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Determination of Optimum Particulate Size for the Production of Some Agricultural Waste Briquettes

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ABSTRACT

This research was carried out on properties of briquettes produced from Groundnut shell and Dokanut shell with a view to finding out which of the two residues can be used more efficiently and rationally as fuel. The agricultural waste of the two residues were sundried, sieved into 0.60mm,1.40mm, 2.00mm, 2.40mm, 3.35mm and 6.35mm respectively, before using the machine fabricated to produced briquette with the addition of starch as the binding agent to produced different particle sizes of briquettes. Ultimate and proximate analyses were carried out to determine the average composition of their constituents. The results indicate that briquettes produced from these two agricultural wastes (Groundnut shell and Dokanut shell) would make good biomass fuels. However, it was discovered that Groundnut shell briquette has more positive attribute than Dokanut shell briquette. The optimization of all process parameters yielded optimum results for the responses (output), the higher the desirability value the better the optimization result and as a result between the two solution generated by the Design Expert software Version 6.0.6., Groundnut as the biomass type yielded a briquette with density of 0.8390kg/m^3, compaction pressure of 1.4669N/m^2, Moisture content of 31.39%, pore content of 49.29%, ash content of 21.28%, crushing strength of 1153.2 N/m^2, soot content of 10.49%,boiling rate of 6.9498 ^{0}C /min and calorific value of 28.953 kJ/kg.

Keywords: *Optimum Particulate, Groundnut Shell, Dokanut Shell, Flame characteristics, Briquettes.*

INTRODUCTION

The use of non -renewable energy for domestic and other applications in Nigeria continues to pose a formidable challenge, especially with the high

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cost of cooking gas, kerosene and the environmental problems associated with firewood. Alternative forms of energy need to be sourced. This has necessitated the need to improve on the use of agricultural wastes such as Groundnut shell and Dokanut Shell as alternatives.

Throughout its native range, the Dokanut tree providing these valued fruits and seeds is among the most appreciated natural resources (Harris, 1996). When forests are cleared Dokanuts are universally left untouched. The tree can grow as high as 40m, become laden with green-and-yellow fruits that look like small mangoes (Harris, 1996). Depending on the species, the fruits vary between sweet and bitter (Harris, 1996). Although the sweet version is mainly enjoyed fresh, it is also turned into jelly, jam or "African-mango juice" (Harris, 1996).

Groundnuts are popular source of food throughout the world including South Africa (Cilliers, 2017). In many countries Groundnuts are consumed as peanut butter or crushed and also used as oil (Cilliers, 2017). In other parts of the world they are boiled, either in the shell or unshelled (Cilliers, 2017). Groundnuts are produced in the tropical and subtropical regions of the world on sandy soils (Cilliers, 2017). Some agricultural residues and wastes are generated in the country, but they are poorly utilized and badly managed, since most of these wastes are left to decompose or they are burned in the field resulting in environmental pollution and degradation (Jekayinfa and Omisakin, 2005). However, scientific studies have concluded that a lot of potential energy abounds in these residues (Fapetu, 2000a).

In Nigeria, a large quantity of Agricultural waste is produced annually and these residues are left to rot away or they are burned like other agricultural wastes (Fapetu, 2000b). These residues could however be used to generate heat for domestic and industrial cottage applications (Fapetu, 2000b). To produce higher quality briquettes pre-heating is a very suitable option Sharif et al, (2008). According to Chesta (2011), the potential of briquetting sugarcane waste and production of this alternative to fuel-wood is to address the global concerns of deforestation and the related environmental degradation. There is an influence of the particle parameters on the properties of Biomass Briquettes when considering two finest stalk materials, the fine combination of stalk material significantly increases the density and strength of the briquettes which will maximize the bonding surface area between the particles (Dainis, Aivars and Imants (2012). The improved Biomass Briquetting machine that has a single

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extrusion heated die screw when compressed can be extruded through the die (Bhattacharya, Augustus and Mizanur (2010). A Briquetting machine that has a mould made of PVC pipe with 40cm(16 inches) long with7.5cm(3inches)diameter can allow water to escape when the briquette is pressed.(Jason and Charlie (2000).

MATERIALS AND METHOD

The Agricultural wastes that were selected were Dokanut shell and Groundnut shell., The Agricultural wastes were sundried, grinded and sieved into different particle sizes ranging from 0.6mm, 1.40mm, 2.00mm, 2.40mm ,3.35mm to 6.35mm respectively. A briquetting machine was fabricated as part of this research work to primarily perform its function of producing briquettes made from Dokanut shell and Groundnut shell., Some quantity of the specimen collected were kept in a bowl and finally mixed with an organic binder known as starch for proper bonding processes to take place., After this exercise was done, the mixed specimen were taken to the briquetting machine and later fed into the cylinder comprising of 20 slots. The hydraulic jack was used as a means of compressing the specimens with the top pressure plate along side, after which the top pressure plate was opened when the specimens were finally compacted and referred to as briquettes. The briquettes produced were all taken to the instrumentation laboratory to record their various masses with the use of a chemical balance.

Machine Design and Construction Processes

When selecting materials for a machine, first consideration is what materials are suitable for the product, the way the product will be made and method of construction: cost are all vital elements. The material selected for construction of this briquetting machine was mild steel which has a high strength, good ductility and moderate hardness. It has good machinability to be formed into shape and is readily available in the market. These are properties suitable for a press material. In the design approach it was ensured that the stress level is below yield point (456x106N/m^2) to ensure safety. The design was done based on the given design consideration.

