



Journal of Engineering for Development, Vol. 13(2), December (2021) pp.77-91

DESIGN AND FABRICATION OF A MELON SHELLING MACHINE WITH A CHAFF SEPARATION CHAMBER

¹Ikpoza, E; and ²Ogiemwonyi, O.

^{1,2}Department of Production Engineering, University of Benin, Benin City, Nigeria

¹**Email:** emmanuel.ikpoza@uniben.edu

ABSTRACT

Melon seeds are popular in sub Saharan Africa and Asia. Egusi as it is popularly called, is a major food crop in Nigeria because of its protein-rich edible seeds, which are commonly used in the preparation of local soup or stew and snacks. One major drawback however, in the consumption of melon is the rigor involved in separating the seeds from its shell which is often done manually by local farmers. This study focuses on designing and fabricating an electrically driven melon shelling machine with the incorporation of a chaff separation chamber. The machine consists of a frame, hopper, shelling chamber, rotor, chaff separation chamber and the discharge outlets. The shelling unit consists of a rotating impeller made of mild steel of 15mm in width. The machine was tested with melon seeds at constant speed and feed rate, using moisture contents of 5%, 10%, 15%, 20% and 25% by weight (w.b). The melon shelling efficiency (MSE) increased as the moisture content increased, but beyond 20% w.b, there was a decrease in shelling efficiency. Maximum shelling efficiency was obtained at a moisture content of 20% w.b. and feed rate of 11.8 Kg/hr as 48.15%. This shelling efficiency obtained has shown that there is a prospect in the mechanization of the processing and handling operation.

Keywords: Melon Seeds, Shelling, Machine, Separation Chamber

Article Information:

Received 20 November, 2021

Revised 02 December, 2021

Accepted 05 December, 2021

Available online 08 March, 2022

1.0 INTRODUCTION

Melon seeds, commonly called “Egusi”, a name widely used throughout West Africa, is produced by the melon plant which belongs to the Cucumber family known as Cucurbitaceae which is found mainly in the warmer part of the world. They consists of 118 genera with about 825 species. There are mainly four types cultivated in West Africa, cucumeroipsis manii, citrulus lanatus, lagenaria siceraria and citrulus vulgaris. The cultivars found in Nigeria are Bara, Serewe, Sofin, variety “E” and “N” types. The Bara size is 16mm x 9.5mm is found in northern and western Nigeria. The weight of 100 seeds is about 14g. Serewe are cultivated in eastern Nigeria and are 15mm x 9mm in size. The 100 seed weight is about 12g. The “E” and “N” types are from Niger and Benue state respectively. The “E” type has 100 seed weight of 16g and it is 16mm x 10mm in size. The “N” type is 7mm x 4mm in size with a 100 seed weight of 5g. Melon seeds are very rich in dietary oils (50%) and proteins (37.4%) (Ajibola et al., 1990).



Plate 1: Examples of Melon Specimens

In West and Central African countries especially in Cameroon and Nigeria, the yellow type and white type melon seeds are manually shelled and their cotyledons is extracted and used in the preparation of soup and pudding. Other potential ways of processing the crop involves the extraction of oil from the cotyledon seeds which could be used in the pharmaceutical application or as cooking oil. The shells could also be used as a potential poultry feed ingredient (Ogbe and George, 2012). However, the tedious and time consuming process involved in the manual shelling of the seeds is a limiting factor to the mass production and industrialization of this sector. Most local inhabitants use alternative protein and dietary oil sources because the commercialized manually shelled seeds sold in the local market are relatively expensive. A few studies investigating the development and the use of mechanical system to address the problem associated with the traditional method of shelling melon seeds has been carried out (Shittu and Ndrika, 2012). Tests concluded on these machines show that the yield rates were on the average not more 30% (Okokon et al, 2010). Apparently, the low efficiencies could be due to the lack of process optimization (rotational speed of machine impeller, feed rate of melon seeds during the shelling, moisture content of the seeds and the impact force of machine impeller) during the operation. Melon seeds have long served as a vital food in Nigeria. The first stage in its consumption and processing involves the separation of the melon seeds from its outer shell (chaff). The separation task has, over time

proven to be difficult and time consuming. Hence, the need for a portable machine that performs this function effectively for domestic use.

