DESIGN, FABRICATION AND PERFORMANCE TEST OF MELON SHELLING MACHINES

Orobome Agberegha

ABSTRACT: *Melon seeds are popular in the sub-Saharan Africa and Asia. Egusi as it is called is a popular fruit in Nigeria because of the edible seeds, which are commonly used in the preparation of local soup or stew and snacks. In Nigeria, farmers and other users of melon perform melon shelling through the cumbersome and wasteful manual methods. This study focuses on devising a better method for the removal of the shell to obtain the seeds. Results from preliminary investigations carried out on some physical and engineering properties of the pod seed were used in the design of the shelling machine. The machine consists of a frame, the hopper, the shelling chamber or unit made of a rotating impeller disc, rotor and the seed or discharge outlet. The shelling unit consists of a rotating impeller made of mild steel of 15mm thick. The discs are separated by vanes, 5mm thick and 10mm high. The vanes are attached to provide a central feeding port of 70mm diameter and the seeds are confined to move between the vanes. The impeller is mounted horizontally on the vertical shaft, centrally positioned with a cylindrical ring of 360mm internal diameter and thickness 8mm. The machine was tested with melon seeds at constant speed and feed rate, using moisture contents of dried seeds, 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. The maximum shelling efficiency was obtained at a moisture content of 20% w.b. as 84%. The high shelling efficiency obtained in the shelling of melon and minimal loss has shown that there is a prospect in the mechanization of the processing and handling operation.*

KEYWORDS: Melon Seeds, Egusi, Shelling Efficiency, Pod, Shelling

INTRODUCTION

Melon (citrulus Vulgaris or lanatus) is one of the most popular vegetable crops in Africa. It has tendril climbing herbaceous annual crop, which grows better in some part of the savannah belt region of Nigeria. The seed belongs to the cucumber family, which is used for extracting oil, and is popularly called ‘’egusi’’, a name widely used throughout West Africa. The crop had been in cultivation for at least 4000 years mainly for seed schippers. The crop does well on a sandy free chaining soil. It can also be planted as an intercrop with crops like maize, okro, cassava, yam because they are weed suppressors. When planted, it can be harvested between two and half to three months and with good management there can be a seed yield of 350 – 400kg per hectare. The main cultivars found in Nigeria are Bara, Serewe and Sofin. Bara also known as papa has large brown seeds with thick black edges thickened towards the apex, about 16 x 9.5mm and is common in the northern and western part of Nigeria. While Serewa seeds are smooth, light brown, with a light whitish edge that is not thickened about 15 x 9mm in dimension. They are mainly found in eastern Nigeria. Analysis made on melon by Ajilola et al (2011) indicates that melon seed consists about 50% oil by weight, 37.4% of protein, 2.6% fibre, 3.6% oil, 6.4% moisture. Out of the oil content of the seed 50% is made of unsaturated fatty acids which are Linolectic (35%) and oleic (15%) and 50% saturated fatty acids which are stearic and palmitic acid. The presence of unsaturated fatty acid makes melon nutritional desirable and suggests a possible hypocholestroleric effect (lowering of blood cholesterol). Research has shown that the consumption of melon seeds and its products reduces the chances of developing terra arterial or heat diseases. Melon has an amino acid profile that compares favourably with the soybeans and even white of egg. Also USDA Nutrient database has shown that melon is rich source of sodium (Na), Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn) and fat. The melon seed has a lot of advantages among which are the following: the oil extracted from it can be used in manufacture of margarine, shortening and cooking olis, while the residual cake is used for producing melon snacks known as ‘’robr’’. Despite the large productivity and nutritional benefit of this crop, there has been a hindrance to the use of melon for large scale production of oil and protein sources. This is as a result of the inability to process melon to meet the capacity required for industrial use over a specified period of time. The origin of the melon is Africa and Asia (Douglas, I982) and areas where it is widely cultivated include the Caribbean, Indonesia, and Africa. In Nigeria, the existence of melon dates back to the 17th century. Egusi belongs to a family of vegetables, or preferably pseudo-pulse crops known as Citrullus Lanatus. It is an important source of edible oil, vitamin E, protein, potassium, calcium magnesium, iron and sodium. Its soft cotyledon is encased in a hard outer shell. The cotyledon could have its edible oil extracted (44 to 50% oil content in seed), ground and used for sauces' (36 to 60% protein content in seed), roasted or boiled and eaten. Egusi is a luxury; it costs $6 per kg after the coat is removed. All over Nigeria, egusi is eaten by those who can afford it. The factor that makes it so expensive is the time spent by women and children to dehull or shell the seed. Though there are some experimental decorticators on trial, there are no efficient machines at Ilorin, Nigeria to releave the process of dehulling by hand..This work has attempted a different shelling technique to bring a better efficiency at dehulling egusi. Egusi comes under the family of vegetables known as Cucurbitaceae, which are found mainly in the warmer parts of the world. They consist of 118 genera with about 825 species.

Design Consideration

The mechanics of the melon shelling machine includes compression, shearing and impact. The developed machine utilizes the principle of impact force and this was chosen because it has been utilized in the design of the machines for coarse, medium and fine grinding materials. The following factors were considered in the design melon shelling machine.

(i) Materials of adequate strength and stability were considered in the research design. (i.e mild steel);

(ii) The machine was designed to have maximum capacity of 20kg of melon per batch so that machine could be affordable for small scale farmers.

(iii) The materials that are considered in carrying out the research design are locally with available best materials.

(iv) Consideration was given to the cost of items and materials for the ultimate aim of utilizing the cheapest available materials, yet satisfying all strength requirements.