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The manually operated briquetting machine was designed to the following specifications:

(i) Pressure to be applied should be within a range of 0.2MPa and 10MPa on the material,

(ii) Design procedure for compression helical spring

The basic briquetting machine has the power to magnify input forces to compact materials using only a factor of the force ordinarily needed. The goal in this design is to design an efficient briquetting machine capable of compacting within a pressure of 0.2MPa to 10MPa. The press is manually operated and has at least 20 struts and 20 compaction cylinders which can produce 20 pieces of briquettes at a time. The briquetting machine consists of the following parts:

- ♦ The frame support,
- ♦ Hydraulic jack,
- ♦ Return spring,
- ♦ Bottom pressure plate,
- ♦ Strut Compaction cylinder,
- ♦ Top pressure plate and
- ♦ Upper plate of compaction block.

The Main Frame and Mould

The main frame has a length, width and height of 750mm x 318mm x159mm all welded together to produce a rectangular shape.The upper part of the frame that form the mould is made from a 6mm thick mild steel plate formed into a box shape. The mould has the following functions:

(i) The chamber where the compression of the material occur,

(ii) It gives the press its essence,

(iii) It affords the briquettes its basic cylindrical shape.

The bottom plate is made of 6mm thick mild steel plate and has a length of 312mm, considering the plate as thin cylindrical shell, the tensile stress acting in a direction tangential to the circumference is given by

$$\sigma_c = \frac{Pd}{2t} \qquad (1)$$

Where

$\sigma_c =$ Circumferential stress in N/m^2

d = internal diameter of the shell,

t = thickness of the shell(plate)

p = intensity of the internal pressure.

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For mild steel material, the circumferential stress is numerically equal to 0.8 times the yield point stress of the material (Khurmi and Gupta, 1980). Taken the Yield strength of mild steel in tension as 250MPa,

$\sigma_c =$ 0.8 x 250 =200MPa

Substituting the values into equation 1 and also considering the Compacting pressure of 10MPa

t = 3.975mm

Where d is numerically equal to the height of the load = 159mm
Using a factor of safety of 1.5

t = 1.5 x 3.975 = 5.962mm $\cong 6mm$

Speed is given by

$$V = \frac{d}{t} \qquad (2)$$

$$V = \frac{0.159}{120} = 0.001325 m/s$$

The cover plate covers the mould and it acts as a piston which compresses the material.

Design procedure for compression helical spring

Spring material = Carbon steel

The permissible stress for carbon steel for average service obtained from standard tables = 385MPa and the corresponding modulus of rigidity, G = 80 GN/m^2 (Sharma and Aggarwal, 1999).
For stability, size and efficient use of the material, a spring index of 6 is selected.

But spring index, $\mathbf{S} = \frac{D}{d}$ ________(3)

Where D = mean coil diameter
d= wire diameter

To accommodate the effect of curvature and direct shear, the Wahl's correction factor, C is obtained as:

$$C = \frac{4s-1}{4s-4} + \frac{0.615}{s} \_\_\_\_\_\_\_\_ (4)$$

$$C = \frac{4 x 6-1}{4x6-4} + \frac{0.615}{6} = 1.2525$$

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For a start, a mean coil diameter of D = 37.5mm is assumed.
The wire diameter, d is therefore obtained from the relation.

$$\sigma = \frac{8WD}{\pi d^3} C \qquad (5)$$

Where σ = permissible shear stress

W = maximum load for the spring material
W = crushing strength x total area of briquette

The crushing strength of 0.11368m diameter of Dokanut briquette was obtained experimentally as 4340.63N/m².

W = 4340.63 x 0.11368 = 493.44N

Substituting the values into equation (5).

d = 0.00535mm = 5.35mm

From standard table, a standard wire size of d = 5.893 with SWG/4 is selected. Thus, the actual value of S is given by

$$S = \frac{D}{d} = \frac{37.5}{5.893} = 6.36$$

The actual mean coil diameter,

D = Sxd = 6.36 x 5,893 = 37.48mm

External or outside diameter, D_o = D+d = 37.48+5.893

D_o = 43.373mm

Inside diameter, D_1 = D – d = 37.48-5.893 = 31.587mm.

The number of turns is obtained from the equation,

$$\delta = \frac{8WD^3 n}{Gd4} \qquad (6)$$

Where δ = deflection of spring.

Since this is a compression spring, the deflection will be small. Assuming a deflection of 12.5mm, the number of turns,

$$n = \frac{\delta \, x \, Gd^4}{8WD^3}$$

$$n = \frac{0.0125 \, x \, 80 \, x \, 10^9 \, x \, (0.005893)^4}{8 \, x \, 493.44 \, x \, (0.03748)^3}$$

$$n = \frac{1.205996}{0.20951} = 5.76 = 6$$

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Using a factor of safety of 2.5 for fatigue loading.

n = 6x2.5 = 15 (nxN)

Since this is a compression spring, a total of 1.82 in inactive turns is allowed so that the effective number of turns.

$n^1 = n + 1.82$

$n^1 = 15 + 1.82 = 16.82 = 17$ turns

the spring rate, K is given by

$K = \frac{W}{\delta} = \frac{493.44}{12.5} = 39.48$N/mm

The solid length, Ls = n^1d = 17 x 5.893 = 100.181mm

The free length, Lf = n^1d + max + 0.15max

Lf = 100.181+ 12.5 + 0.15 x 12.5 = 114.556mm

Use Lf = 120mm for safe clearance

The pitch of the spring.