In Nigeria, some researches has been carried out on the design and fabrication of mechanical devices with the aim of easing the melon shelling operation. Fashina (1971) constructed a melon seed shelling machine which works on the principle of bending by feeding seeds through sets of rollers having ridges on their surfaces. Odigboh (1979) designed an impact melon shelling machine that works on the principle of impact force from the spinning disc. Also, Fadamoro (1999), constructed a manually operated melon shelling machine that works by frictional forces between rotating and stationary discs. Melon shelling by extrusion method was discovered by Obienwe (1999). Other researchers who have worked on designing a melon shelling machine include, Ogbe and George 2012, who performed experiments which suggests that the unshelled melon seeds will properly be shelled when steamed than when in its original dry state. This led to the concept of steaming the melon first in a steaming chamber before allowing them to come into the shelling compartment where they fall into a spinning (rotating) disc with vanes which throw them rather vigorously to impinge on a rough wall where they are shelled by both impact and friction. After the melon seeds are properly shelled in the shelling chamber, they are then ready for separation.

The aim of this project is to design and fabricate a portable melon shelling machine comprising of a shelling and a chaff separation chamber.

2.0 MATERIALS AND METHODS

Mild steel was used in this design. The mild steel was used for the frame, the hopper and the chaff separation chamber. The end product was painted to enhance its ability to resist corrosion. The machine was designed to be electrically powered. Two electric motors were incorporated in the machine. The first motor rated at 1hp drives the impeller in the shelling chamber while the other rated at 0.04hp drives the fan in the chaff separation chamber. The different parts of the melon shelling machine were fabricated according to design specifications and assembled together mainly by welding, and use of nuts and bolts for ease of assembly and disassembly. The isometric drawing the complete assembly drawing of the machine is presented in the Figure 1.

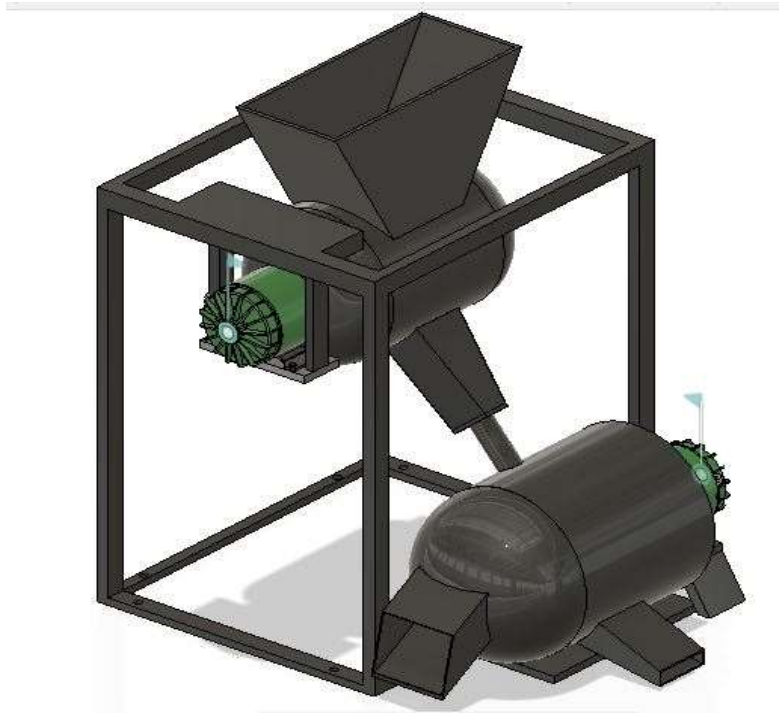


Figure 1: Isometric View of Melon Shelling Machine

The sheller employs the principle of energy absorption by the melon seeds, as a result of collision between the seeds and the stationary wall of the drum and this causes the cracking and removal of the husk from the seed. Unshelled melon seeds are fed into the hopper of the sheller. When the sheller attains a suitable speed of about 950 rpm, the bottom of the hopper is manually opened to allow the seeds to fall directly into the shelling chamber. The melon seeds which are dropped into the shelling chamber from the hopper move anti clockwise in the space between the varied rotating disc and the rough stationary drum. Since the average thickness of the melon seed is 2.5mm, the seeds will tend to move in a single row. The rotation of the impeller causes the removal of the coat from the cotyledon of the seeds as they rub against the rough surface of the fixed wall of the drum. The chaff and the cotyledon fall by gravity into the chaff separation chamber. A regulated fan installed in this chamber blows off the chaff and the cotyledon fall by gravity and are collected at the discharge unit of the sheller. The air velocity in the cleaning chamber must be less than the minimal velocity of the melon seeds.