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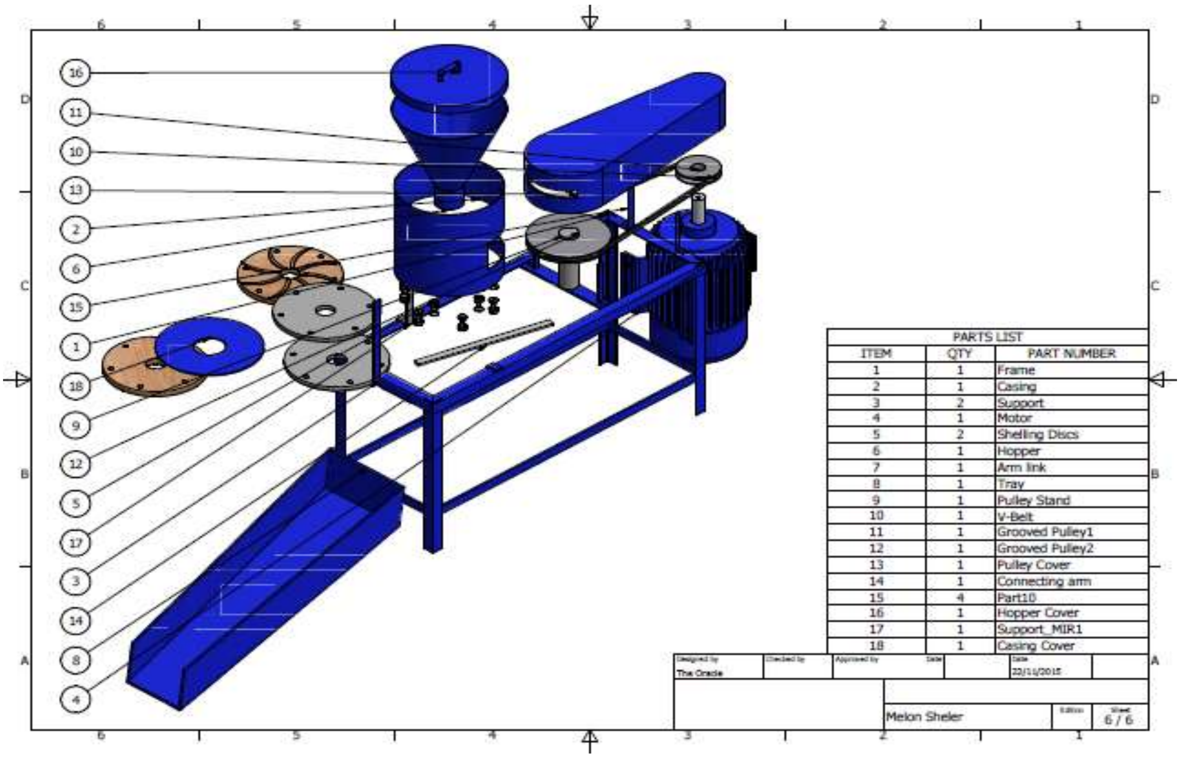
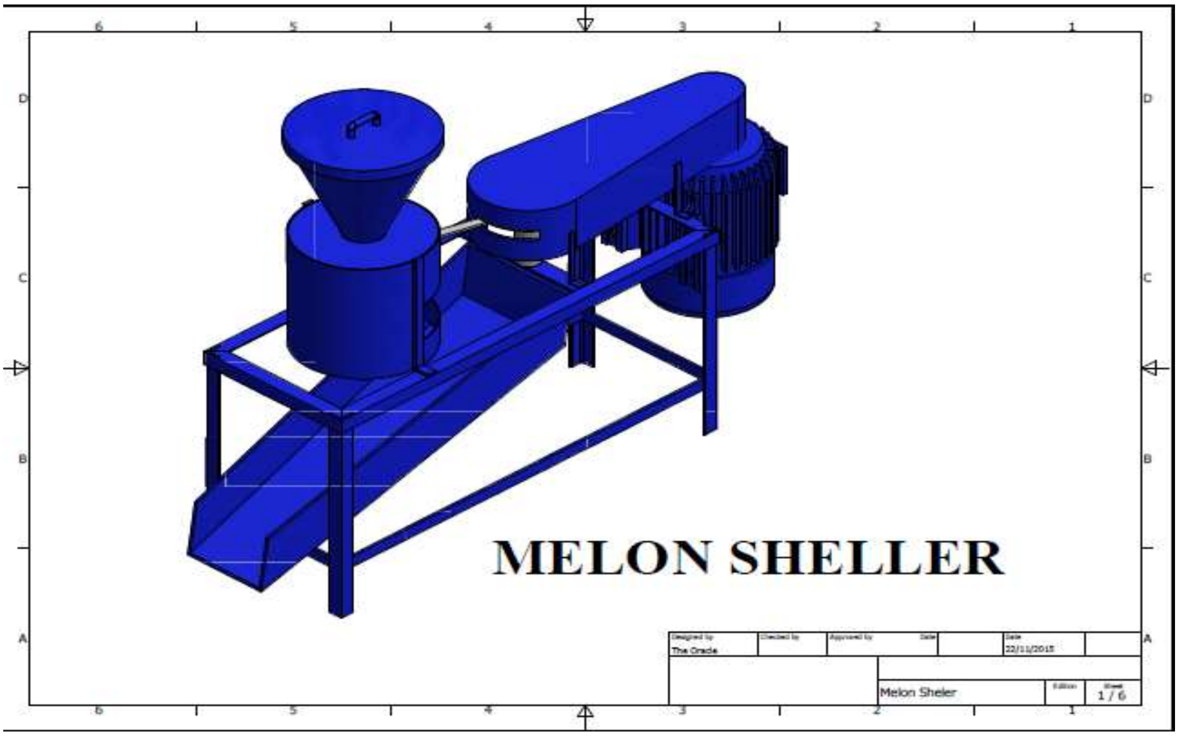
Pictorial view of various Units