$P = \frac{free\ Length}{n^1-1} = \frac{120}{17-1} = \frac{120}{16} = 7.5mm$

Provision for burkling effect

USING $W_{cr} = K \times K_B \times Lf$

Where W_{cr} = critical axial load.

K = spring rate

K_B = bulking factor depending upon the ratio Lf/D

For $\frac{L_f}{D} = \frac{120}{37.48} = 3.20$

K_B = 0.71 for built – in end spring (obtained from standard tables).

Wcr = 39.48 x 0.71 x 120 = 3363.696N.

Since W < Wcr, the spring is safe.

Therefore, the design parameters are:

Wire diameter, d = 5.893mm

Mean coil diameter, D = 37.48mm

Number of turns = 17

Free length, Lf = 120mm

Solid length Ls = 100.181mm

Pitch, P = 7.5mm

With the designed parameters, the spring was carefully selected.

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Table 1: Data of Groundnut shell briquette and Dokanut shell briquette

Diameter (MM)	Density of groundnut shell briquette (KG/M³)	Density of dokanut shell briquette (KG/M³)
0.6	1.3202	1.3910
1.4	0.0222	0.2230
2	0.0854	0.1061
2.4	0.0523	0.0722
3.35	0.0231	0.0354
6.35	0.0063	0.0088

Diameter (MM)	Compaction pressure ofgroundnut shellbriquette (N/M²)	Compaction pressure of dokanut shell briquette (N/M²)
0.6	1.9330	2.0366
1.4	0.7532	0.7569
2	0.4120	0.5118
2.4	0.3018	0.4166
3.35	0.1844	0.2826
6.35	0.0934	0.1300

Diameter (MM)	Moisture content of groundnut shellbriquette (%)	moisture content of dokanut shell briquette (%)
0.6	34.375	25
1.4	33.69	25.92
2	24.84	26
2.4	23.24	37.25
3.35	17.2	39.305
6.35	16.67	41.02

Diameter (MM)	Pore content of groundnut shell briquette (%)	Pore content of dokanut shell briquette (%)
0.6	54.97	71.25
1.4	49.47	69.01
2	37.93	66.41
2.4	36.2	59.16
3.35	35.67	45.34
6.35	34.24	19.62

Diameter(MM)	Ash content of groundnut shell briquette (%)	Ash content of dokanut shell briquette (%)
0.6	18.22	16.73
1.4	28.24	25.3
2	29.33	26.64
2.4	33.33	29.82
3.35	41.38	37.17
6.35	51	45.95

Diameter (MM)	Crushing strength of groundnut shell briquette (N/M2)	Crushing strength of dokanut shell briquette (N/M2)
0.6	1164.981	4340.6300
1.4	293.925	1359.4000
2	97.2503	921.3190
2.4	42.514	552.6761
3.35	15.112	362.6768
6.35	2.724	147.8760

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Diameter (mm)	Soot content of groundnut shell briquette (%)	Soot content of dokanut shell briquette (%)
0.6	11.20	6.60
1.4	10.60	6.80
2	10.00	6.90
2.4	6.30	10.40
3.35	5.40	10.50
6.35	5.80	13.00

Diameter(mm)	Boiling rate ofgroundnut shell briquette (°C/min)	Boiling rate ofdokanut shell briquette (°C/min)
0.6	7.25	10.90
1.4	5.60	8.70
2	4.61	6.72
2.4	3.70	4.81
3.35	3.29	3.87
6.35	2.60	2.81

Diameter(mm)	Calorific value of groundnut shell briquette (mj/kg)	Calorific value of dokanut shell briquette (mj/kg)
0.6	30.380	34.023
1.4	28.308	32.813
2	18.354	30.228
2.4	16.360	21.200
3.35	14.008	15.292
6.35	13.056	14.963

Source: Researchers

Experimental design by design expert software version 6.0.6.

Std	Run	Block	Factor 1 A: Diameter mm	Factor 2 B: Biomass Type
2	1	Block 1	0.60	GroundNut
5	2	Block 1	1.40	Ground Nut
10	3	Block 1	2.00	Ground Nut
11	4	Block 1	2.40	Ground Nut
4	5	Block 1	3.35	Ground Nut
3	6	Block 1	6.35	Ground Nut
6	7	Block 1	0.60	Doka Nut
1	8	Block 1	1.40	Doka Nut
12	9	Block 1	2.00	Doka Nut
9	10	Block 1	2.40	Doka Nut
7	11	Block 1	3.35	Doka Nut
8	12	Block 1	6.35	Doka Nut

A Response Surface Methodology (RSM) of the Design expert software version 6.0.6 was used which resulted in 12 runs, the input factors were the diameter of the shell briquette and biomass type.The diameter of the shell briquette was varied at 6 levels while the biomass type was varied at 2 levels. The responses were inputed for each run accordingly and analyzed

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using analysis of varriance (ANOVA) and regression analysis interface of the software. Quadratic Model was used all through for all the responses (Y), and it is a second order polynomial regression in the order of:

$$Y = \hat{a}_0 + \hat{a}_1 X_1 + \hat{a}_2 X_2 + \hat{a}_{12} X_1 X_2 + \hat{a}_{11} X_1^2 + \hat{a}_{22} X_2^2 + \epsilon$$

The functional relationship existing between the input and output variables were used to develop model equations. Experimental data were inputted into the design interface of the Design expert software and hence model generated equations for the responses. The following equations were generated using quadratic model of the software and were all in terms of coded factors as written.