2.1 Design Calculations

2.1.1 Dynamics of the Shelling Operation

In the shelling chamber, the melon seeds are confined to move between the rotating blade assembly (spinning disc) the rough wall of the chamber and between the vanes and the spinning disc. However, it is difficult to predict accurately the path of the seeds within this space as their motion is bound to be random considering the possibility of multiple impacts at the surface of the spinning disc and also the rough wall as well as the sides of the vanes. If we assume that the melon seeds reach the spinning disc with negligible initial velocity and we also assume that the seeds acquired the angular velocity, ω^2 , directed away from the center. Neglecting possible multiple impacts on vanes resulting from supplementary acceleration or

the so called Coriolis acceleration as well as sliding friction force will both reduce the onward acceleration to give the resultant force on each seeds of mass m as:

$$mw^2 - \mu m 2\omega \frac{dr}{dt} - \mu mg = m \frac{d^2r}{dt^2} \quad (1)$$

or in terms of acceleration in radial direction

$$\frac{d^2r}{dt^2} + 2\mu\omega \frac{dr}{dt} - \omega^2 = \mu g \quad (2)$$

The solution of the differential equation (2) gives an expression for radial distance covered at time t as:

$$r = \frac{\mu g}{\omega^2} + Ae^{\omega p t} + Be^{\omega m t} \quad (3)$$

$$\frac{dr}{dt} = A\omega p e^{\omega p t} - B\omega m e^{\omega m t} \quad (4)$$

where,

$$p = \sqrt{\mu^2 + 1} - \mu \quad (5)$$

and A and B are constants.

If we let $r = \frac{\mu g}{\omega^2}$ from equation (3)

$$Ae^{\omega p t} + Be^{\omega m t} = 0$$

Hence,

$$\frac{dr}{dt} = \frac{d^2r}{dt^2} = 0$$

This means that the seeds are fed into the spinning disc at a distance given by

$$r = a > \frac{\mu g}{\omega}$$

To evaluate the constants A and B, let the initial conditions be that

$$r = a \text{ and } \frac{dr}{dt} = 0 \text{ at } t = 0$$

Then from equation (4),

$$A\omega p = B\omega M \quad (6)$$

or

$$B = A\left(\frac{p}{m}\right)$$

And from equation (3.3),

$$\left\{a - \frac{\mu g}{\omega^2}\right\} = A\left\{1 - \frac{p}{m}\right\}$$

Hence,

$$A = \left\{a - \frac{\mu g}{\omega^2}\right\} / \left\{1 - \frac{p}{m}\right\}$$

and

$$A = \left\{a - \frac{\mu g}{\omega^2}\right\} / \left\{1 + \frac{m}{p}\right\}$$

Subject to the simplified assumptions made, the melon seeds emerges from the spinning disc with a radial velocity V_r given by equation (3) and a tangential velocity. Since the impact surface provided by the rough surface of the cylindrical outer wall is concentric with the spinning disc, only the component normal to the surface will be effective in splitting the melon shell by impact. The component of V tangential to the surface will provide the rubbing action needed to separate the cotyledon from the split melon shells.

2.1.2 Operating Speed Calculation

Coefficient of friction $\mu = 0.64$

Acceleration due to gravity $g = 9.8m/s$

Radius of disc 1 = $0.095m$

$$P = \sqrt{(0.64^2 + 1)} - 0.64 = 0.877$$

$$M = \sqrt{(0.62^2 + 2)} + 0.64 = 1.75$$

$$A = \frac{[0.095 - (0.64 \times 9.81) / \omega^2]}{[1 + 0.877 / 1.75]}$$

$$= 0.0696 - \frac{4.183}{\omega^2}$$

$$B = \frac{[0.095 - (0.64 \times 9.81) / \omega^2]}{[1 + 1.75 / 0.877]}$$

$$= \frac{0.03171 - 2.0960}{\omega}$$

$$V_r = [0.0696 - 4.183 / \omega^2] \omega (0.877) e^{\omega p} - [0.03171 - 2.0960 / \omega^2] \omega (1.75) e^{\omega mt}$$

Now at $t = 0$

$$e^{\omega p} = e^{\omega mt} = 1$$

We have that

$$V_r = [0.0696\omega - 3.668 / \omega^2] - [0.03171\omega - 3.668 / \omega^2]$$

$$V_r = 0.03789\omega$$

$$\text{Now from } V^2 = V_r^2 + \omega^2 R^2 \tag{7}$$

$$29.27^2 = (0.03789\omega)^2 + \omega^2 (0.095)^2$$

$$\omega = 286.12 \text{ rad/s}$$

Therefore, speed in rev/minute (rpm),

$$N = \frac{\omega \times 60}{2 \times \pi} \tag{8}$$

$$N = \frac{286.12 \times 60}{2 \times \pi} = 2732.27 \text{ rpm}$$

Thus, a motor having an rpm range from between 2700 rpm and 3000 rpm should be used. A motor of speed 2860 rpm is chosen to be specific.