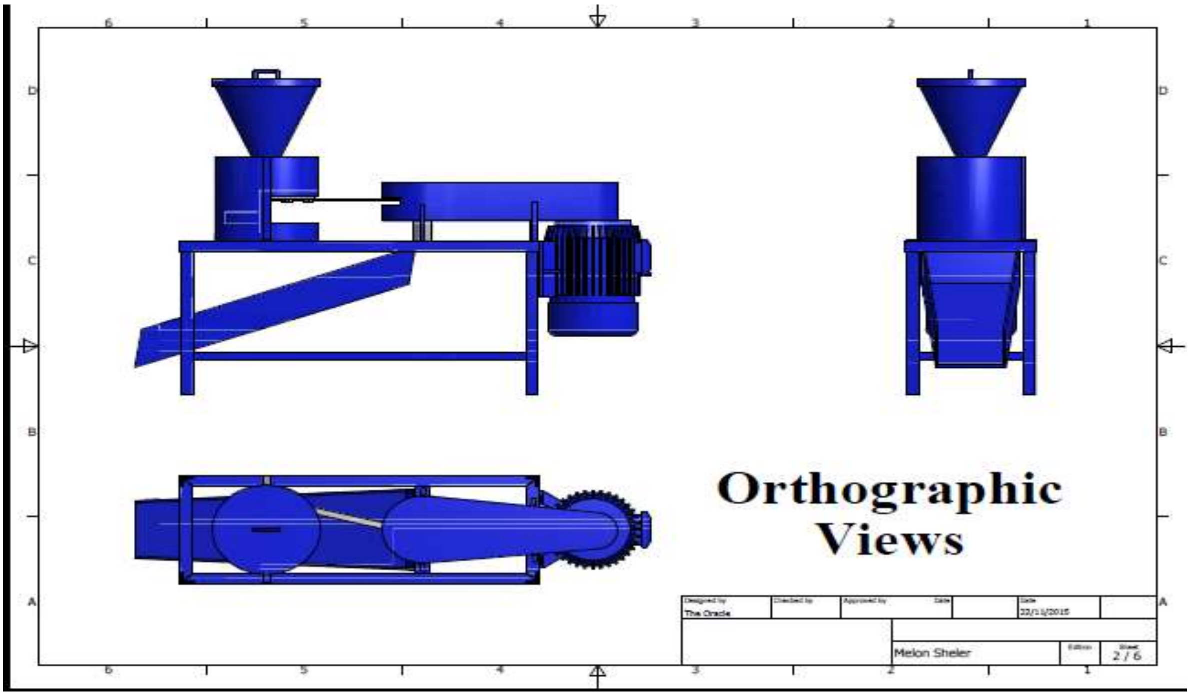
The Exploded view the melon shelling



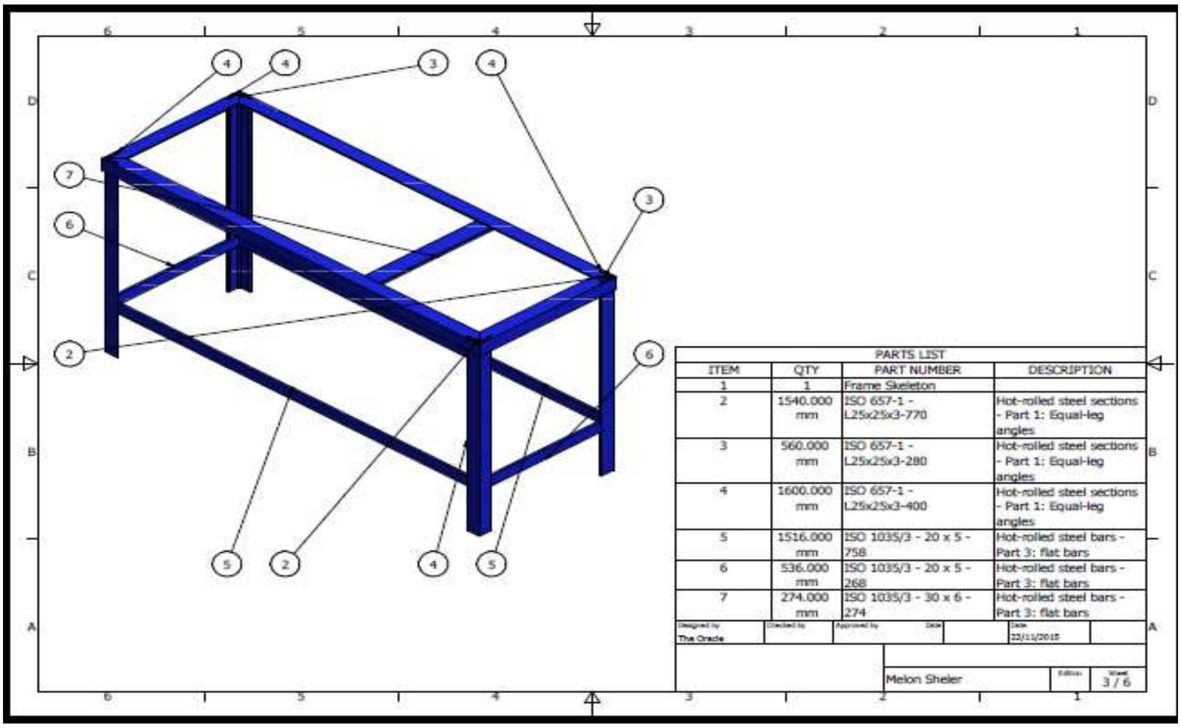
The coupled view of the Melon Shelling Machine



The Orthographic view of the Melon Shelling Machine



The Melon Shelling Machine Frame.



PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Frame Skeleton	
2	1540.000 mm	ISO 657-1 - L25x25x3-770	Hot-rolled steel sections - Part 1: Equal-leg angles
3	560.000 mm	ISO 657-1 - L25x25x3-280	Hot-rolled steel sections - Part 1: Equal-leg angles
4	1600.000 mm	ISO 657-1 - L25x25x3-400	Hot-rolled steel sections - Part 1: Equal-leg angles
5	1516.000 mm	ISO 1035/3 - 20 x 5 - 758	Hot-rolled steel bars - Part 3: flat bars
6	536.000 mm	ISO 1035/3 - 20 x 5 - 268	Hot-rolled steel bars - Part 3: flat bars
7	274.000 mm	ISO 1035/3 - 30 x 6 - 274	Hot-rolled steel bars - Part 3: flat bars

The Melon Shelling Discs

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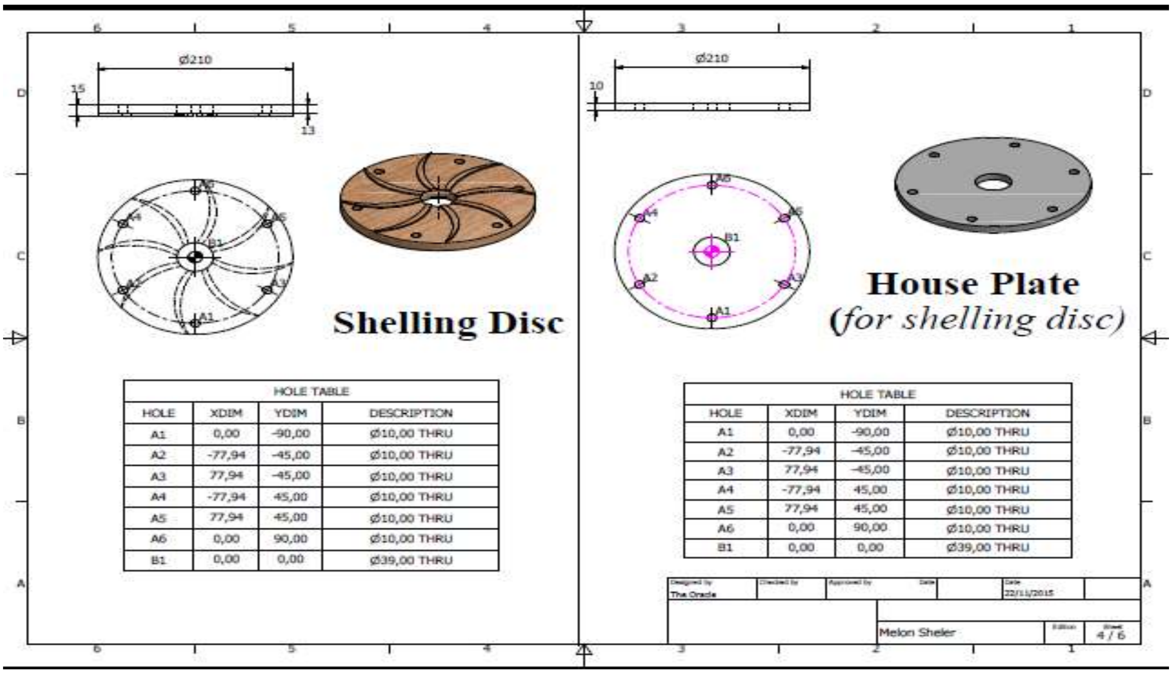


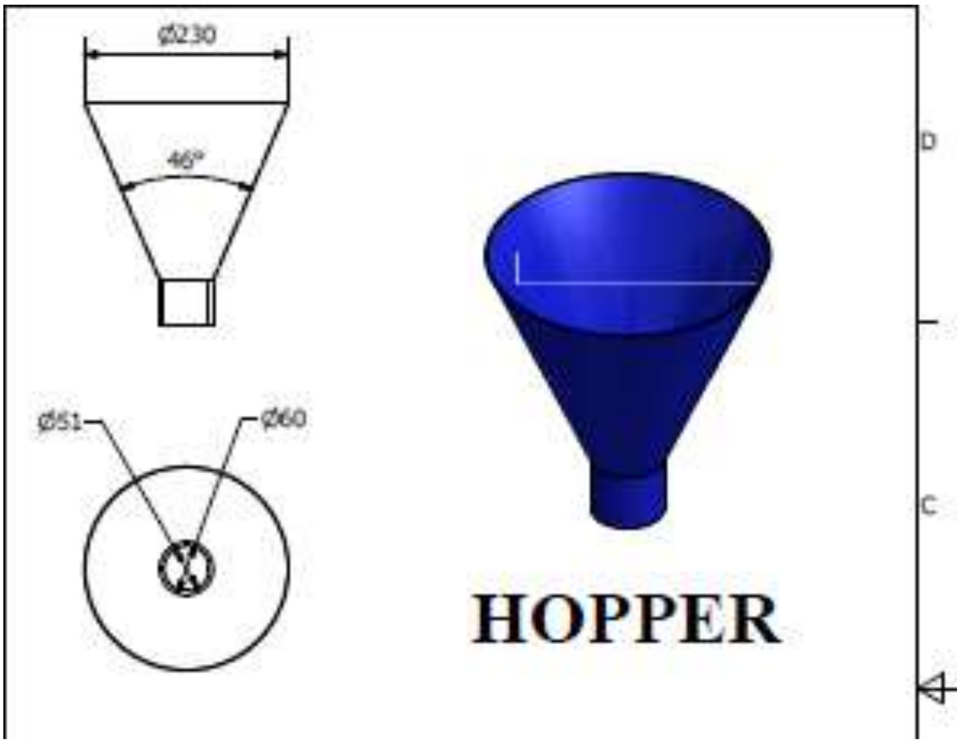
HOLE TABLE (Shelling Disc)