Density (kg/m^3)

$$= -0.26 - 0.51 * A + 0.019 * B + 0.82 * A^2 - 0.029 * A * B \quad (R^2 = 0.7561) \quad (1)$$

Pressure (N/m^2)

$$= -0.065 - 0.80 * A + 0.036 * B + 1.02 * A^2 - 8.562 * 10^{-3} * A * B \quad (R^2 = 0.9027) \quad (2)$$

Moisture Content (%)

$$= +28.04 - 0.32 * A + 6.20 * B + 1.19 * A^2 + 9.06 * A * B \quad (R^2 = 0.7700) \quad (3)$$

Pore Content (%)

$$= +40.59 - 18.93 * A + 4.30 * B + 5.06 * A^2 - 9.30 * A * B \quad (R^2 = 0.9401) \quad (4)$$

Ash Content (%)

$$= +38.97 + 15.36 * A - 1.88 * B - 5.77 * A^2 - 0.82 * A * B \quad (R^2 = 0.9863) \quad (5)$$

Crushing Strength (N/m^2)

$$= -281.43 - 1111.82 * A + 352.04 * B + 1538.78 * A^2 - 557.94 * A * B \quad (R^2 = 0.8298) \quad (6)$$

Soot Content (%)

$$= +8.17 + 0.17 * A + 1.28 * B + 1.03 * A^2 + 3.18 * A * B \quad (R^2 = 0.7505) \quad (7)$$

Boiling Rate ($^{o}C/min$)

$$= +3.19 - 3.20 * A + 0.66 * B + 2.74 * A^2 - 0.86 * A * B \quad (R^2 = 0.9721) \quad (8)$$

Calorific Value (kJ/kg)

$$= +15.36 - 10.29 * A + 2.05 * B + 8.66 * A2 - 1.06 * A * B \quad (R^2 = 0.8991) \quad (9)$$

Where, A= Diameter (mm); B= Biomass type

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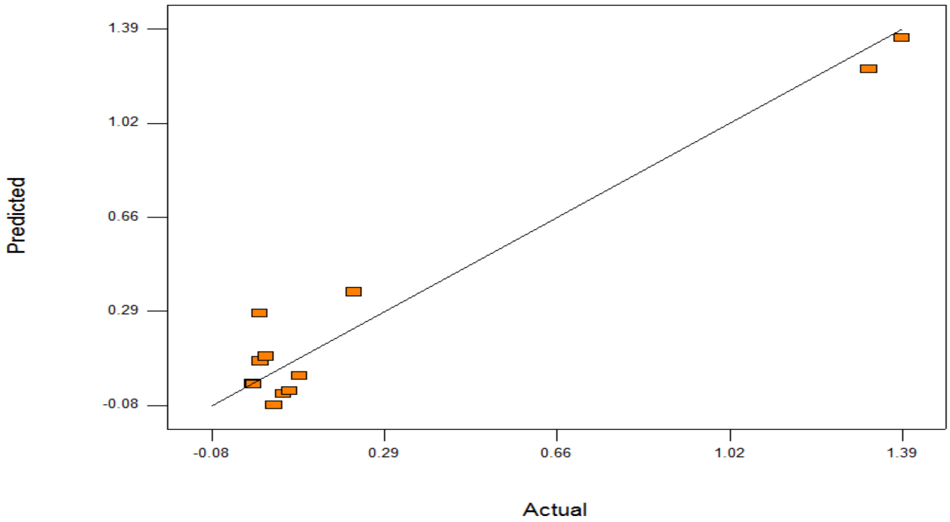
Model Adequacy Checking

After developing model equations, checking its adequacy is necessary for how properly fitted is the predicted data to the experimental data, to know the errors.

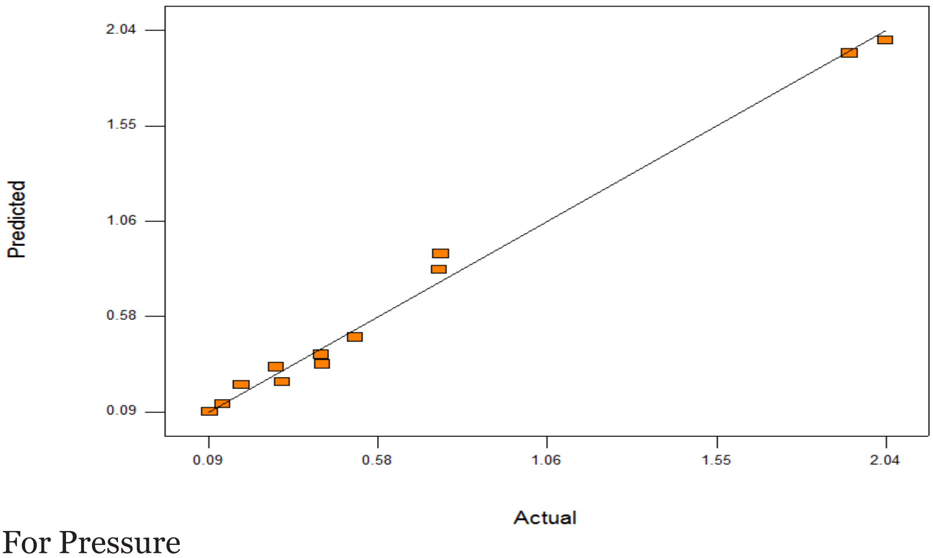
The statistical tools used were R^2, R^2_{Adj}, $R^2_{Pred.}$, PRESS, Model P-value, Adequate precision, and Coefficient of variation (%).

