P_T = P_{inner\ drum} + P_{shaft} + P_{peeling}$

$P_{peeling}$ is negligible since seeds are not resident in decorticating room but flow through in pieces.

Therefore, $P_T = P_{inner\ drum} + P_{shaft}$

But shaft and inner drum are joined together

So $P_T = P_{inner\ drum\ with\ drum} = T_{inner\ drum\ with\ shaft} \times V_{inner\ drum\ with\ shaft}$ (4)

$V_{inner\ drum\ with\ shaft} = \frac{2 \times \pi \times N}{60}$ m/s (5)

$T_{inner\ drum\ with\ shaft}$ is the torque ($N_m$)

N is the number of revolution per minutes of inner drum with shaft

$T_{inner\ drum\ with\ shaft}$ = mass × acceleration due to gravity × radial distance (6)

*3.1.4 Determination of Torque Transmitted by the Electric Motor*

$T = 9.55\frac{P}{n}$ (shigley 2004) (7)

Where P = electric motor power

n = the number of revolution per minute of the electric motor

*3.1.5 Determination of belt length*

The belt length was obtainable as given by (khurmi and Gupta, 2005)

$L = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{D_2 - D_1}{4C}$ (8)

And the centre to centre distance between driving pulley and driven pulley is given as

$C = 2(D_1 + D_2)$ (9)

Where $D_1$ and $D_2$ are the diameters of the pulley respectively

C = centre to centre distance between driving pulley and driven pulley

To obtain speed of driving and driven pulley

$V_1 = \frac{\pi D1N1}{60}$ (10)

$V_2 = \frac{\pi D1N2}{60}$

Where $N_1$ and $N_2$ are the revolutions per minute for the driving pulley and driven pulley respectively.

*3.1.6 Lap Angles determination*

Equations as expressed;

$\alpha_1 = 180 - 2 \sin^{-1} (\frac{D_2 - D_1}{2C})$ (11)

$\alpha_2 = 180 + 2 \sin^{-1} (\frac{D_2 - D_1}{2C})$

Where: $\alpha_1$ = the angle of lap for driving pulley (rad)

$\alpha_2$ = the angle of lap for driven pulley.

C = centre to centre distance between driving pulley and driven pulley (mm)

*3.1.7 Determination of Belt Tensions*

$P = (T_1 - T_2) V$ (Akintunde et al, 1983) (12)

Where, P = belt power (W);

V = belt speed (m/s)

$T_1$ and $T_2$ are tensions on the tight and slack sides respectively (N)

Using belt ratio for an open belt;

$(\frac{T_1}{T_2}) = e^{f\alpha}$ (13)

Where, f = coefficient of friction between belt and pulley

*3.1.8 Determination of Shaft Torque*

The torque is determined as follows

$T = \frac{(T_1 - T_2)D_2}{2}$ (Akintunde et al, 1983) (14)

*3.1.9 Determination of Shaft Diameter*

$S_S = \frac{16}{\pi d^3} \sqrt{M^2 + T^2}$ (M.F. Spotts 1998) (15)

Where T is torque,

M is bending moment of shaft,

d is shaft diameter of the machine,

$S_S$ is maximum shear stress.

*3.1.10 Determination of work done*

Torque = Force × length of handle (16)

**4. Calculations**

*4.1 Calculation of outer and inner drum of peeling chamber*

*4.1.1 Fixed/Outer drum*

Length = 60cm = 600mm

Diameter of drum = 12cm = 120mm

Where r = radius of drum = $\frac{d}{2} = \frac{120}{2}$ = 60mm

From equation (1), the Volume of fixed/outer cylinder

= 3.142 × $60^2$× 600 = 6786720 $mm^3$ = 6786.72 $cm^3$

*4.1.2 Inner drum*

Length = 55cm = 550mm

Diameter of drum = 6cm = 60mm

Where r = radius of drum = $\frac{d}{2} = \frac{60}{2}$ $30mm$

From equation (1), the Volume of inner cylinder

= 3.142 × $30^2$ × 550 = 1555290$mm^3$ = 1555.29$cm^3$

From equation (2), the volume of cylinder that will contain the roasted groundnut

= 6786.72 – 1555.29 = 5231.43cm$^3$

*4.1.3 Groundnut quantity (mass)*

Therefore from equation (3) the mass of groundnut seeds to be contained in the cylinder

Where ρ = density of an average groundnut = 1.01g/cm$^3$

V = Volume = 5231.43cm$^3$

M = ρ × v = 5231.43 × 1.01 = 5283.74 g/cm$^3$

M = 5.28kg

*4.1.4 Power Required to Peel Roasted Groundnut Seed*

Total power required is calculated using equations as specified by Akintunde et al, 2005

$P_T = P_{inner\ drum} + P_{shaft} + P_{peeling}$

$P_{peeling}$ is negligible since seeds are not resident in decorticating room but flow through in pieces.

