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The Physical, Proximate and Ultimate Analysis of Rice Husk Briquettes Produced from a Vibratory Block Mould Briquetting Machine

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ABSTRACT

Briquettes play significant roles in the production of eco-friendly fuels and as substitutes for non-renewable sources of energy. But the selection of the right materials is essential for good briquette production.The selection of agro-wastes for domestic and industrial purposes depends on the proximate and ultimate compositions. In this study, investigations were carried out on the physical, proximate and ultimate analysis of rice husk briquette produced from a vibratory block mould briquetting machine fabricated by the Desfabeng Co. LTD. Bida, Niger State, Nigeria.The proximate and ultimate compositions of the briquettes were determined in accordance with ASTM analytical methods while the physical properties were determined by direct measurements and calculations. The results of the physical properties investigated were; Height of briquette (0.21m), diameter of briquette (0.08m), mass of briquette(1.10kg), volume of briquette(0.001m^3), maximum density(1,100kg/m^3), relaxed density(500kg/m^3), density ratio(0.45), relaxation ratio(2.2), colour(brown), texture(rough). The proximate analysis gave the following results; % volatile matter (68.20), % ash content (16.10), % moisture content (12.67), % Fixed carbon (15.70). With the aid of a Parr isoperibol bomb calorimeter, the heating value was found to be 15,175KJ/Kg. The ultimate analysis gave the result for % carbon, hydrogen, oxygen, nitrogen and sulphur content as 45.20, 5.80, 47.60, 1.02 and 0.21 respectively. From the results obtained it can be seen that briquettes produced from rice husk using the vibratory block mould briquetting machine would make good biomass fuels as it has a high % volatile matter and a low % ash content.

Keywords: *Briquette, Biomass, Rice husk, Fuel*

1. INTRODUCTION

Energy availability in the rural as well as urban areas of Nigeria is fast becoming a great challenge with the high cost of cooking gas and kerosene and environmental problems associated with firewood (Oladeji, 2011). This has drawn attention to the need for an urgent transition to a more sustainable energy system that would be affordable and eco-friendly. As such many researches are on-going on the prospects of using agro wastes and other biomass for the production of solid fuels called briquettes which would serve as substitutes to the depleting non-renewable energy sources.

A briquette is a block of flammable matter used as fuel to start and maintain a fire. Briquettes are produced through a process known as briquetting. This process involves the densification of loose biomass residues, such as sawdust, straw, rice husk etc, into high density solid blocks that can be used as a fuel. Common types of briquettes are charcoaland biomass briquettes. Biomass briquettes (including pellets, which are very small briquettes) replace fossil fuels or wood for cooking and industrial processes. They are cleaner and easier to handle, and cut greenhouse gas emissions.

Rice husk is the membranous outer covering of the rice. It is an exceptional biomass normally available with 10-12% moisture and the ash contains fewer alkaline minerals. It makes an excellent fuel although its calorific value is less than wood (Francis and Peters, 1965). Utilization of rice husk, as alternative source of fuel in drying has made it more valuable rather than considering it as an agricultural waste. Rice husk offers much potential for energy generation and biomass-to-energy projects, protect the environment, reduce poverty and improve the quality of life for the rural poor(Ahiduzzaman, 2007).

According to Rajvir et al. (1980), rice husk is quantitatively the largest by-product of rice milling industry and constitutes one fifth of paddy on a dry weight basis. However, rice husk in its present form, just like any other agricultural residues, cannot be effectively used for energy conversion. This is because utilization of agricultural residues is often difficult due to their uneven characteristics. It is widely accepted that the majority of the residues in their natural forms have lower density, higher moisture content and lower energy density. Besides, the low bulk density and dusty characteristics of the biomass also cause problems in transportation, handling and storage (Husan et al., 2002). The application of biomass briquetting i.e. transforming the loose biomass into briquettes is an effective way to solve these problems and contribute towards alleviation of energy shortage and environmental degradation (El-Saeidy, 2004).

Fuel briquettes produced under different conditions have been reported to have different handling characteristics. These characteristics are also found to be strongly affected by the raw material properties. If biomass or agro-waste briquettes are to be used efficiently and rationally as fuel, they must be characterized to determine parameters such as the moisture content, ash content, density, volatile matter, and heating value among others. The result of these determinations indicates the positive and negative attributes of the agro waste briquettes. Among the positive attributes of agro-waste briquettes are low moisture content, high crushing strength, high density, slow flame propagation, low ash content, high amount of carbon, and substantial heating value. According to Yang et al., (2005), moisture content isaveryimportantpropertywhichaffectstheburning characteristicsofbiomass.Volatilemattercontenthas alsobeenshowntoinfluencethethermalbehaviourof solidfuels (Loo et al., 2008).