HOLE	XDIM	YDIM	DESCRIPTION
A1	0,00	-90,00	Ø10,00 THRU
A2	-77,94	-45,00	Ø10,00 THRU
A3	77,94	-45,00	Ø10,00 THRU
A4	-77,94	45,00	Ø10,00 THRU
A5	77,94	45,00	Ø10,00 THRU
A6	0,00	90,00	Ø10,00 THRU
B1	0,00	0,00	Ø39,00 THRU

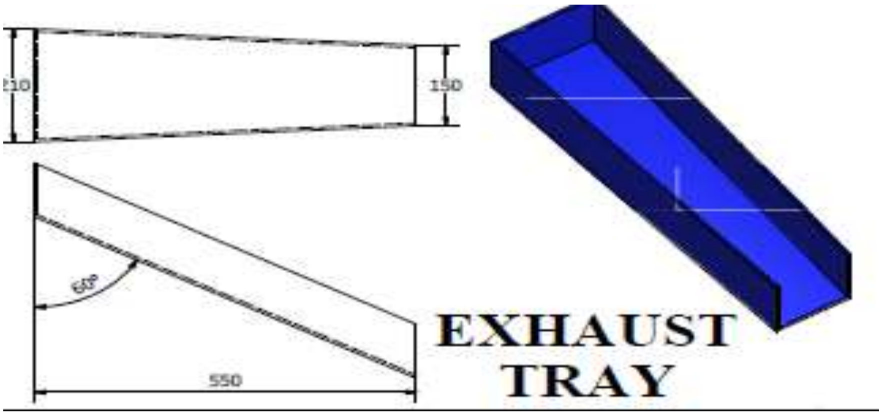
HOLE TABLE (House Plate)

HOLE	XDIM	YDIM	DESCRIPTION
A1	0,00	-90,00	Ø10,00 THRU
A2	-77,94	-45,00	Ø10,00 THRU
A3	77,94	-45,00	Ø10,00 THRU
A4	-77,94	45,00	Ø10,00 THRU
A5	77,94	45,00	Ø10,00 THRU
A6	0,00	90,00	Ø10,00 THRU
B1	0,00	0,00	Ø39,00 THRU

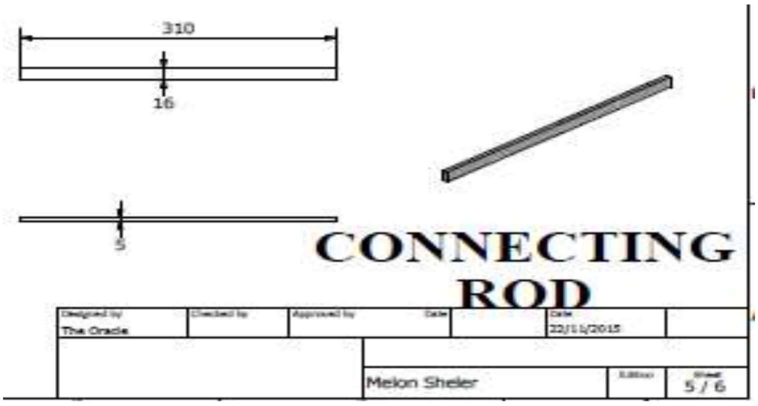
The Hopper



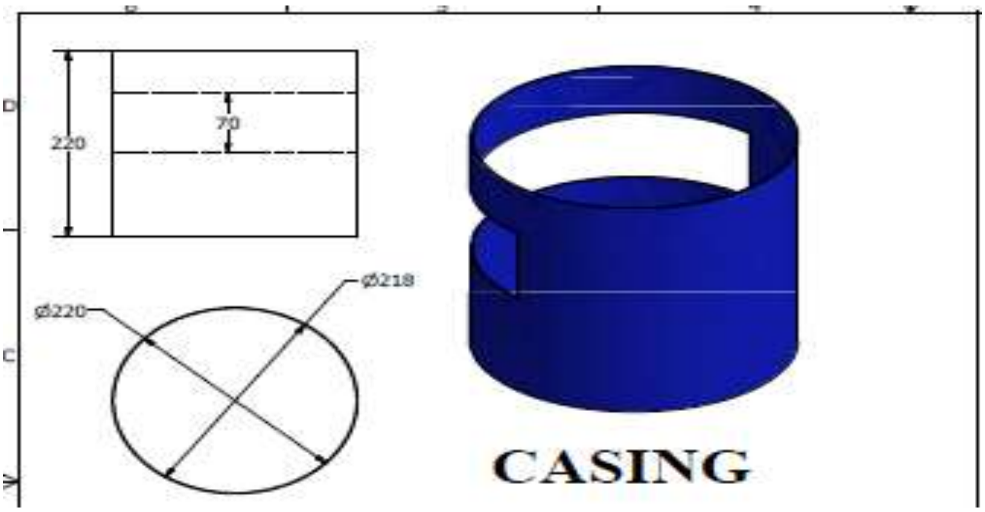
The Exhaust Tray



The connecting Rod



The Casing



Design Analysis of Machine Elements in Various Units

Design for the Pulley

$$\pi d_1 N_1 = \pi d_2 N_2$$

$$d_1 = 55mm$$

$$N_1 = 1440mm$$

$$d_1 = 300mm$$

$$d_2 = \frac{55 \times 1440}{300}$$

$$= 264mm$$

Design for the belt

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

$$C = \left(\frac{D_2 + D_1}{2}\right) + D_1$$

$$= \left(\frac{264 + 55}{2}\right) + 55$$

$$= \left(\frac{319}{2}\right) + 55$$

$$= 159. + 55$$

$$= 214.5$$

$$L = 214.5 + \frac{\pi}{2}(55 + 264) - \frac{264 + 55}{4 \times 214.5}$$

$$= 429 + 1.57(319) - \frac{319}{858}$$

$$= 429 + 500.8 - 0.372$$

$$= 429 + 500.45$$

$$= 929.46$$

$$= 93mm = 0.93mm$$

The angle of wrap of the belt

$$\text{Sin}\,\beta = \frac{R - r}{c}$$

$$= \frac{132 - 27.5}{214.5}$$

$$= \frac{104.5}{214.5} = 0.49$$

$$\sin\beta = 0.49$$

$$\beta = \sin^{-1} 0.49 = 29^0$$

$$\alpha_1 = 180 - 2\beta$$

$$= 180 - 2 \times 29$$

$$= 180 - 58$$

$$= 122^0$$

$$\alpha_2 = 180 + 2\beta$$

$$= 180 + 2 \times 29$$

$$= 180 + 58$$

$$= 238^0$$

Design for the Power

$p = T \times \omega$

There T = Torque

$\omega =$ Speed in radians

$T = \omega\ r$

$r =$ radius of disc

Therefore,

$p = \omega^2 r$

Design for the power of the Electric Motor

Converting from rev/mm to rad/sec a factor of $\frac{\pi}{30}$ is used

Therefore, $\omega = 1440 \times \frac{\pi}{30} = 150.7 rad/\sec$

$p = 150.7^2 \times 0.22$

$= 4996$

$= 5000\ \ W$

Design for the power of the Shelling motor Converting from rev/mm to rad/sec a factor of is used of $\frac{\pi}{30}$ is used