Therefore, $P_T = P_{inner\ drum} + P_{shaft}$

But shaft and inner drum are joined together

So $P_T = P_{inner\ drum\ with\ drum} = T_{inner\ drum\ with\ shaft} \times V_{inner\ drum\ with\ shaft}$

$V_{inner\ drum\ with\ shaft} = \frac{2 \times \pi \times N}{60}$ m/s

$T_{inner\ drum\ with\ shaft}$ is the torque ($N_m$)

N is the number of revolution per minutes of inner drum with shaft = 150rpm

From equation (6),

Mass = 5.28 kg

Acceleration due to gravity = 10m/s

Radial distance = 0.05m

$T_{inner\ drum\ with\ shaft}$ = 5.28 × 10 × 0.05 = 2.64

From equation (4),

The number of revolution per minutes of inner drum with shaft (N) = 150rpm

$T_{inner\ drum\ with\ shaft} = 2.64$

$P_{inner\ drum\ with\ shaft}$=2.64 × $\frac{2 \times 3.142 \times 150}{60 \times 1000}$ = 0.041KW = 41 watts = 0.055Hp

Using the factor of safety of 2, power required is 0.11 Hp = 82.02 watts, therefore a motor of 0.161Hp, 120 watts is chosen to power the inner drum, shaft and peel the seeds.

*4.1.5 Torque Transmitted by the Electric Motor*

From equation (7)

Where P = electric motor power 120W

n = the number of revolution per minute of the electric motor = 1500rpm

T = 9.55 × $\frac{120}{1500}$

T = 9.55 × 0.08 = 0.764Nm

*4.1.6 Analysis of Driving and Driven Pulley*

The diameter of driving pulley and driven pulley selected are $D_1$ =40mm, $D_2$ = 40mm respectively

But $N_1$ = 1500 rpm as seen on 0.161 Hp (120W) electric motor and it has a gear ratio of 1:10. Therefore $N_2$ = $\frac{1500}{10}$ = 150rpm

*4.1.7 Belt length*

From equation (3.9) Where $D_1$ = 40mm and $D_2$ = 40mm

centre to centre distance between driving pulley and driven pulley

C = 2 (40 + 40) = 160mm

From equation (8), the belt length was obtainable as given

Therefore $L = 2 \times 160 + \frac{\pi}{2}(40 + 40) + \frac{40 - 40}{4 \times 160}$

L = 445.66 mm

From equation (10), the speed of driving and driven pulley

Where $N_1$ =1500 rpm

$N_2$ = 150 rpm

$V_1$ and $V_2$ are the speed (m/s) of the driving pulley and driven pulley respectively.

$$V_1 = \frac{3.142 \times 40 \times 1500}{60} = 3.14\text{m/s}$$

$V_1$ = 3.14m/s

$$V_2 = \frac{3.142 \times 40 \times 150}{60} = 0.314\text{m/s}$$

$V_2$ = 0.31m/s

*4.1.8 Lap Angles*

From equation (11) the lap angle

Where $D_1$ = 40mm and $D_2$ = 40mm, C = 160mm

$\alpha_1 = 180 - 2 \sin^{-1}\left(\frac{40-40}{2 \times 160}\right)$

and

$\alpha_2 = 180 + 2 \sin^{-1}\left(\frac{40-40}{2 \times 160}\right)$

$\alpha_1 = 180^oC$ $\alpha_1 = 3.14rad$

$\alpha_2 = 180^oC$ $\alpha_2 = 3.14rad$

*4.1.9 Belt Tensions*

Where, P = 120 W;

V = 0.314m/s

Thus from equation (12), $T_1 - T_2 = 382$ N

From equation (13) the belt ratio for an open belt;

Where, f = coefficient of friction between belt and pulley

For rubber pulley and rubber belt, f = 0.42 (khurmi and Gupta, 2005)