The proximate and ultimate compositions of agro waste briquettes vary from one type to another. Since briquettes can be made from wide varieties of agro-residues, selection of the best briquettes has to be made based on the analysis of its proximate and ultimate compositions. This will go a long way to ensure judicious use of these wastes.

The objective of this research is therefore to produce rice husk briquettes using a vibratory block mould briquetting machine fabricated by Desfabeng Co. LTD. Bida, Niger State, Nigeria.The physical, proximate and ultimate analysis of the briquettes was then carried out.The findings of this study is expected togive an indication if briquettes produced by the machine from rice husk would make good biomass fuels that can meet the standard criteria of briquettes for efficient burning with a view to releasing sufficient heat energy as fuel for domestic and industrial utilization.

2. MATERIALS AND METHODS

2.1. Research Area

The research area was conducted in Bida Metropolis of Niger State. The work was carried out in two different locations:

i. The rice processing unit, National Cereals Research Institute, Badeggi-Bida, Niger State, Nigeria. This was where the rice husks were obtained. The proximate and ultimate analysis of the formed briquettes was also carried out in the Biochemistry laboratory of the institute.

ii. The fabrication unit, Desfabeng company Nigeria Limited, Lemu road, Bida, Niger State, Nigeria. This was where the briquette production was carried out using the vibratory block mould briquetting machine.

2.2. Briquette Production

The collected rice husk samples were screened from stones and other impurities that might inhibit proper briquette formation. The heating mantle was switched on and water was poured into the pot and placed on the heating mantle. After boiling, the hot water was then mixed with the starch until a sticky gel was produced (Plate 1). The rice husk was then wetted with water so as to enhance uniform mixing with the binding agent (Starch). The binder (starch) was then mixed with the wetted rice husk in the proper binder-mix ratio. This mixture was then poured into the mould of the briquette machine. With the combined effect of the compression and the ejection stroke, the briquettes were formed as shown in plate 2. The produced briquettes were placed in an oven dryer for efficient moisture removal. After the drying process, the briquettes were removed from the dryer and a solid mass was formed capable of being used as a substitute for wood fuel (Plate 3). The formed briquettes were subjected to physical, proximate and ultimate analysis.

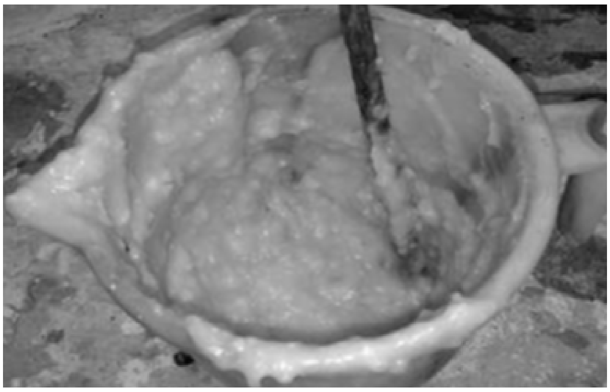

Plate 1: Binder (Starch)

Plate 2: Briquette Production Process

Plate 3: Formed Briquettes

2.3. Determination of the Physical, Proximate and Ultimate Properties of the Briquettes

2.3.1. Physical properties of the briquettes

Four briquettes were randomly selected from each production batch for evaluation of the physical properties.The average maximumdensity of the briquettes from the rice husk was determined immediately after ejection from the mould and this was calculated as the ratio of the average mass to the volume of briquette. The mass was obtained by using a digital weighing scale, while the volume was calculated by taking the dimensions of the cylindrical briquettes (radius and height). By applying the formula for the volume of a cylinder ($\pi R^2 H$), the volume of the formed briquette was obtained.

The relaxed density of the briquettes from the rice husk was determined in the dry condition after drying in an oven dryer. It was calculated simply as the ratio of the briquette's mass after drying to its volume. Relaxed density can be defined as the density of the briquette obtained after the briquette has remained stable. It is also known as spring back density.