Model Validation using Graphical Approach

Figures: Plot of Predicted values versus Actual (Experimental) values



For Density



For Pressure

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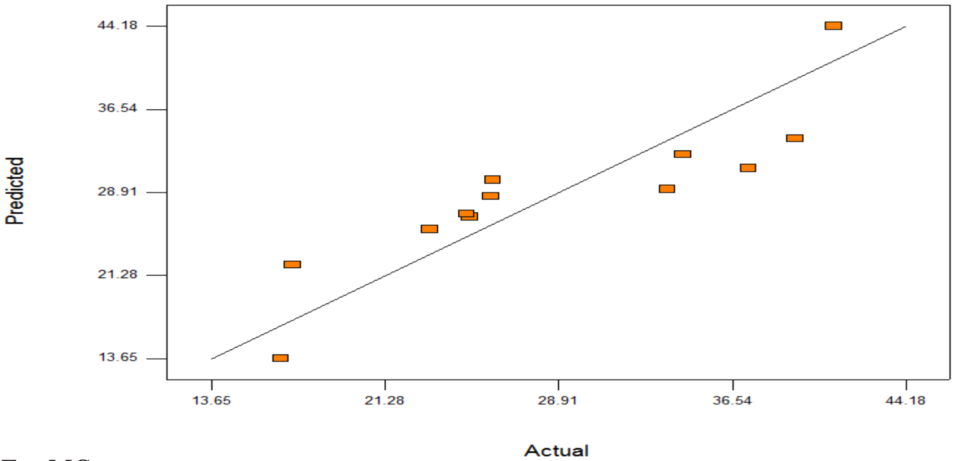
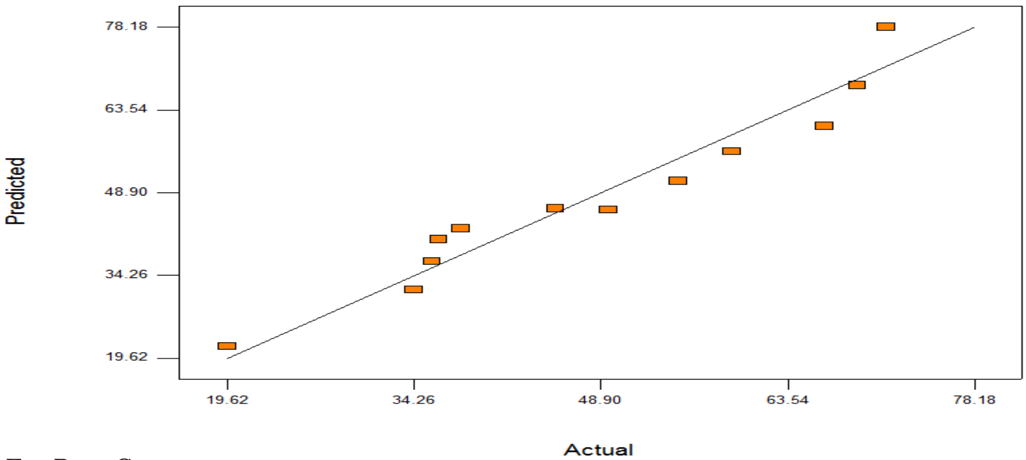
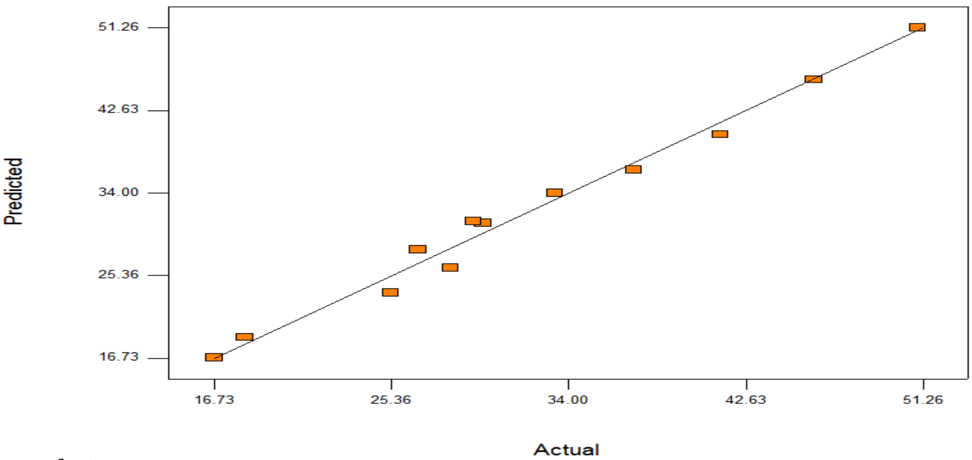