$\frac{T_1}{T_2} = e^{0.42 \times 3.14}$

$\frac{T_1}{T_2} = e^{1.319}$

$T_1 = 3.74T_2$

From equation (20) $T_1 = 382 + T_2$

$382 + T_2 = 3.74T_2$

$382 = 3.74\ T_2 - 1\ T_2$

$T_2 = \frac{382}{2.74} = 139.42\ N$

$T_2$ = 139.42N

$T_1 = 3.74 \times 139.42 = 521.43$N

*4.1. 10 Shaft Torque*

From equation (14), the torque of the shaft

$T_1$ = 521.43N

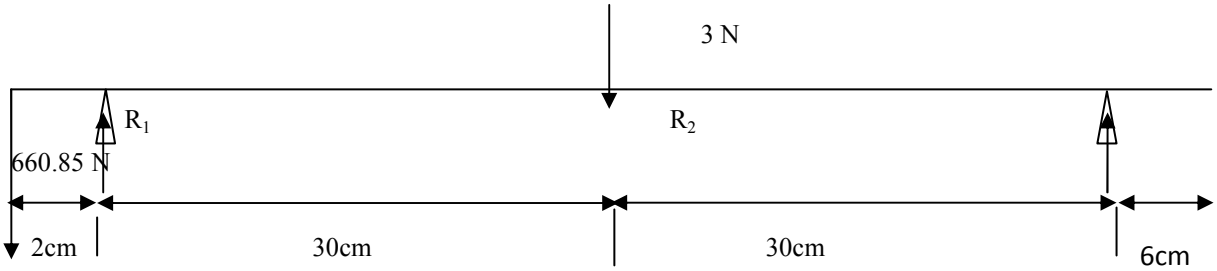
$T_2$ = 139.42N

$D_2$ = 40mm

Neglecting the weight of shaft, total vertical loading acting on pulley

$W = T_1 + T_2 = 521.43 + 139.42 = 660.85$




$R_1 + R_2 - 660.85 - 3 = 0$ (1)

Taking moment about $R_1$ $660.85 \times 0.02 - 3 \times 0.3 + R_2 \times 0.6 = 0$

$13.22 - 0.9 = -0.6\ R_2$

$R_2 = \frac{12.32}{-0.6} = -20.53$

$R_1 = 20.53 + 660.85 + 3$

$R_1 = 684.38$ N

$\sum M = 660.85\ N \times \varkappa - R_1\ (\varkappa - 0.02) + 3(\varkappa - 0.32) - R_2\ (\varkappa - 0.62)$

At $\varkappa = 0$; Mb = 0

At $\varkappa = 0.02$; Mb = 13.23

At $\varkappa = 0.32$; Mb = 211.5 – 205.314 = 6.20

At $\varkappa = 0.62$; Mb = 409.73 – 410.63 + 0.9 = 0

Therefore the maximum bending moment, Mb = 13.23 Nm

*4.1.11 Shaft Diameter*

The shaft, which was made from mild steel which carried combined load of bending moment and torque; hence the design of the shaft was calculated from the formula given in equation (15)

Where T = 7.64 Nm

Mb = 13.23 Mpa

Taking the maximum shear stress $S_S$ of Mild Steel rod to be 42MPa

$$d = \sqrt[3]{\left(\frac{16\sqrt{M^2 + T^2}}{\pi\, S_S}\right)}$$

$$= \sqrt[3]{\left(\frac{16\sqrt{13.23^2 + 7.64^2}}{\pi \times 42 \times 10^6}\right)} = 12.28\text{mm}$$

Diameter of the shaft = 15 mm

*4.1.12 Work done*

From equation (16) the work done to operate the machine manually

$$\text{Force} = \frac{Torque}{Length\ of\ handle}$$

Where Torque = 7.64N/m

And length of handle = 0.12m

Therefore Force $= \frac{7.64}{0.12} = 63.67$N

**5. Materials and Methods**

The hopper is made up of four welded galvanized plate slanting towards an opening to form a trapezoidal cross section. It has two openings. The larger upper opening is for introducing the roasted groundnut seeds into the decorticating unit while the smaller lower opening connects the hopper to the decorticating unit. The fabrication procedure consisted of marking of 200 mm x 200 mm dimension for the larger upper opening and 100 mm x 80 mm dimension for the smaller lower opening and a height of 150mm. The marked sheets were cut and the plates were then welded to form the trapezoidal shape. The surface was then smoothened with an electric grinding machine. The fixed drum which housed the inner drum with the brush like projections where the peeling occurred was made from 1.5 mm thick aluminium sheet. It was 500mm x 500 mm in size which gave a 120 mm diameter. Cutting was carried out in conformity with the marked dimensions. The aluminium plate was rolled to shape by rolling machine and aluminium plate was then welded together to form the cylindrical shape. The fixed drum and the hopper are joined together with bolts and nuts. The outlet throat was fabricated to the fixed drum from galvanized steel plate 100 mm x 120 mm and 240 mm in length. The support frame was fabricated from four square bar of equal length 600mm and four equal length of 200mm mild steel square bar. The components were welded to form the support frames. The casing/body cover which is made up of galvanized steel of height 580mm, length 580mm and its top/base is 180mm was marked and cut. The front view of the casing/body cover is joined to the frame with the help of screws while the back view is welded. The electric motor that is joined together with the blower is the prime mover that supplies power to the inner drum by belt drives.