Density ratio was calculated as the ratio of the relaxed density to the maximum density:

$$Density\ ratio = \frac{Relaxed\ density}{Maximum\ density}$$

In this formula, the maximum density was the compressed density of the briquettes immediately after ejection from the briquetting machine.

Relaxation ratio was also calculated as the ratio of the maximum density to the relaxed density:

$$Relaxation\ ratio = \frac{Maximum\ density}{Relaxed\ density}$$

2.3.2. Proximate analysis of the briquettes

Proximate analysis, which is a standardised procedure that gives an idea of the bulk components that make up a fuel, was done to determine the average of the percentage volatile matter content, percentage ash content, moisture content and percentage content of fixed carbon of the briquettes obtained from four replicates. The procedures of the ASTM standard D5373-02 (2003) was adopted to obtain the following parameters:

2.3.2.1. Percentage volatile matter

The percentage volatile matter (PVM) was determined by pulverising 2g of the briquette sample in a crucible and placing it in an oven until a constant weight was obtained. The briquettes were then kept in a furnace at a temperature of 550°C for 10min and weighed after cooling in a desiccator. The PVM was then calculated using the Equation below:

PVM= $\frac{A-B}{A} \times 100$

Where A is the weight of the oven dried sample and B is the weight of the sample after 10min in the furnace at 550°C.

2.3.2.2. Percentage ash content

The percentage ash content (PAC) was also determined by heating 2g of the briquette sample in the furnace at a temperature of 550°C for 4h and weighed after cooling in a dessicator to obtain the weight of ash (C). The PAC was determined using the Equation below:

PAC= $\frac{C}{A} \times 100$

2.3.2.3. Percentage moisture content

The percentage moisture content (PMC) was found by weighing 2g of the briquette sample (E) and oven drying it at 105°C until the mass of the sample was constant. The change in weight (D) after 60min was then used to determine the sample's PMC using the Equation below:

PMC= $\frac{D}{E} \times 100$

2.3.2.4. Percentage fixed carbon

The percentage fixed carbon (PFC) was computed by subtracting the sum of PVM and PACfrom 100 as shown in the Equation below:

Fixed Carbon= $100\% - (PAC + PVM)$

Furthermore, the heating value of the briquettes produced was examined and the procedure was in accordance with the ASTM E 711-87 (2004). The apparatus used was the Parr isoperibol bomb calorimeter.

2.3.3. Ultimate analysis of the formed briquettes

Estimations of important chemical elements that make up biomass, namelypercentage carbon,hydrogen,oxygen,nitrogenandsulphur, weredeterminedthrough‘ultimate’analysis.ThesepropertiesweredeterminedinaccordancewithASTManalyticalmethodsasprescribedby Jenkins et al., (1998).

3. RESULTS AND DISCUSSIONS

3.1. Physical Properties

As shown in table 1, the result of the physical properties of the formed rice husk briquette revealed that the formed briquette has a fairly large volume of 0.001m^3 and a mass of 1.10kg which means it would be able to maintain combustion for a relatively long period of time given its volume and mass. The density of the rice husk briquette was found to be 1,100kg/m^{3}whichis exactly the same with the result obtained for the density of sawdust charcoal briquette reported by Akowuah et al., (2012). This result falls within the range recommended by Grover et al., (1994) for sawdust briquette produced by screw extrusion process. The briquettes will not crumble during transportation and storage because the values obtained for the density is quite high. The values of 1,100 kg/m^3, 500 kg/m^3, 2.2 and 0.45 were obtained for maximum density, relaxed density, relaxation ratio and density ratio for rice husk briquette respectively. Also the physical condition of the briquettes revealed that their external surfaces were rough and the structure of the cross section was compact and homogenous having a brownish colour. These are good indices for efficient burning of the briquettes.

Table 1: **Physical Properties of Rice Husk Briquette**

PARAMETERS	VALUES
Height of briquette (m)	0.21
Diameter of briquette (m)	0.08
Mass of briquette (kg)	1.10
Volume(m^3)	0.001
Maximum Density(Kg/m^3)	1,100
Relaxed Density(Kg/m^3)	500
Density Ratio	0.45
Relaxation Ratio	2.2
Colour	Brown
Texture	Rough

3.2. Proximate Analysis

The result of the proximate analysis of the formed briquette is presented in table 2 below. Volatile matter refers to the part of the biomass that is released when the biomass is heated (up to 400 to 500°C). During this heating process the biomass decomposes into volatile gases and solid char. Biomass typically has a high volatile matter content (up to 80 percent).