2.1.3 Shaft Design

Material:

AISI 1117 Hot rolled

Tensile strength = 62ksi = 427Mpa

Yield strength = 34ksi = 234Mpa

Ductility (% elongation in 2m) = 33

Brinnel hardness (HB) = 124

Design factor $N = 4$ (some impact of load is expected on rotating disc).

Using the maximum shear stress theory and the Soderberg criteria, the following equation results and it is useful for calculating the required minimum diameter for the shaft.

$$d = \left[\frac{32N}{\pi} \sqrt[3]{\frac{KM}{\sigma}} + \left[\frac{T}{\sigma} \right]^2 \right] \quad (9)$$

Where,

N = Factor of safety = 4

Kt = Stress Concentration Factor = 2.5

M = Bending Moment

T = Torque

σ_n = Endurance Strength (modified) = 341600000N/m²

σ_y = Yield Strength = 234000000N/m²

2.1.4 Design of the Chaff Separator

It was considered that the melon chaff is blown forward in the separator by a blower (fan) with horizontal velocity U , at a height OA , measured from a level of about 60mm below the lowest point of the separator end P_2 . Since U is horizontal, it has no component in the vertical direction. Similarly, since g which is the acceleration due to gravity, acts vertically, it has no component in the horizontal direction. We may thus, treat the horizontal and vertical motion independently. Consider the vertical motion from O to A . Due to the available space, the height OA is limited to 240mm and for similar a reason, the horizontal distance AB is tentatively taken to be 200mm. Since this is the range we expect the chaff to travel in order to give a reasonable allowance between the chaff and points where it gets to the same level as the lowest point P_2 in the separator.

Generally, in time t , the particle falls a vertical distance say x , given by

$$X = \frac{1}{2}gt^2$$

Where

g = acceleration due to gravity

In the same time, the particle travels a horizontal distance given by

$$y = ut \quad (10)$$

If it is eliminated by using $t = \frac{y}{u}$ in $x = \frac{1}{2}gt^2$

We obtain $x = \frac{gy^2}{2u^2}$ (11)

Horizontal Velocity $\mu = \sqrt{\frac{gy^2}{2x}}$ (12)

Substituting in the values of $y = 200\text{mm}$ (0.2m) and $x = 140\text{mm}$ (0.14m) and $g = 9.81\text{m/s}$ into equation, we have

Horizontal Velocity $u = \sqrt{\frac{9.81 \times 0.2^2}{2 \times 0.14}} = 1.18\text{m/s}$

Therefore, $u_1 = 1.18\text{m/s}$

Thus, the time required for this motion, $t = \frac{y}{u} = \frac{0.2}{1.18}$
 $t = 0.169\text{ s}$

2.1.5 Blower Design

We shall use a velocity of $V = u_1 = 1.18\text{m/s}$ (since it is greater than, u_2) in our design for the fan. Thus, with, $V = 1.18\text{m/s}$ we now know that the air flow rate should be at an air speed of 1.18m/s.

Cross sectional area of the separator can be obtained by assuming that the shape of the separator which will be a trapezoidal frustum reduces to a cuboid for ease of analysis, with a mean depth $H = 190\text{mm}$ (0.19m) and a breadth, $B = 160\text{mm}$ (0.16m).