**6. Testing**

The machine was started and the decorticating cylinder is rotated. The roasted groundnut seeds were fed into the decorticating chamber through the hopper. The fixed cylindrical drum in conjunction with the decorticating cylinder located inside the fixed cylindrical drum brushes and peels the roasted groundnut seeds. The peeled roasted groundnut seeds chaffs are moved by the rotating beaters through the slots in the concave. The chaffs and peeled roasted groundnut then falls into an aspiration box.

The blower separated the chaffs from the roasted groundnut seeds which were collected in a tray attached to the inclined pan or chute. The time taken to complete the peeling was noted using the stop watch and also recorded. The peeled roasted groundnut seeds collected were weighed on the weighing balance. The unpeeled and damaged seeds were also collected and weighed. The test was repeated three more times with 1.5, 1.2 and 1.0 kg of roasted groundnut seeds, using the same procedure.

For the manually operated procedure, the roasted groundnut seeds were fed into the decorticating chamber through the hopper. The cylindrical drum was rotated by turning the handle connected to the shaft passing through the decorticating drum. This procedure was repeated three more times with the weight of the roasted groundnut, example 1.5, 1.0 and 1.0 kg. The peeled roasted groundnut seeds collected were weighed on the weighing balance. The unpeeled and damaged seeds were also collected and weighed.

**7. Results**

The results obtained during the testing manually and electricall of the roasted groundnut peeling machine are shown in Tables 1 and 2 respectively. The machines performance parameters calculated from the results are also shown in the same tables.

**8. Discussion of result:**

The first peeling operation on the roasted groundnut seeds using the constructed machine either manually or electrically showed that the peeled roasted groundnut seeds increased as the number of roasted groundnut seeds to be peeled increased for both variety. The average percentage of peeled roasted groundnut seed during manual operation was 52.3%, while for electrical operation was 61.7%. From the results gotten it can be concluded that the machine is best operated electrically because it has a better peeling efficiency. It was observed that the higher the mass of the roasted groundnut seeds the longer the time of peeling.

During the testing of the project it was observed that the peeling efficiency when electrically operated was higher as compared to the manual operation because the inner drum (shaft) maintains a steady and uniform speed.

From previous work done in year 2000 by Nkochi Abdullahi Kpotun in the department of mechanical engineering at the federal university of technology minna, the efficiency gotten is 40% when operated manually. This present work has a better efficiency when manually operated than that of the previous work because it has

light inner drum made with brush like projection unlike the previous work that is made with a hollow pipe thereby causing most of the roasted groundnut seeds to break.

## 9. Conclusion

A viable machine for peeling roasted groundnut seeds commonly found in Nigeria was fabricated from the available locally sourced materials. The roasted groundnut peeling machine is very applicable for local production, operation, repair and maintenance. The operation of this machine manually and electrically makes it a unique type compare to others. The automatic operation saved energy and did not require high skilled labour. The operational and process performance showed that the machined peeled well over an average of 61.7% and 52.3% of roasted groundnut seeds when electrically and manually operated respectively in three successive peeling. Also a roasted groundnut peeling plant based on this technology could provide employment and at the same time make available quality roasted groundnut seeds at low cost for domestic use and for groundnut oil processing industry and also improve on the processing rate of groundnut. By improving the processing rate of the groundnuts, people in the developing communities will have extra time to spend on other tasks and responsibilities.

Finally the manually and electrically operated roasted groundnut peeling machine saves time and energy when compared with local process of peeling by hands and the roasted groundnut peeling machine can be used when there is electric power but if there is shortage of electric supply it can be used manually.