For MC



For Pore Content



For Ash Content

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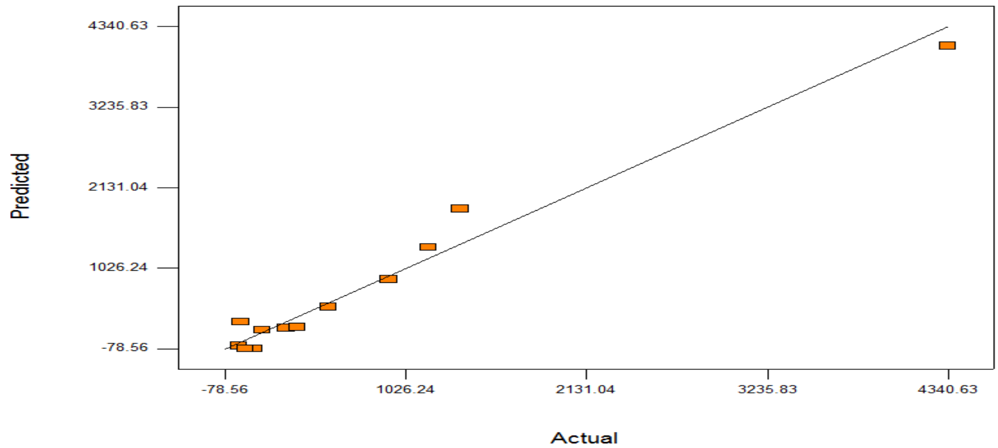
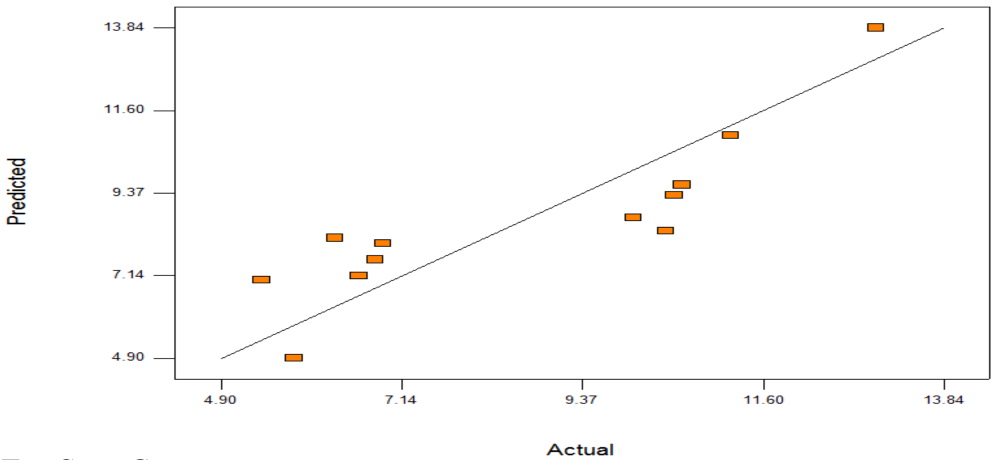
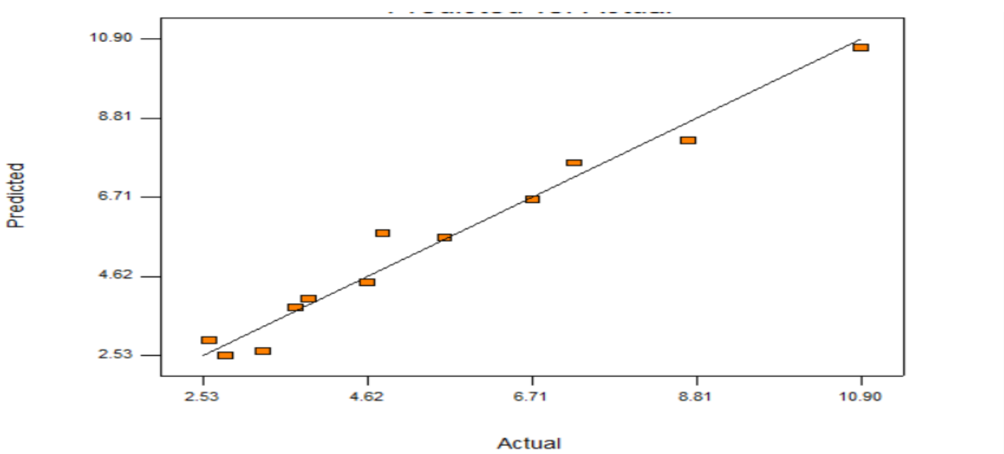


For Crushing Strength



For Soot Content



For Boiling Rate

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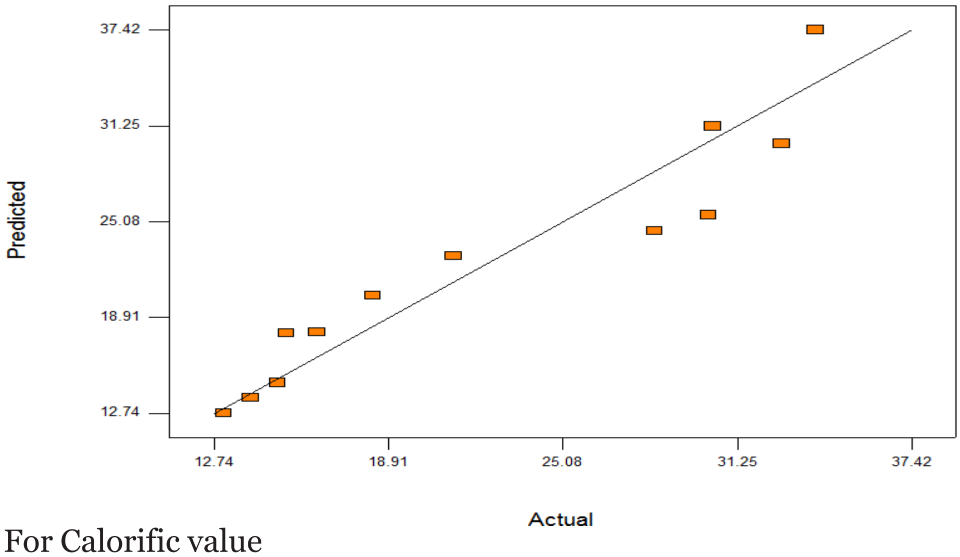

For Calorific value

Validation of developed models is important to ensure that the models satisfactorily describe the behaviour of the system being modelled. Validation of models can be done using graphical or numerical approach. Graphical method was used in this work to validate the developed models. It is advantageous over others due to illustration of a broad range of relationship existing between model and data used. In the figures the parity plot of predicted versus actual shows that all the figure displayed for the responses the points were randomly scattered along 45 degrees line (straight line). Also, the normal probability plot of studentized residual shows that residual behaves as expected and show that errors are evenly distributed as the points fell on straight lines.