therefore, $\omega = 950 \times \frac{\pi}{30} = 99.5 rad/\sec$

$p = 99.5^2 \times 0.15$

$= 1485$

$= 1500\ \ W$

Design for the Bearings

$H_g\ =\ fw\frac{\pi DN}{60}\ watts$

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$$f = 0.326\left(\frac{\mu N}{p}\right)\frac{D}{C} + k$$

W = 48KN

D= 200mm

L= 200mm

$$\mu = 0.025$$

$$k = 0.002$$

$$\frac{C}{D} = 1000$$

$$p = \frac{W}{LD}$$

$$= \frac{48000}{0.2 \times 0.2}$$

$$= 1.2 \times 10^{6}\ N/m^{2}$$

From Makee's equation

$$f = 0.326\left(\frac{0.025 \times 1440}{1.2 \times 10^{10}}\right) \times 1000 + 0.002$$

$$= 0.326 \times 10^{-9} \times 1000 + 0.002$$

$$= 9.78 \times 10^{-7} + 0.002$$

$$= 0.002$$

$$Hg = \frac{0.002 \times 48000 \times \pi \times 0.2 \times 1440}{60}$$

$$= \frac{86901.23}{60}$$

$$= 1.45 \times 10^{3}\ \ W$$

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Performance Evaluation of the Shelling unit

Shelling capacity

$$= \frac{w}{t_1} kg / h$$

The cleaning capacity is the quantity of seeds cleaned per unit time

Shelling efficiency $E_s(\%) = \frac{100Xc}{Xa + Xc}$

Cleaning efficiency $Es(\%) = \frac{100Xd}{Xd + Xb}$

where;

X_a = weight of seeds received at the seed outlet

X_b = weight of chaff received at the seed Outlet

X_c = weight of grain received at chaff outlet

X_d = weight of seeds received at chaff outlet

Source: Nigerian Industrial Standard (1 997)

The fraction of melon seeds completely shelled

$$= \frac{N_1 + N_2}{N_0} X100\%$$

Fraction of seeds partially shelled

$$= \frac{N_0 + N_4}{N_0} X100\%$$

Fraction of seeds unshelled

$$= \frac{N_5}{N_0} X100\%$$

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Table 1

Parameters	*Unshelled seed*	*shelled± cotyledon*	*shelled seed*	*chaff*
7% m.c. Angle of repose (0) (deg)	*35.7*	*40.5*	*43.3*	*-*
Coefficient of friction (0) (deg)	*0.72*	*0.85*	*0.95*	*-*
10% m.c. Angle of repose (0) (deg)	*36*	*45.81*	*44*	*-*
Coefficient of friction (0) (deg)	*0.73*	*1 .03*	*0.97*	*-*
Weight of one seed(g)	*0.124*	*0.124*	*0.022*	*0.0221*
Length of seed(mm)	*12.4*	*-*	*11.0*	*-*
Width of seed(mm)	*7.6*	*-*	*6.5*	*-*
Thickness of seed (mm)	*2.5*	*-*	*1.8*	*-*

Table 2: The average performance data on the shelling part at two different moisture content of 7% and 10% at three different speed of 750, 950 and 1200 rpm.

Parameters						
rpm	*750*	*950*	*1200*	*750*	*950*	*1200*
Weight of unshelled seeds (g) Wus	*7.7*	*7.1*	*118.4*	*11.4*	*73*	*l20.9*
Time to complete shelling t_1 (s)	*4*	*2*	*3*	*11*	*3*	*3*
Time to complete shelling t_2 (s)	*5*	*3*	*5*	*11*	*4*	*4*
No. of seeds in sample (No)	*578.5*	*575*	*955*	*955*	*575*	*955*
No. of seeds shelled and unbroken (N_1)	*36.5*	*17*	*18*	*701*	*537*	*836*
No. of seeds shelled but broken (N_2)	*277*	*244*	*228*	*5*	*7*	*58*
No. of seeds partly shelled and unbroken (N_3)	*29*	*6*	*2*	*1 1 3*	*22*	*26*
No. of seeds partly shelled but broken (N_4)	*217*	*305*	*575*	*3*	*7*	*27*
No. of seeds unshelled (N_5)	*23*	*6*	*3*	*128*	*4*	*8*

Table 4.3: Performance indices of the shelling machine

Parameters	*7%*			*10%*		
Shelling Speed	*750*	*950*	*1200*	*750*	*950*	*1200*
Shelling Capacity (kg/h)	*65*	*128*	*148*	*53*	*88*	*145*
Fully shelled (%)	*54*	*45*	*45*	*74*	*95*	*99*

