Design And Fabrication Of Melon De-Husking Machine

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Abstract— **In this paper, the design and fabrication of melon de-husking machine is presented. The melon de-husking machine is electric powered and has main parts of Hopper, de-husking Chamber, stationary disc/shaft with slots/grooves), a separation chamber (consisting of the blower in the housing and the two separate outlet points for the Cotyledon and the husks) all mounted and fastened to a frame. The design calculations were presented to determine the key parameters of the machine components. The melon de-husking machine was successfully designed and fabricated and the test results show that it has machine capacity of 3 kg per minute. That means in 1 hour the machine de-husked 180kg bag of melon. Also, the test results gotten from the dry melon seed purchased from the market (without being treated) with the moisten content of 7.99% show that the de-husking efficiency of 66% was achieved with 6.6 % of damage to the seed. Further test results gotten from the dry melon seed purchased from the market (and treated) with the moisten content of of 10.17% show that the de-husking efficiency of 73.3 % is achieved with 3.3 % of damage to the seed. In all the results show that the de-husking efficiency increases with treated melon with more appropriate moisture content.**

Keywords— Melon De-Husking Machine, Hopper, De-Husking Chamber, Machine Capacity, Melon Moisture Content, Melon De-Husking Efficiency

1. INTRODUCTION

Over the years, melon has been noted as one of the most widely cultivated seedling in Nigeria [1,2,3]. Yearly, several tons of Melon are harvested across the nation. Melon seed has many applications [4,5,6]. While in some places melon seeds are used for human feed [7,8], in some other cases, they are used for animal feed and industrial purposes [9,10,11]. The oil from the melon seed s also very useful and some industries use the melon seed oil for their products [12,13,14].

Despite the large harvest of melon, significant percentage of the melon are lost due to poor post-harvest handling of the melon seed [15,16,16,17,18]. Also, the melon seed that are preserved after harvest are processed, especially by first removing the outer yellow shell [19,20,21].

In developing countries like Nigeria, manual approach has been the dominant method adopted for removing the outer shell of the melon [22,23,24]. However, some mechanized approaches have been devised. However, the efficiency of those machines are significantly low in the region of 60% [25,26,27]. As such, this paper seek to present the design and fabrication of melon de-husking machine that can have efficiency well above 60%. This will enhance the productivity and minimize the shelling cost of melon seed.

2. METHODOLOGY

2.1 THE MELON SEED ATTRIBUTES AND DIMENSIONAL CHARACTERISTICS

The pictorial description of the melon de-husking machine is given in Figure 1. In this work, the various dimensional characteristics of melon seeds were considered. This involves measurement of physical characteristics of melon seeds for five dimensional quantities as stated in Table 1. Images of two different varieties of melon are shown in Figure 2.

An outer shell which is hard, covers the softer edible inner kernel or cotyledon. Pertinent to the shelling process is the fact that the dry melon seed has 7.99% moisture content. The dry seeds are brittle and crack with a small squeezing of the seed along the axis of the edge and perpendicular to the flat surface of seed. The brittle shell, breaks and may also cause the cotyledon to be broken. This is undesirable; and lowers the value of cotyledon. The moisture content of seed is increased to between 14 to 21% before shelling, to increase the bending properties of seed before shelling. This way, shelling is achieved without breaking the cotyledon [28].

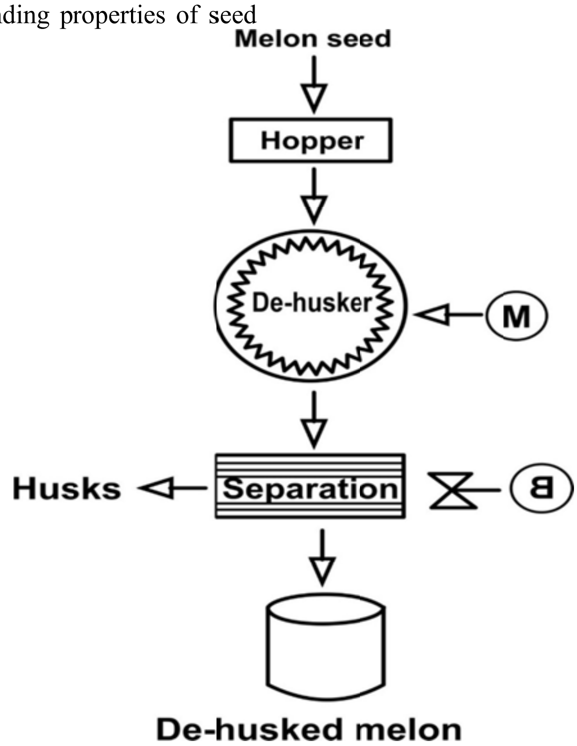

Figure 1 The pictorial description of the key components of the melon De-husking machine

Table 1 Dimensional characteristics of seeds.