CONCLUSION AND RECOMMENDATIONS

The graph shows the relationship between the actual value obtained from the experiment and the predicted value obtained from the developed model considering the line fitness, it shows that there is a close relationship between the predicted value and the actual value and thus shows that the model is valid for the experiment at 95% confidence level. The particle size variation and proper blending of the materials will also assist in making cooking to be very fast

The optimization of all process parameters yielded optimum results for the responses (output), the higher the desirability value the better the

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optimization result and as a result between the two solution generated by the software the one with a higher desirability function of 0.4115 was selected as the best optimization result. This can be interpreted thus, that in order to get optimum result of all the responses for briquette it is best to select a diameter of 0.94 mm and use Ground nut as the biomass type and these will yield a briquette with density of 0.8390 kg/m^3, compaction pressure of 1.4669 N/m^2, Moisture content of 31.39%, pore content of 49.29%, ash content of 21.28%, crushing strength of 1153.2 N/m^2, soot content of 10.49%, boiling rate of 6.9498°C/min and calorific value of 28.953 kJ/kg.

1. Biomass technology should be encouraged.
2. Government should not focus on Non renewable energy alone
3. Designing of machines that can produce briquettes under high pressure without the use of binder should be encouraged.
4. Finer particle sizes should be sieved to produce a better briquette.
5. Equipment needed for various analysis should be made available at all times by the Government for easy access

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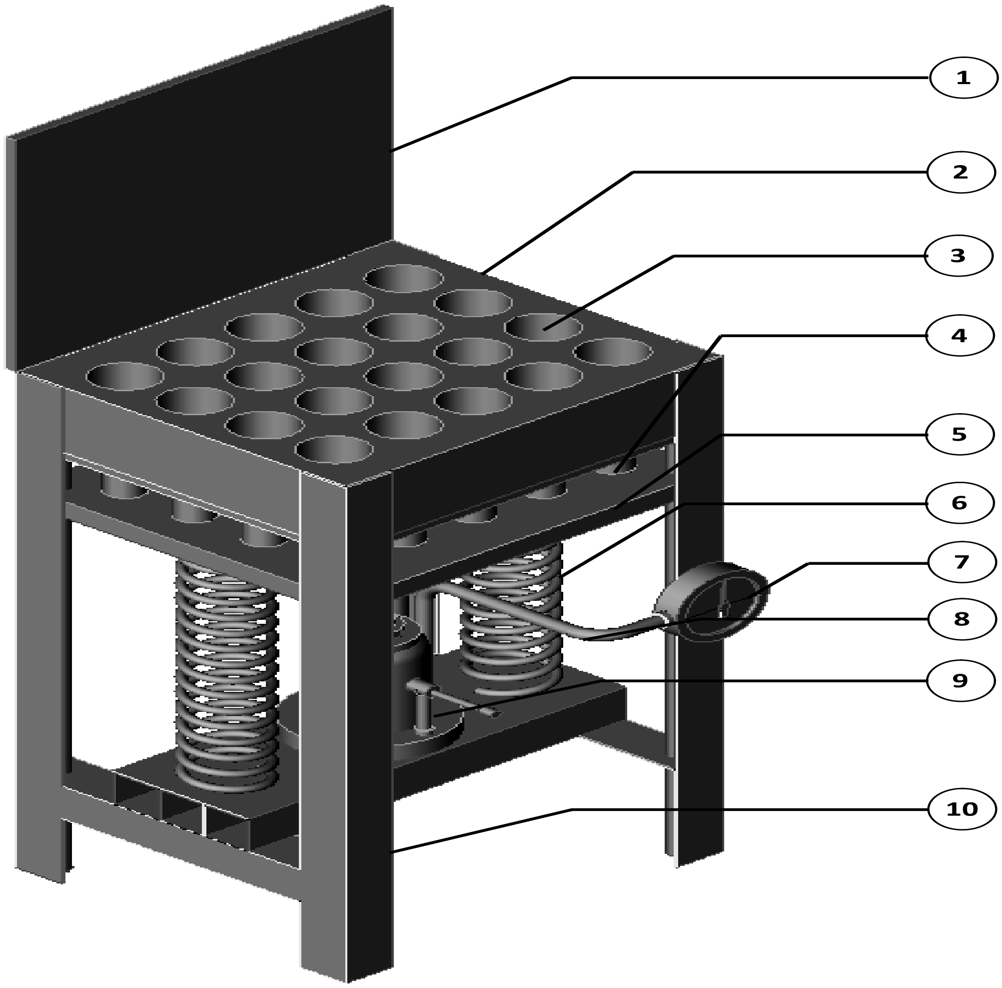
Isometric Projection of the Briquetting Machine