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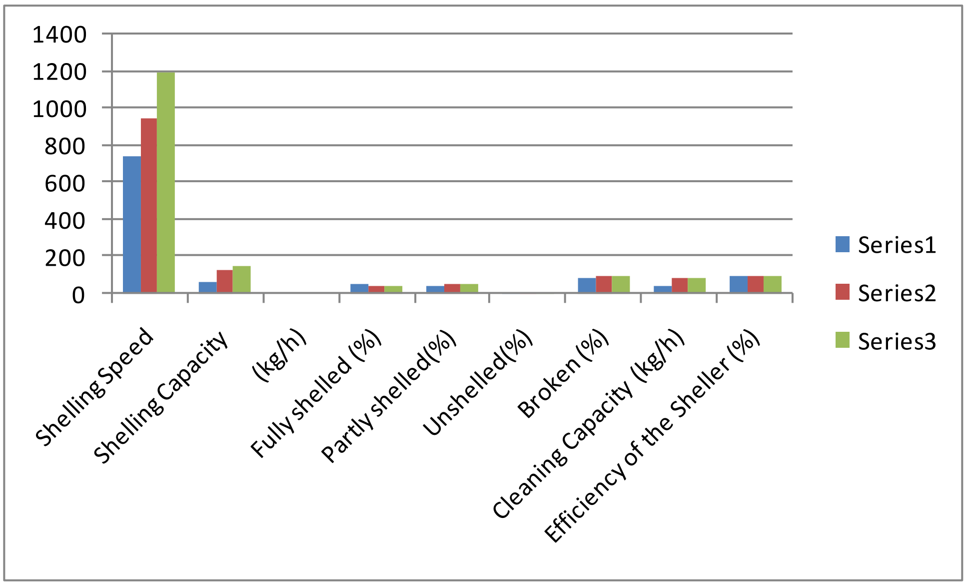
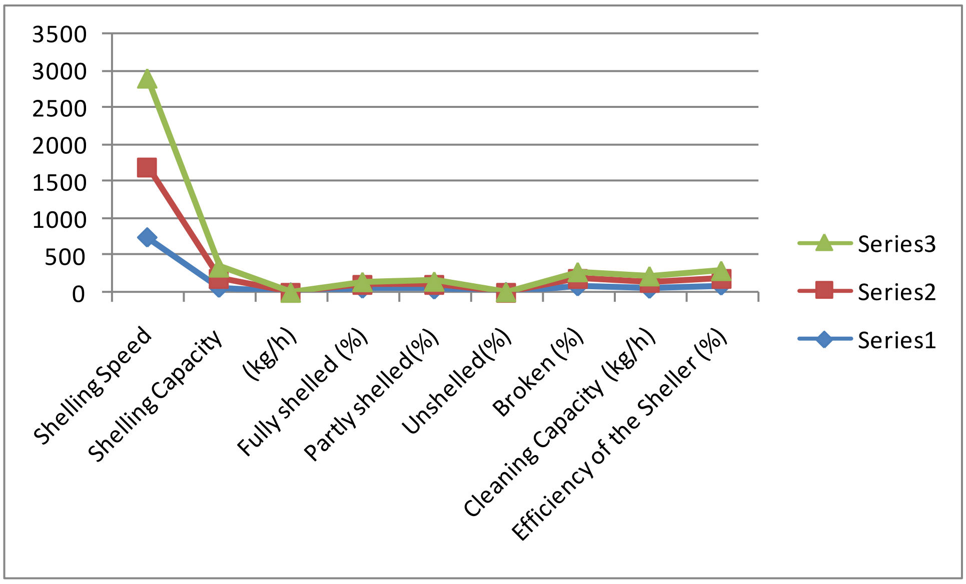
Partly shelled(%)	*42*	*54*	*54*	*12*	*5*	*6*
Unshelled(%)	*4*	*1*	*1*	*13*	*1*	*1*
Broken (%)	*85*	*95*	*98*	*1*	*2*	*9*
Cleaning Capacity (kg/h)	*52*	*85*	*85*	*39*	*66*	*109*
Efficiency of the Sheller (%)	*96*	*98*	*100*	*87*	*99*	*99*

RESULTS

Results from table Table 4.3 at 7% moisture content





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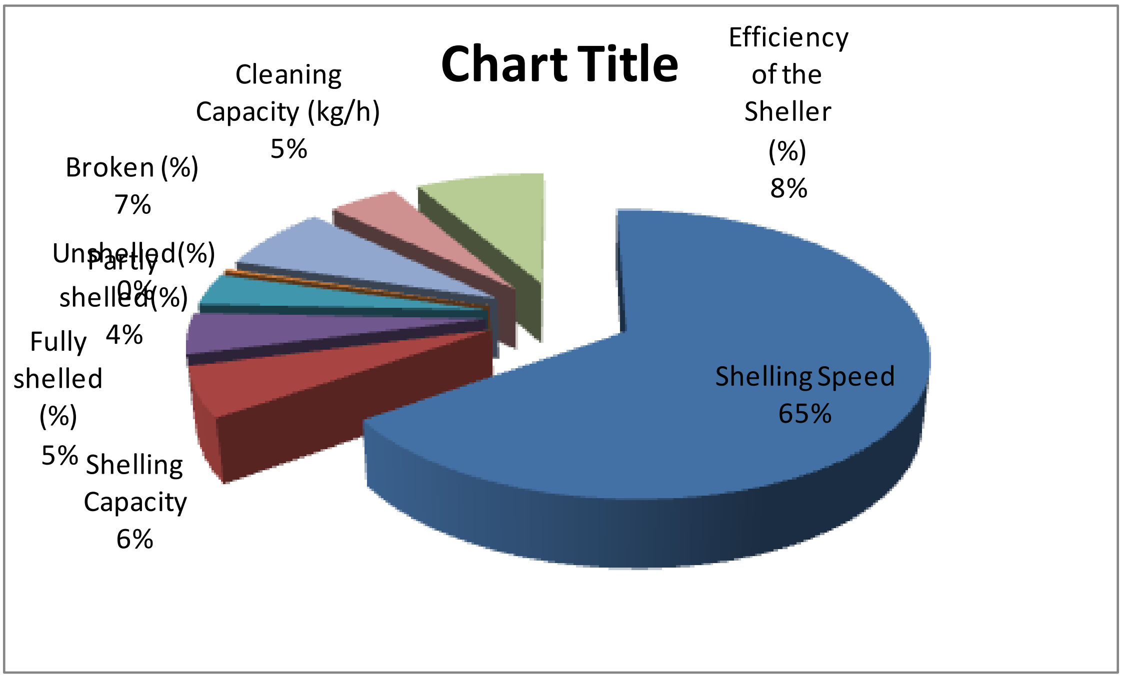