Parameter	Melon seed (Variety "E")	Melon seed (Variety "N" - Bara)
Widths (mm)	10	10
Lengths (mm)	15.5	20
Density (kg/m3)	407	406
Thickness (m)	20	19
Surface area (mm^2)	37	36

(a): Melon seed (Variety "E") **(b): Melon seed (Variety "N" - Bara)**

Figure 2 Images of two different varieties of melon

2.2 THE DESIGN CALCULATIONS FOR THE MELON DE-HUSKING MACHINE

2.2.1 DETERMINATION OF THE MOISTURE CONTENT

a) The moisture content, M.C of the melon is determined as follows;

$$\text{M.C (\%d.b)} = \frac{w_{db} - w_{ad}}{w_{db}} \times 100 \quad (1)$$

w_{db} = Weight before drying and w_{ad} = Weight after drying. The amount of water that must be added to obtain the desired moisture content is given by using the formula:

$$Q = (A\,(b-a)) / (100-b) \quad (2)$$

Where Q = the amount of water to add (kg), A = the weight of the initial sample to be introduced into the machine (kg), b = the desired final moisture content (%) and a = moisture content before conditioning (%).

2.2.2 POWER REQUIREMENTS

The total power that will be required by the machine for melon de-husking is calculated using models specified as;

$$P_T = P_{impeller} + P_{shaft} + P_{shelling} \quad (3)$$

$P_{shelling}$ is negligible since the seeds will not be resident in the de-husker but flow through in pieces during the operation process. Then;

$$P_T = P_{impeller} + P_{shaft} \quad (4)$$

But, shaft and impeller are mechanically coupled together, hence;

$$P_T = P_{impeller\ with\ shaft} \quad (5)$$

Analyzing further for the power requirement,

$$P_{impeller\ with\ shaft} = T_{impeller\ with\ shaft} \times V_{impeller\ with\ shaft} \quad (6)$$

$$\text{Similarly, } V_{impeller\ with\ shaft} = \frac{2\pi N}{60} \text{ m/s} \quad (7)$$

In this analysis, the following factors are considered; $T_{impeller}$ denotes the applied torque (Nm) while N signifies the number of revolution per minute of the impeller with shaft set at 350 rpm. Also,

$$T_{impeller\ with\ shaft} = \text{mass} \times \text{acceleration due to gravity} \times \text{radial distance} \quad (8)$$

For this type of analysis, standard figures are applied, notably; Mass (m) = 5.6 kg, Radial distance (R) = 0.095 m and acceleration due to gravity (g) = 10 m/s2 . Then, for the computation of the torque related to the impeller with shaft, therefore;

$$T_{impeller\ with\ shaft} = 5.6 \times 10 \times 0.095 = 5.32 \text{ Nm}$$

So,

$$P_{impeller\ with\ shaft} = \frac{5.32 \times 2 \times 3.142 \times 350}{60 \times 1000}\ .$$

Then,

$$P_{impeller\ with\ shaft} = 0.195 \text{ kW} \approx 0.329 \text{ HP}.$$

In this analysis, a factor of safety of 2, for mild steel materials under static loading is considered and power required in this case is 0.66 Hp. Therefore, an electric motor of 1HP is used to power the melon de-husking machine impeller, shaft and to shell the seeds during operation.

2.2.3 DETERMINATION OF SHAFT DIAMETER

The diameter of the solid shaft used in transmitting the rotary motion from the electric motor to the melon de-husking chamber is determined as follows: For the optimal de-husking speed which is taken as N = 350 rpm. Also, power required by the solid shaft is selected as Power (P) = 0.195 kW while the factor of safety (FOS) for mild steel under static loading is 2. Then, the ultimate shear stress, τu for mild steel is taken as 360 Mpa. But for the allowable shear stress in this analysis is given as;

$$\tau = \frac{\tau u}{FOS} \quad (9)$$

$$\tau = \frac{360}{2} = 180\ MN/m^2$$

$$\text{Torque transmitted by the shaft, } T = \frac{p \times 60}{12\pi N} \quad (10)$$

Evaluating Eq. (10) yields T= 5.32 Nm and given that torque transmitted by a solid shaft is guided by Eq. (11). In this situation,

$$T = \frac{\ }{16} \times \tau \times d^3 \quad (11)$$

Also,

$$d^3 = \frac{16T}{\tau} \quad (12)$$

Therefore,

$$T = \frac{16 \times 5.32}{13.142 \times 180 \times 10^6}$$

The solid shaft applied in this case is taken as $d^3 = 1.728 \times 10^{-6}$;

$d = \sqrt[3]{1.728 \times 10^{-6}}$ since, d = 0.01232m, then, this solid shaft diameter will be suitable as d = 12 mm. From the above analysis, a 12mm diameter solid shaft is chose for the de-husking chamber to transmit the rotary motion from the electric motor to the de-husking impeller

2.2.4 MACHINE CAPACITY

This explains the capacity of the machine in terms of the quantity of melon seeds de-husked per unit time. It expresses the method of determining the machine capacity in this context. Therefore;

$$C_m = \frac{M_s}{T} \quad (13)$$

Where, C_m = Machine Capacity (kg/hr); M_s = Mass of seeds shelled (kg); T = Time taken to complete the operation (min.).