Therefore, cross sectional area of the separator is expressed as

$A = B \times H$ (15)
 $A = 0.19 \times 0.16$
 $= 0.0304\text{m}^2$

Air flow rate, $V = \text{Area} \times \text{Velocity}$ (16)
 $= 0.0304 \times 1.18$
 $= 0.0359\text{m}^3/\text{s}$

2.1.6 Power Requirement of the Blower (Fan)

The power required to drive the fan is given by

$\hat{W} = \frac{hegV}{\eta_m}$ (17)

Where,

h = pressure rise across the fan

e = density of water = 100kg/m³

g = acceleration due to gravity = 9.81m/s

V = volume flow rate of air in fan = 0.0359m³/s

η_m = mechanical efficiency of the fan = 0.95 (assumed)

$h = \frac{V^2}{2g}$ (18)

where,

$V =$ velocity of air in m/s = 1.18m/s

$$h = \frac{1.18^2}{2 \times 9.81} = 0.0709m$$

$$\hat{W} = \frac{0.0709 \times 1000 \times 9.81 \times 0.0359}{0.95} = 26w$$

This could also be expressed as 0.026kw or 0.035hp

Now considering the fact that the mixture will contain chaff particles and other impurities, we fix the required at 0.03kw. Hence, a 0.03kw motor is used and the fan is mounted to the motor (motor 2) shaft directly.

2.1.7 Shape of the Chaff Separator.

From the analysis in case two, we can calculate the horizontal distance AB covered by the particle using the expression:

$$\begin{aligned} y &= ut \cos \alpha \\ &= 0.8859 \times 0.3027 \cos 45^\circ = 0.1896 \\ &= 189.6 \text{ mm} \end{aligned} \tag{19}$$

This horizontal distance of $y = 189.6 \text{ mm}$ is less than 300mm which is the distance between the point from which the melon enters the separator and at the end of the separator. The implication of this is that there is the possibility that not all the chaff would directly come out from the separator. Some of the chaff would fall down before getting to the tip of the separator. For each of the chaff to be able to fall out from the separator, the lower surface of the separator has to be tilted at an angle of repose, given by

$$\theta = \tan^{-1} \mu \tag{20}$$

Where,

μ = Coefficient of friction between the chaff and the mild galvanized steel which has been determined to be 0.68 from the literature reviewed.

Hence,

$$\begin{aligned} \theta &= \tan^{-1} 0.68 \\ \theta &= 34.2^\circ \end{aligned}$$

Therefore, the surface receiving the chaffs has to be fitted at an angle greater than 34.2° to the horizontal. This basically, accounts for the trapezoidal shape of the separator as show in the design concept in Figure 1.

2.1.8 Shelling Efficiency

The effectiveness of the machine in terms of number of seeds shelled was based on the shelling efficiency metric (Shittu and Ndrika, 2012) which is expressed as:

$$\eta = \frac{Wsb - Wsu}{Wt} \times 100\%$$

Here, η is the shelling efficiency, Wsu is the number of unbroken seeds that were shelled, Wsb is the number of broken seeds that were shelled (broken), and is the total number of seeds.

$$\eta = \frac{23 - 9}{32} \times 100\%$$

$$\eta = 43\%$$

2.1.9 Likelihood of Damaging Shells

A similar measure is made of the number of damaged seeds (Shittu and Ndrika, 2012) which is:

$$\eta_b = \frac{Wub + Wsb}{Wt} \times 100\%$$

Where η_b is the percentage of seeds which are broken, Wub is the number of broken unshelled seeds, Wsb is the number of broken seeds that were shelled (broken), and Wt is the total number of seeds.