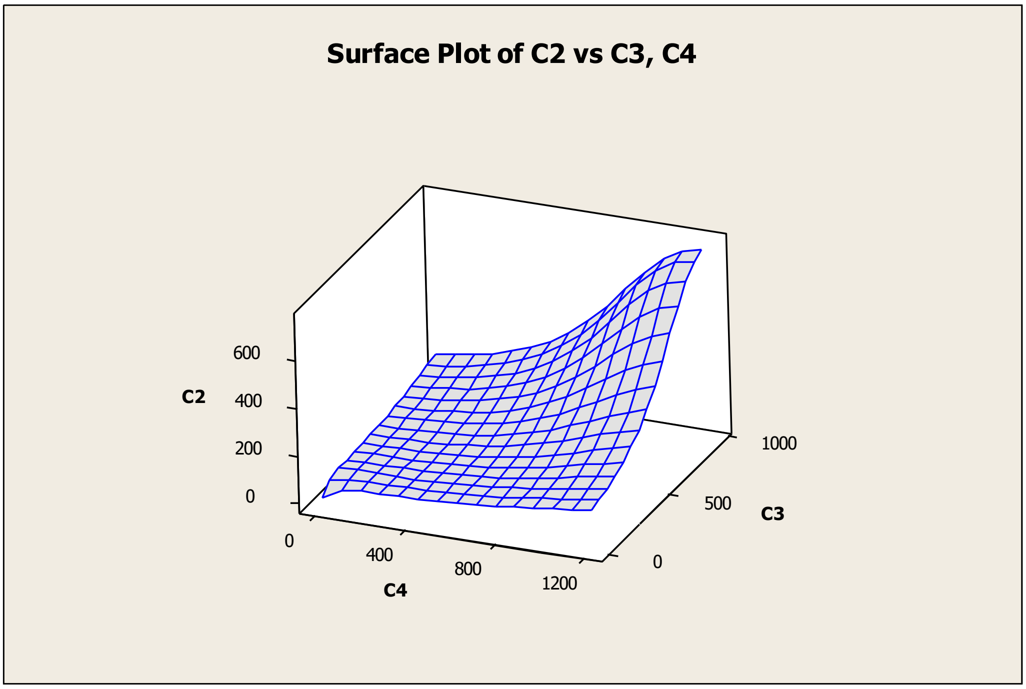

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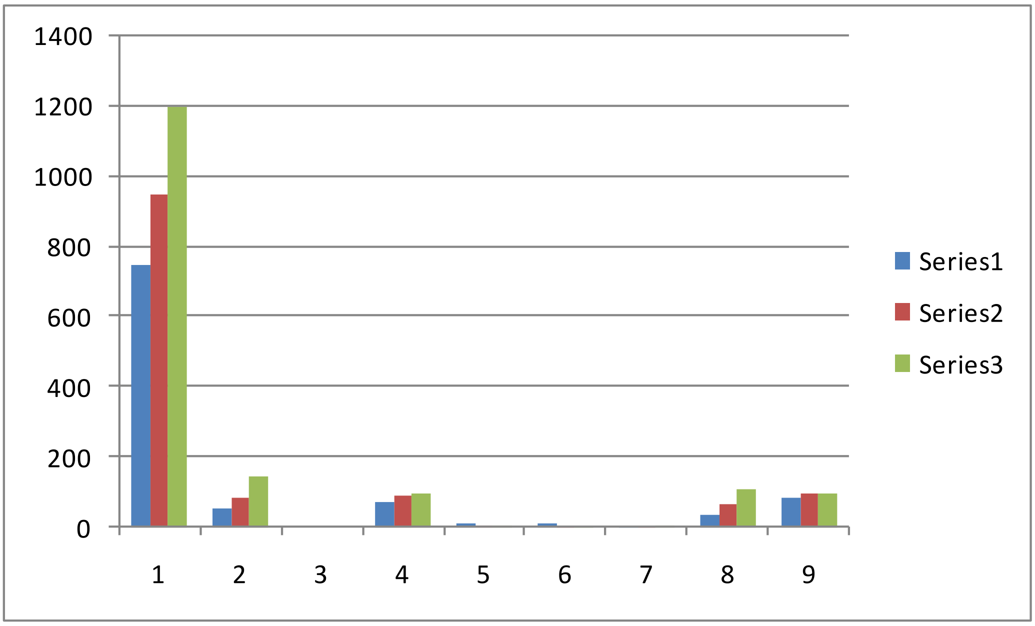
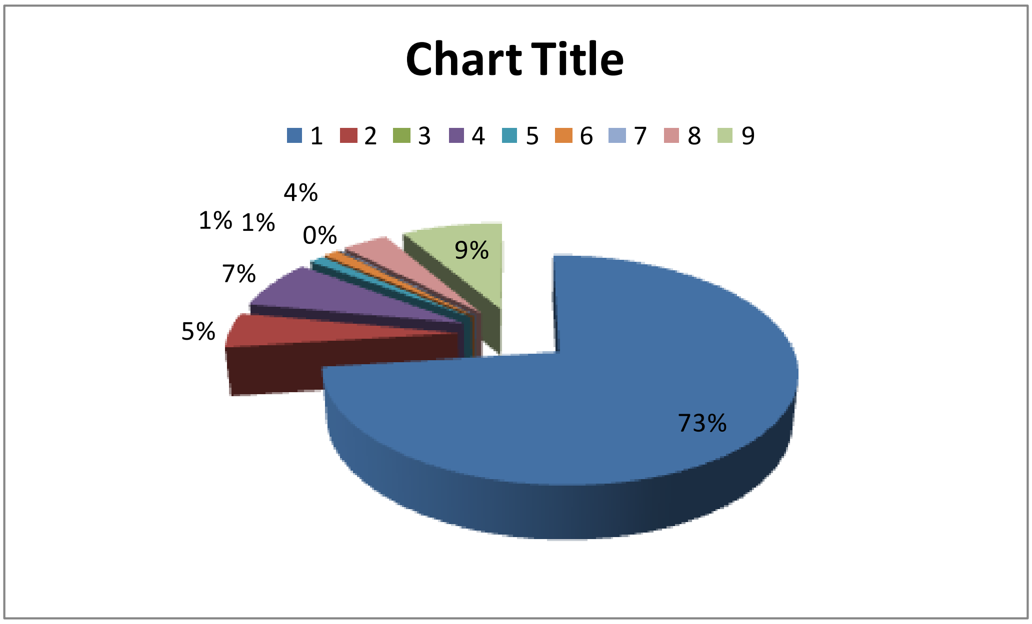
Results from table Table 2 at 10% moisture content





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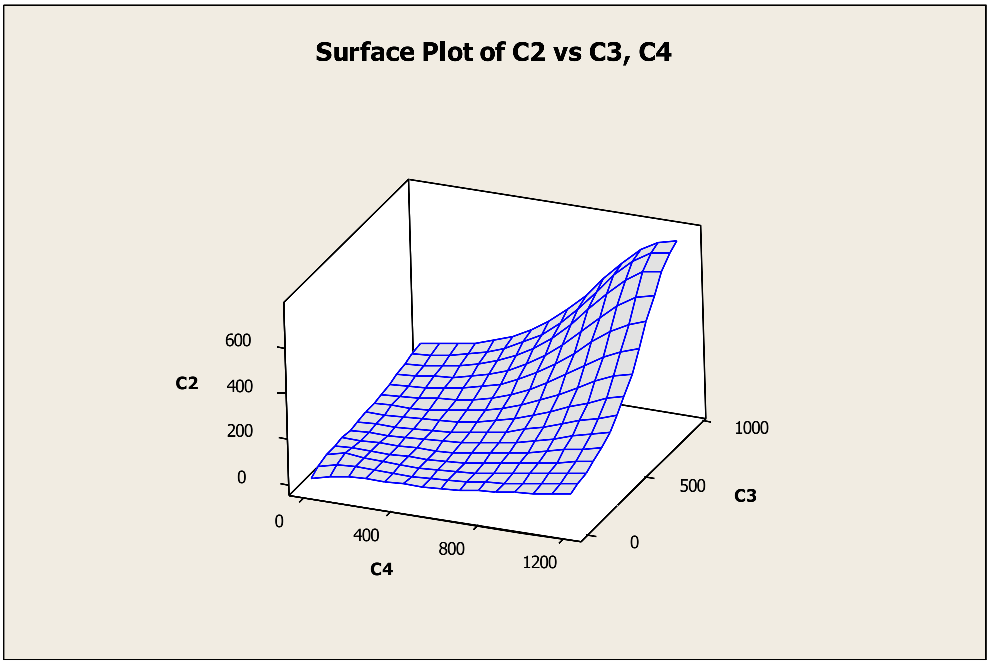
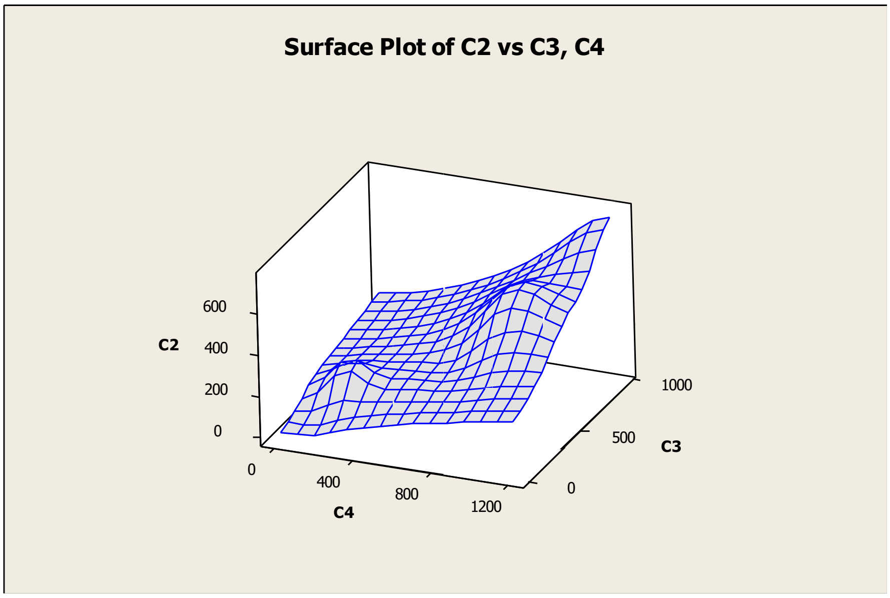