After all the components have been fabricated, the de-husking machine was assembled based on and tested.

3. RESULTS AND DISCUSSION

3.1 THE COMPLETELY FABRICATED MELON DE-HUSKING MACHINE

The isometric drawing of the melon de-husking machine is shown in Figure 3 while Figure 4 and Figure 5 show (the back view and front view respectively) of the fabricated melon seed de-husking machine.

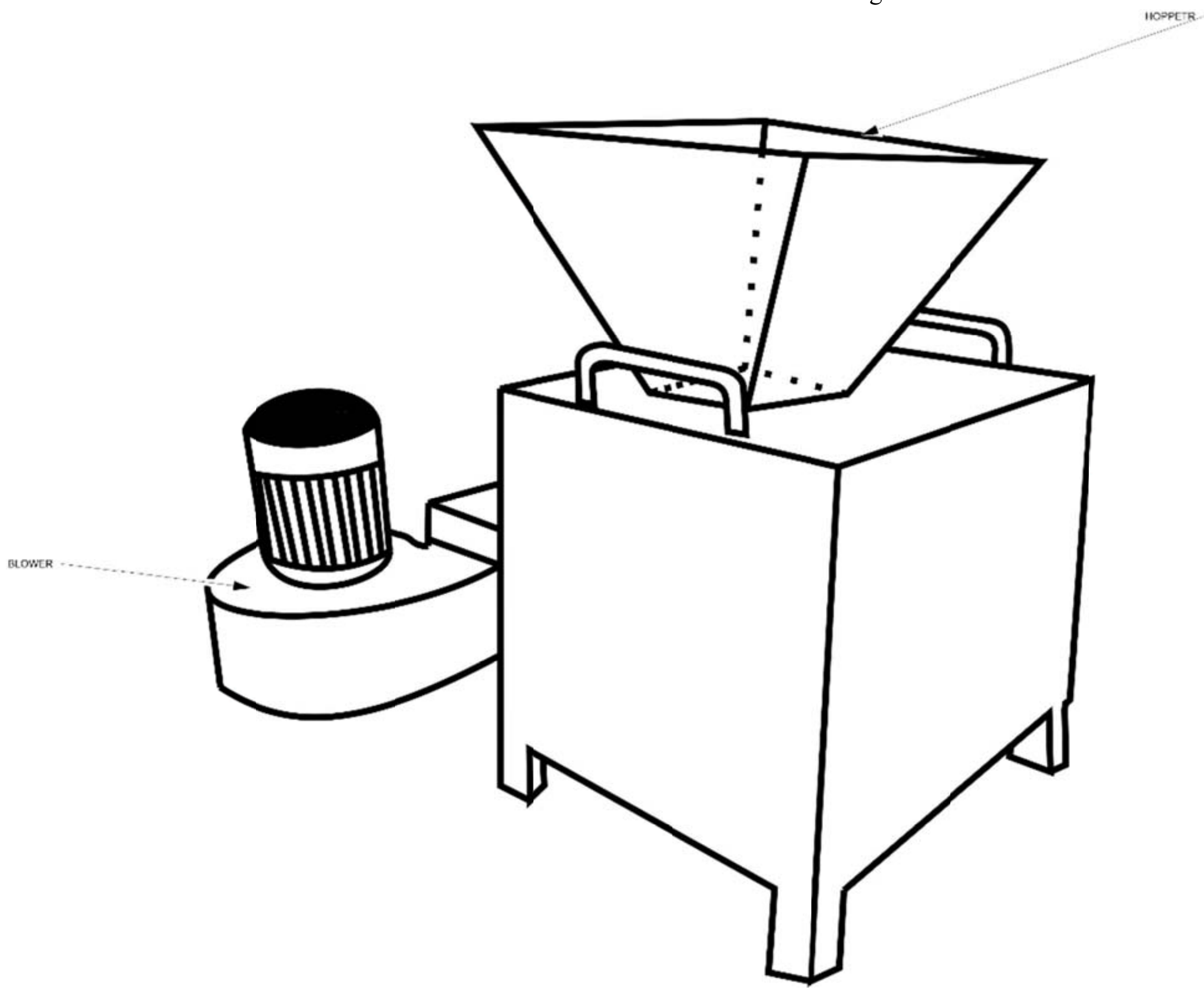

Figure 3 Isometric drawing of the melon de-husking machine

Figure 4 The completely fabricated machine (the back view)