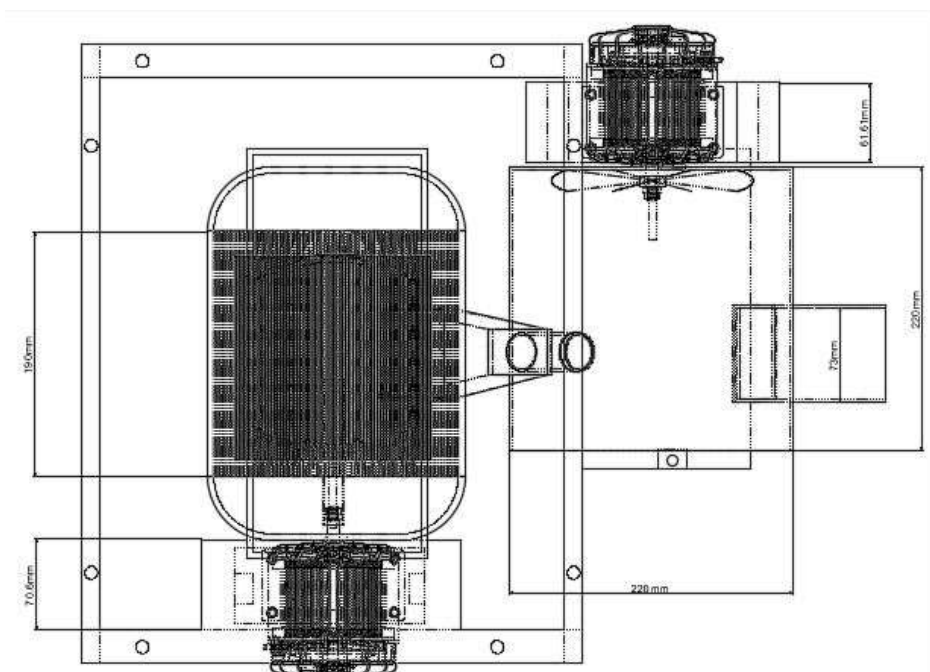


Figure 2: Orthographic Views with Dimensions (Front View)

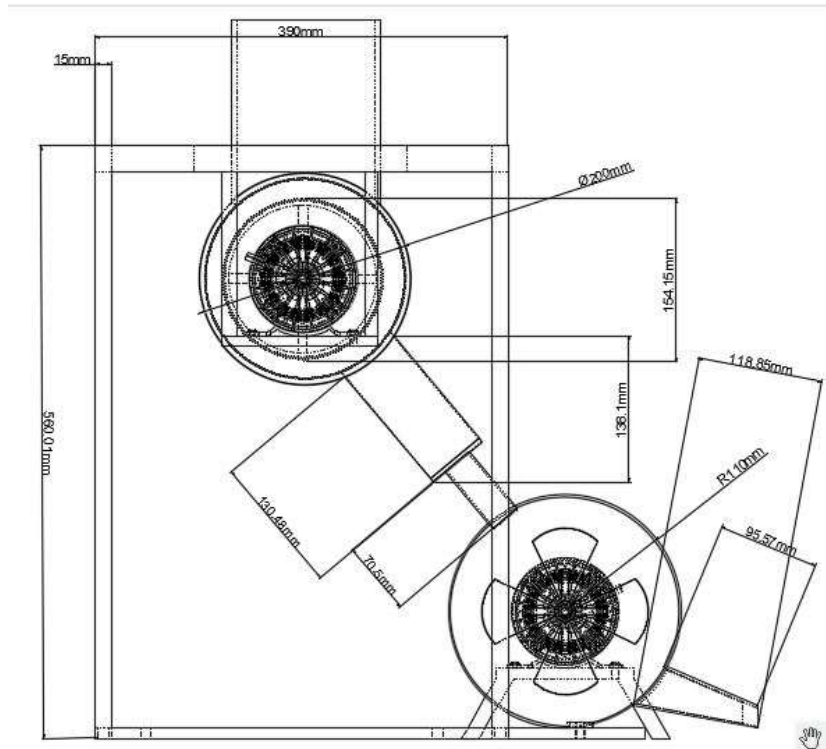


Figure 3: Orthographic Views with Dimensions (right side elevation)

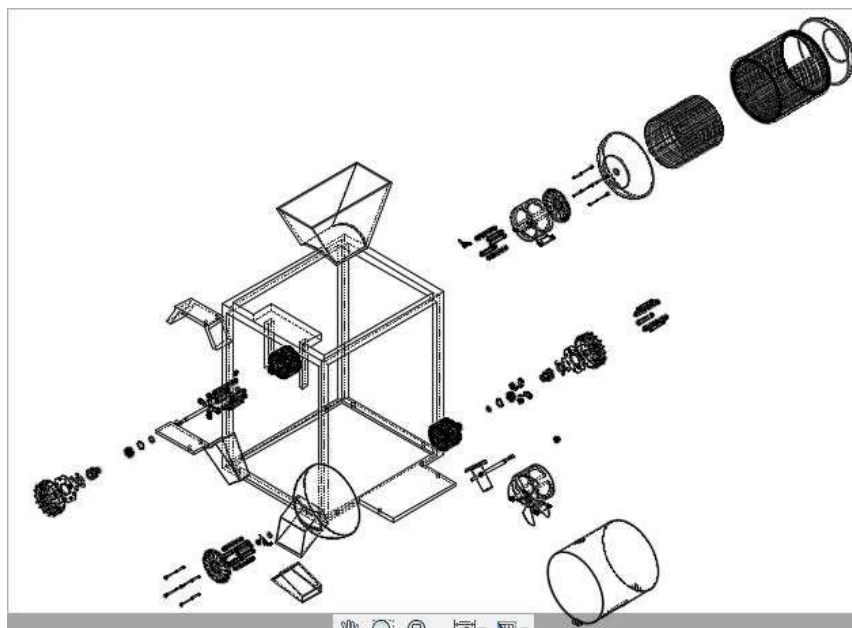


Figure 4: Exploded View of the Melon Shelling Machine

3.0 FABRICATION

The fabrication of the components were done in the Department of Production Engineering workshop, faculty of Engineering, University of Benin, Benin City. The different parts of the melon shelling machine were fabricated according to design specifications and assembled

together mainly by welding, and use of nuts and bolts for ease of assembly and disassembly. Plate 2 shows the fabricated machine.