S/N	DESCRIPTION	QTY	MTL	MFG
1	Top Pressure Plate	1	M/S	FAB
2	Upper Plate Of Compaction Block	1	M/S	FAB
3	Compaction Cylinder	20	M/S	FAB
4	Struct	20	M/S	FAB
5	Bottom Pressure Plate	1	M/S	FAB
6	Return Spring	2	M/S	PUR
7	Pressure Gauge	1	M/S	PUR
8	Pressure Gauge Tube	1	M/S	PUR
9	Hydraulic Jack	1	M/S	PUR
10	Frame Support	1	M/S	FAB

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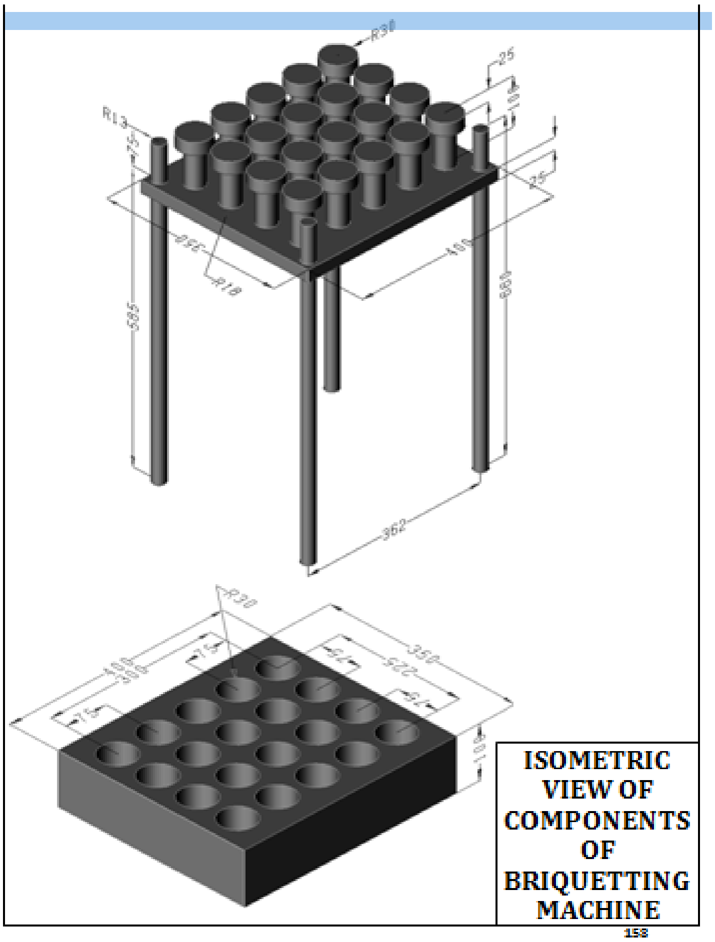
Isometric View of the Components of a Briquetting Machine



REFERENCES

Bhattacharya S, Augustus M and **Mizanur R.** (2010). A Study on improved Biomass Briquetting. Energy program, school of Environment Resources and development Asian Institute of Technology P. O Box 4 Klong luang, Pathumthani 12120, Thailand.

Chesta T. (2011)Producing Fuel Briquettes from Sugar Cane Waste, Mechanical Engineering department, University of Sheffied EWB – UK National Research and Education Conference 2011.

Cillers A. J. (2017).Groundnut production: A concise guide, ARC Grain Crops Institute, Potchefstroom.

This Article is Licensed under Creative Common Attribution-NonCommercial 4.0 International
https://creativecommons.org/licenses/by-nc/4.0/

Dainis A, Aivars K and **Imants N.** (2012). *Influence of the particle parameters on the properties of Biomass Briquettes, Institute of Mechanics, Faculty of Engineering, Latvia University of Agriculture.*

Fapetu, O.P. (2000a). "Management of Energy from Biomass". Nigerian Journal of Engineering Management. 1(1):14-19.

Fapetu, O. P. (2000b). "Production of Charcoal from Tropical Biomass for Industrial and Metallurgical Process". Nigerian Journal of Engineering Management. 1(2): 34-37.

Harris D. J. (1996).A revision of the Irvingiaceae in Africa. Bull. Jard. Bot. Belg. 65:143 – 196.

Jason D and **Charlie F** (2000) Briquette Presses for alternative fuel use published in Echo Appropriate technology note, 17391. Durance road North Ft, Myers Fl 33917, USA.

Jekayinfa, S. O. and **Omisakin, O.O.** (2005). "The Energy Potential of Some Agricultural Wastes as Local Fuel Materials in Nigeria". Agricultural Engineering International: The CIGR E-Journal of Scientific Research and Development. Vol. III Manuscript EE 05 033.

Khurmi R.S.and Gupta (1980).Machine Design, S.Chand publishing, A division of S.Chand and company Ltd.(An ISO 9001:2000 company) 7361,Ram Nagar, New Delhi- 110055.

Olorunnisola, A. O. (2004). "Briquetting of Rattan Furniture Waste". Journal of Bamboo and Rattans 3(2): 133-149, 245-262.

Sharif A, Mizanur R, Aminul I, Mohammad M and **Nawsher A** (2008) Role of Biomass Briquetting in the Renewable energy sector and poverty Diminution for Bangladesh, Rural power company ltd (RPCL), Proceedings of the 4^{th} BSME – ASME international conference on thermal Engineering 27 – 29 December, 2008

Sharma P.C and **Aggarwal D.K.**(1999).Machine Design (SI Units) S.K.Jataria and Sons, Daryaganji Delhi- 110002.

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