Results of Performance evaluation

At 7%



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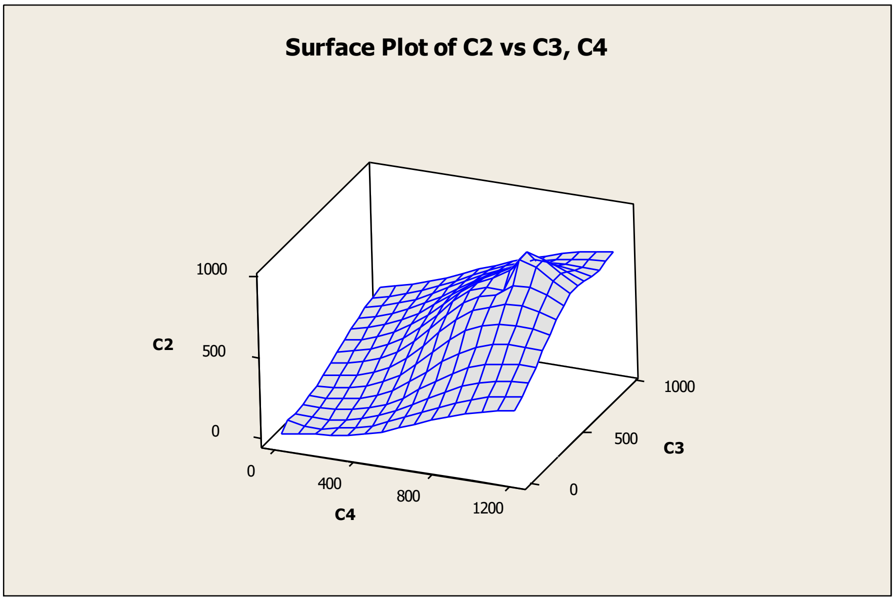
At 10%



DISCUSSION FROM RESULT ANALYSIS

The parameters studied were the percentage number of shelled and unshelled melon seeds, shelled but broken seeds and the partially shelled melon seeds at 7% and 10% wb and concave speeds of 750, 950 and 1200 rpm. At concave speeds of 750, 950 and 1200 rpm, and moisture content of 7% wb, the calculated shelling capacity of the sheller were 65, 128 and 148kg/h respectively.

CONCLUSION

A melon shelling machine has been designed and fabricated and evaluated for performance and the performance evaluation of the machine has shown that fruit moisture content, machine speed and power has significant effect on the machine overall performance indices. The machine has a compact design and a robust outlook. It will contribute to the enhancement of melon crop processing as it could be used to eliminate tediousness of the present traditional methods of processing melon pods seeds fruit. The operation of this machine makes it a unique type compare to others. The automatic operation of the machine has saved a lot of energy and did not require professional skills to operate it; therefore skill labour is not required. In general the machine has been fabricated with locally made materials and has been put test, and the machine has performed satisfactorily. If this machine is commercialized it will increase the output of finished melon seeds ready for consumption, also save wastage of this special food and create a lot of employment opportunities for a growing economy like Nigeria.

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

REFERENCES

[1] O. B. Otaru : Modification of a manually operated melon sheller, University of Ilorin, Project work, Department of Mechanical Engineering (2005), p2-3.

[2] R. R. Schippers: "African Indigenous Vegetables". An overview of the cultivated species p (2000) 55 - 63

[3] G. A. Makanjuola : A study of some of the physical properties of melon seeds. Journal of Agricultural Engineering Research (1977), Vol. 17(1) p.128-137

[4] E. U. Odigboh : Impact of egusi shelling machine, Transactions of the AsAE (1979), p. 1264-1269.

[5] M. T. 1ge : Improved technology of processing melon seed, Transaction of the ASAE (1982) vol.20 p. 1124 - 1126.

[6] Oja, P (1991), Construction of melon shelling machine, University of Ilorin, Deptartment ofAgricultural Engineering.

[7] M. O. Oyeleke : Modifying a melon shelling machine, University ofIlorin, Dept; of Mechanical Engineering (2006), p.9 - 19.

[8] B. F. Okokon, E. Ekpenyong and A. U. Ukpobo : Shelling Characteristics of melon seeds .. Journal of Food, Agriculture and Environment (2005) vol. 3 (1) p. 110-114

[9] Adekunle, A.S., Ohijeagbon, I.O., Olusegun, H.D. 2009. Development and Performance Evaluation of Manually and Motorized Operated Melon Shelling Machine using impact technique. Journal of Engineering Science and Technology Review, 2:12-17.

[10] Ajilola ,O.O, Eniyemo, S.E, Fasina, O.O, Adeeko., K.A. 1990. Mechanical extraction of oil from melon seeds. Journal of Agricultural Engineering Research, 45, 1.

[11] Aviara, N.A., Gwandzung, M.I, Hague M.A.N. 1999. Physical properties of Guna seeds. Journal of Agricultural Engineering Research,73: 105-111.

[12] Davies, R.M. 2010. Engineering properties of three varieties of melon seeds as potentials for development of melon processing machines. Advanced Journal of Food Science and Technology, 2: 63-66.

[13] Makanjoula G.A. 1972. Study on some of the physical properties of melon seed. Journal of Agricultural Engineering Research, 17:128 – 137.

[14] Manuwa, S.I. Afuye, G.G. 2004. Moisture dependent physical properties of soya bean (Var-TGx 1871-5E). Nigeria Journal of Industrial Studies, 3:45-54.

[15] Nwosu, R.C. 1988. Engineering Properties of Egusi fruit and the design of Egusi seed extraction equipment. B.Eng. Project Report, Department of Agricultural Engineering, University of Nigeria, Nsukka.

[16] 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, 2:35-39.

[17] Okokon, F.B., Ekpenyong, E., Nwaukwa, C., Akpan, N. Abam, F.I. 2010. Impact force of melon during shelling. Agricultural Engineering International: CIGR Journal, 12:182-188.

[18] Oloko S.A., Agun, B.J., Jimoh, A.A. 2002. Design and fabrication of melon washing machine. World Journal of Biotechnology, 3: 481 – 486.

[19] Oloko S.A. and Agbetoye. 2006. Development and performance evaluation of a melon depodding machine. Agricultural Engineering International: CIGR journal. Manuscript PM 06 018. Vol. VIII.

[20] Oluwole, O.O., Adedeji, A.S. 2012. Effect of moisture content and inner drum rotation speed on the shelling performance of a melon sheller. Journal of Science and Technology, 2: 21-26.

Print ISSN: ISSN 2055-6551(Print), Online ISSN: ISSN 2055-656X(Online)

[21] Oriaku, E.C, Agulanna, C.N., Chiwetalu, G. Ekwereike, G.C. 2013. Comparative performance analysis of melon (colocynthis citrullus l.) de-husking and separation machines by principle of impact and attrition. International Journal of Multidisciplinary Sciences and Engineering,