Plate 2: Fabricated Melon Shelling Machine

3.1 Hopper

The hopper serves the purpose of admitting unshelled melon into the shelling chamber. The hopper opens directly into the shelling unit through a centralized hole. The hopper is meant to receive the melon seeds before they are eventually moved into the shelling chamber. The hopper was made up of four welded mild steel metal sheet slanting towards a small opening. The mild steel metal sheet was marked out with the aid of a steel set square, steel ruler and scribe. An allowance of 10mm was given on all edges of the sheet to cater for hemming. For this particular design, a dimension of 240mm x 240mm x 180mm was used. Cutting was done using a shearing machine, chisel and hammer. The cut sheet was later folded and thereafter welded using manual metal arc welding.

3.2 Shelling Chamber

The shelling chamber is the compartment where shelling occurs. It consists of the shelling drum, the shelling vanes and the shelling disc (Plate 3 and Figure 5). The shelling drum was made of mild steel and the inner part of the drum was lined with one quarter inch rods. The shelling disc was made from mild steel. They were arranged side by side at an angle of 120° to each other and welded to the shelling disc at an angle of 45°. The shelling chamber incorporates an opening at the bottom part, which serves as an outlet for the shelled melon seeds.



Plate 3: Pictorial View of Shelling Disc

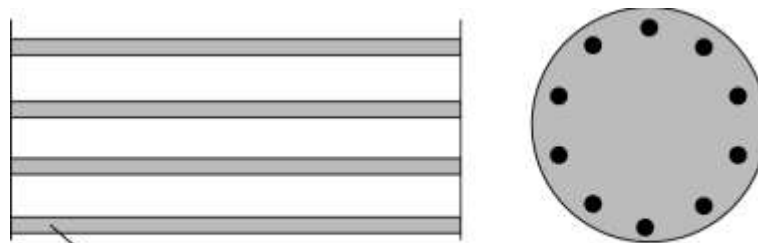


Figure 5: Schematic representation of Thrashing Vanes and its Configuration on a Circular Disc

4.0 RESULTS AND DISCUSSION

The melon shelling machine as designed and fabricated was tested to ascertain its efficiency in its function. Tests were carried out using Melon type A and type B. the efficiencies were calculated in the sections that follow.

4.1 Calculation for Shelling Efficiency (%) for Seed Type A Using Various Feed Rates (Kg/hr)

$$\eta = \frac{W_{sb} - W_{su}}{W_t} \times 100\%$$

Here, η is the shelling efficiency, W_{su} is the number of unbroken seeds that were shelled, W_{sb} is the number of broken seeds that were shelled (broken), and W_t is the total number of seeds.

First Sample using a feed rate of 6.85Kg/hr

$$\eta = \frac{21 - 8}{29} \times 100\% = 44\%$$

Second Sample using a feed rate of 11.80Kg/hr

$$\eta = \frac{20 - 7}{27} \times 100\% = 48\%$$

Third Sample using a feed rate of 13.00Kg/hr

$$\eta = \frac{25 - 17}{42} \times 100\% = 19\%$$

Fourth Sample using a feed rate of 18.40Kg/hr

$$\eta = \frac{19 - 8}{27} \times 100\% = 41\%$$

4.2 Calculation for Shelling Efficiency (%) for Seed Type B Using Various Feed Rates (Kg/hr)

$$\eta = \frac{W_{sb} - W_{su}}{W_t} \times 100\%$$

Similarly, η is the shelling efficiency, W_{su} is the number of unbroken seeds that were shelled, W_{sb} is the number of broken seeds that were shelled (broken), and is the total number of seeds.