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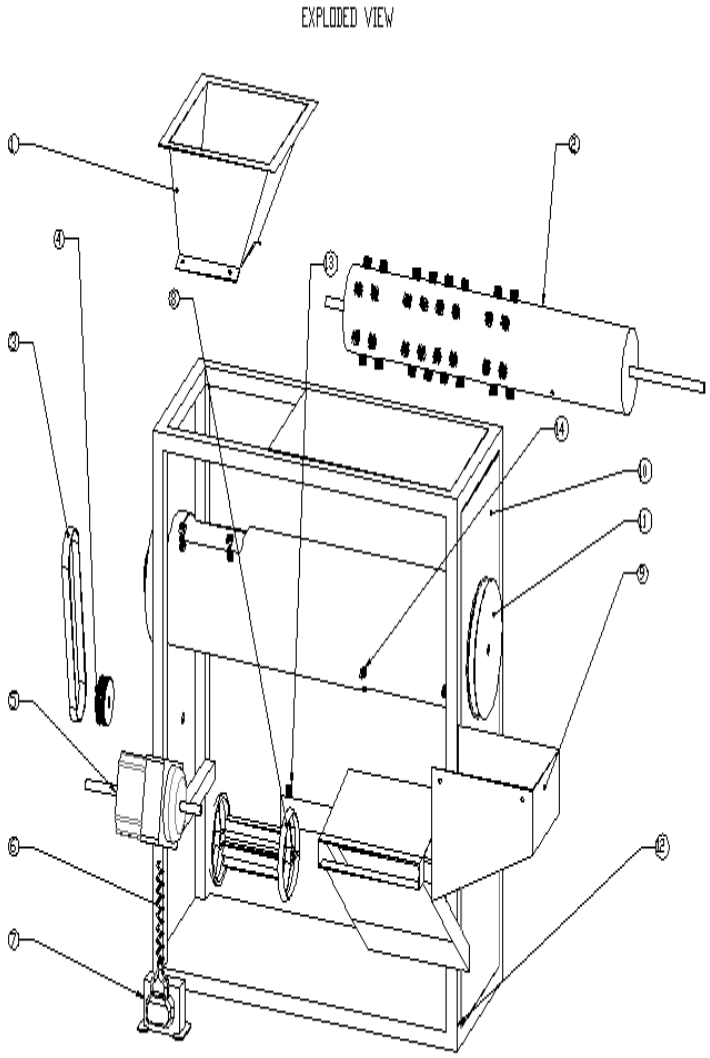
TABLE 1: Result when manaally operated

| s/no | Weight of groundnut seeds fed into the hopper, $W_t$ (kg) | Weight of peeled groundnut seeds $W_s$ (kg) | Weight of unpeeled groundnut seeds $W_u$ (kg) | Effective time of peeling $T_m$ (sec) | Peeling Efficiency (%) |
|---|---|---|---|---|---|
| **1** | 1.5 | 0.78 | 0.72 | 624 | 52 |
| **2** | 1.0 | 0.55 | 0.45 | 565 | 55 |
| **3** | 1.0 | 0.5 | 0.5 | 530 | 50 |

TABLE 2: Result when electrically operated

| s/no | Weight of groundnut seeds fed into the hopper, $W_t$ (kg) | Weight of peeled groundnut seeds $W_s$ (kg) | Weight of unpeeled groundnut seeds $W_u$ (kg) | Effective time of peeling $T_m$ (sec) | Peeling Efficiency (%) |
|---|---|---|---|---|---|
| **1** | 1.5 | 0.93 | 0.57 | 578 | 62 |
| **2** | 1.2 | 0.8 | 0.4 | 554 | 66 |
| **3** | 1.0 | 0.57 | 0.43 | 549 | 57 |




| No | Parts | Materials | Dimension | Finishing |
|---|---|---|---|---|
| 1 | Hopper | Galvanized steel | | Welded |
| 2 | Decorticating drum/inner drum | Plastic with brush like projections | | Screwed |
| 3 | Belt | Rubber | | |
| 4 | Pulley | Rubber | Ø40mm | Screwed |
| 5 | Electric motor | | 0.161hp, 120watts | |
| 6 | Connecting wire | | | |
| 7 | Transformer | | | Screwed |
| 8 | Blower | | | |
| 9 | Outlet throat | Galvanized steel | 240mm×140mm×60mm | Cut and smoothened |
| 10 | Casing/bodycover | Galvanized steel | 580mm×580mm×180mm | Painting |
| 11 | Fixed drum/ | Aluminium sheet | 600mm× Ø120mm | |
| 12 | Frame | Mild steel | 600mm×200mm | Welded |
| 13 | Groundnut outlet | Galvanized steel | 135mm×20mm | Welded |
| 14 | Fixed drum/ | Aluminium sheet | 600mm×120mm | Rolled and welded |

Figure 1: Exploded View of The Roasted Groundnut Decorticating Machine.

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