Figure 5 The Completely fabricated machine (the front view)

3.2 THE MACHINE CAPACITY

The machine capacity in term of quantity of melon seeds de-husked per unit time is expressed in Equation 13 as; $C_m = \frac{M_S}{T}$, hence ;

$$C_m = \frac{3}{1} = 3\text{kg/min.}$$

Therefore, in 1 hour the machine de-husked 180kg bag of melon.

3.3 THE RESULTS OF DE-HUSKING MELON WITHOUT BEING TREATED

The results of de-husking melon without being treated are given in Table 2 where;

W0 = the weight of melon seeds in the sample

W1 = the weight of melon seeds De-husked and unbroken seeds

W2 = the weight of melon seeds De-husked but broken seeds

W3 = the weight of melon seeds partially De-husked and unbroken seeds

W4 = the weight of melon seeds partially De-husked but broken seeds

W5 = the weight of melon seeds De-husked chaff

Table 2 Result from De-Husking Melon without treated

MC (%)	Time (Min)	W0	W1	W2	W3	W4	W5	%E	%D
7.99	2	3kg	2kg	0.4kg	0.2kg	0.2kg	0.2kg	66	6.6

From Table 2 the de-husking machine efficiency (fully de-husked without breakage) and the percentage of damage (not de-husked but broken) were calculated for the untreated melon seed (melon seed purchased in the market with the moisture content of 7.99%) using Equation 15 and Equation 17 respectively.

De-husking Efficiency (%E)

$$= \frac{\text{Total weight of melon fully de-husked and not broken}}{\text{Total melon Fed}} \times 100 \quad (14)$$

Hence;

$$\%E = \frac{W1}{W0} \times 100 \quad (15)$$

Seed Damaged (%D)

$$= \frac{\text{Total melon not De-husked but broken \& crushed}}{\text{Total melon Fed}} \times 100 \quad (16)$$

Hence;

$$\%D = \frac{W4}{W0} \times 100 \quad (17)$$

Therefore, from the results in Table 2 for the untreated melon we have;

De-husking Efficiency (%E) $\%E = \frac{W1}{W0} \times 100 = \frac{2}{3} \times 100 = 66.6\%$

Seed Damaged (%D) $= \frac{W4}{W0} \times 100 = \frac{0.2}{3} \times 100 = 6.6\ \%$

Therefore, the results gotten from the dry melon seed purchased from the market (without being treated) with the moisten content of 7.99% show that the de-husking efficiency of 66% is achieved with 6.6 % of damage to the seed.

3.4 THE RESULTS OF DE-HUSKING MELON AFTER BEING TREATED

A sample was dried in an oven at 110°C for 8 minutes and the moisture content (%) was obtained as follows:

$$M_c = \frac{3.34-3}{3.34} X\ 100 = 10.17\%$$

The results of de-husking melon after being treated and having moisture content of 10.17% are given in Table 3. From Table 3 the de-husking machine efficiency (fully de-husked without breakage) and the percentage of damage (not de-husked but broken) were calculated for the treated melon seed (melon seed purchased in the market and treated with the moisture content of 10.17%) using Equation 15 and Equation 17 respectively and results in Table 3.

De-husking Efficiency (%E) $\%E = \frac{W1}{W0} \times 100 = \frac{2.2}{3} \times 100 = 73.3\%$

Seed Damaged (%D) $= \frac{W4}{W0} \times 100 = \frac{0.1}{3} \times 100 = 3.3\ \%$

Therefore, the results gotten from the dry melon seed purchased from the market (and treated) with the moisten content of 10.17% show that the de-husking efficiency of 73.3 % is achieved with 3.3 % of damage to the seed.

Table 3 Result from De-Husking treated Melon

MC (%)	Time (Min)	W0	W1	W2	W3	W4	W5	%E	%D
10.17	2	3.0kg	2.2kg	0.3kg	0.2kg	0.1kg	0.2kg	73	3.3

4. CONCLUSION

The paper presented the design along with fabrication of melon de-husking machine. The design calculations were presented to determine the key parameters of the machine components. Also the analytical models for the machine capacity, melon moisture content, melon de-husking efficiency and percentage of damaged seeds were also presented. The designed machine was fabricated and the isomeric view of the machine was presented along with some sample test results of the machine capacity, de-husking efficiency and percentage of damaged seed. In all the results show that the de-husking efficiency increases with treated melon with more appropriate moisture content.

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