First Sample using a feed rate of 12.20Kg/hr

$$\eta = \frac{25 - 16}{41} \times 100\% = 22\%$$

Second Sample using a feed rate of 13.30Kg/hr

$$\eta = \frac{26 - 17}{43} \times 100\% = 20\%$$

Third Sample using a feed rate of 21.75Kg/hr

$$\eta = \frac{25 - 17}{42} \times 100\% = 19\%$$

Fourth Sample using a feed rate of 27.30Kg/hr

$$\eta = \frac{23 - 19}{42} \times 100\% = 10\%$$

Figure 6 shows the graph of shelling efficiency (%) to Feed Rate (kg/hr) Using Microsoft Excel

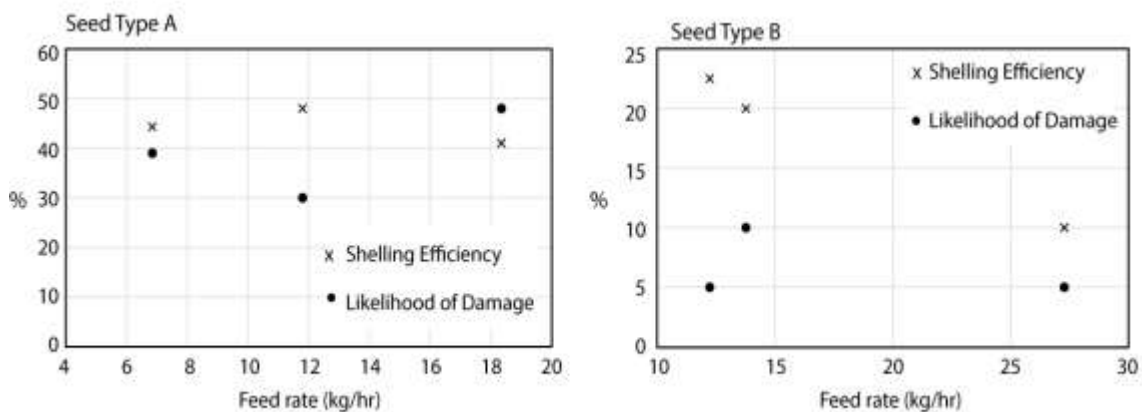


Figure 6: Graph of Shelling Efficiency (%) to Feed Rate (kg/hr) Using Microsoft Excel

5.0 CONCLUSION

This research was aimed at designing and fabricating a portable melon shelling machine comprising of a shelling and separation chamber. This was done with a view to ease the rigors involved in manually shelling of melon seeds. The assembly of the components was done using different joining processes like welding, soldering and the use of bolts, nuts and screws. The machine was tested and its efficiency evaluated.

Performance test were carried out on the machine using two types of seeds (yellow and white) seeds. Among the independent parameters are the feed rate of the melon seeds, soaking time as well as the critical spreading time. It was found that when type B seeds were wetted in water for 30 minutes, and were then passed through the shelling machine multiple

times (4 passes), an optimum shelling efficiency of 48.15% was obtained, at a feed rate of 11.8Kg/hr. The efficiency obtained is a clear indication that there is a bright prospect in the mechanization of the shelling of melon seeds.

REFERENCES

Ajibola O. O., Eniyemo S. E., Fasina O. O., Adeeko K. A. 1990, Mechanical Expression of Oil from Melon Seeds, Journal of. Agric. Engineering Resources. Vol 45, pp 45-53

Fadamoro, I. 1999, Design and Construction of a Manually Operated Melon Sheller, Mechanical Engineering Dept., University of Ilorin, Nigeria,.

Fashina, A B., 1971, The Design and Development of a Melon sheller, Project for B.Sc. Agriculture Hons. University of Ife, Nigeria, 1971.

Obienwe, V.S, Aviara, N.A, Hague M.A.N, 1999. Physical Properties of Guna Seeds, Journal of Agricultural Engineering Research, 73: 105-111

Odigboh, E.A. 1979, A Spinning Disc Melon Seeds Shelling Machine Development, Design And Prototype Construction, NIJO Tech.,3(2):274-286

Ogbe, A.O. and George, G.A.L, 2012, Nutritional and anti – nutrient composition of melon husks, potential as feed ingredient in poultry diet. Research Journal of Chemical Sciences, 12:35-39.

Okokon, F.B, Ekpeyong, E; Nwauka, C; Akpan, N. Abam; F.I 2010. Impact force of melon during shelling. Agricultural Engineering International: CIGR Journal, 12:182-188.

Shittu S.K. and Ndrika, V.I.O. (2012). Development and performance tests of a melon (egusi) seed shelling machine. Agric Eng Int: CIGR Journal, 14(1), pp.1-11.