However, for the rice husk briquette produced, a volatile content of 68.20% was recorded. This is high and signifies easy ignition of the briquette andproportionateincreaseinflamelengthassuggested by Loo et al., (2008). Thehighvolatilemattercontentindicatesthat duringcombustion,mostofthe formed briquettes willvolatiliseandburnasgas in combustion chambers. Ash,whichisthe inorganic matter left out after complete combustion of the biomass was found to be 16.10%. This is the percentage of impurity that will not burn during and after combustion. The low ash content indicates that it is suitable for thermal utilisation. Higher ash content in a fuel usually leads to lower calorific value (Loo et al., 2008).

The fixed carbon of a fuel is the percentage of carbon available for char combustion. For the formed briquettes, it was found to be 15.70% . The low fixed content makes it tend to prolong cooking time by its low heat release. As such the fixed carbon gives a rough estimate of the heating value of a fuel. The moisture content of the rice husk briquette was 12.67 %. This result was within the limits of 15% recommended by Wilaipon, (2008), for briquetting of agro-residues.The high heating value calculated for briquette produced from rice husk was 15,175 KJ/kg. This energy value is sufficient enough to produce heat required for household cooking and small scale industrial applications. It also compares well with most biomass energy such as groundnut shell briquette-12,600 kJ/kg (Musa, 2007), cowpea- 14,372.93 kJ/kg, and soybeans-12,953 kJ/kg (Enweremadu, et al., 2004).

Table 2: Proximate Analysis of Rice Husk Briquette

PARAMETERS	VALUES
Volatile matter (%)	68.20
Ash content (%)	16.10
Moisture Content (%)	12.67
Fixed carbon (%)	15.70
Heating Value(KJ/Kg)	15,175

3.3. Ultimate Analysis

Table 3 below, presents the ultimate analysis of the formed rice husk briquettes. Ultimate Analysisinvolves the estimation of important chemical elements that makes up the biomass, namely carbon, hydrogen, oxygen, nitrogen and sulphur. The basic method for doing an ultimate analysis is to burn a sample of biomass in a platinum crucible in a stream of air to produce carbon dioxide and water. The results of ultimate analysis of the formed rice husk briquette gave 45.20%, 5.80%, 47.60%, 1.02%, and 0.21% for contents of carbon, hydrogen, oxygen, nitrogen, and sulphur, respectively. The amount of carbon and hydrogen content in the briquette is very satisfactory as they contribute immensely to the combustibility of any substance in which they are found, (Musa, 2007). The low sulphur and nitrogen contents in the briquettes are welcomed development as there will be minimal release of sulphur and nitrogen oxides into the atmosphere and that is an indication that the burning of briquettes examined in this work will not pollute the environment, (Enweremadu, et al., 2004).

Table 3: Ultimate Analysis of Rice Husk Briquette

PARAMETERS	VALUES
Carbon content (%)	45.20
Hydrogen content (%)	5.80
Oxygen content (%)	47.60
Nitrogen content (%)	1.02
Sulphur content (%)	0.21

4. CONCLUSION

Using an already fabricated briquetting machine to densifyloose ricehusk wastes, rice husk briquettes were produced. The physical, proximate and ultimate analysis of the formed briquettes was carried out and the following conclusions were made:

I. Rice husk generated in large quantities from rice mills which when burnt directly pollutes the environment can be converted into high-quality and durable solid fuel briquettes that will be suitable for both domestic and industrial energy production.

II. The formed rice husk briquette with a high volatile content of 68.20% can easily be ignited for combustion purposes. The high volatile matter content also indicates that during combustion, most of the formed briquettes will volatise and burn as gas in combustion chambers.

III. The high heating value of 15,175 KJ/kg calculated for briquette produced from rice husk indicates that rice husk briquettes can produce heat required for household cooking and small scale industrial applications.

IV. Also the briquettes producedwould be environmentally friendly due to the low nitrogen (1.02%) and sulphur (0.21%) contents.

REFERENCES

Ahiduzzaman, M. (2007).Rice Husk Energy Technologies in Bangladesh. Agricultural Engineering International: the CIGR E journal Invited Overview No. 1. Vol. IX.

Akowuah, J. O., Francis, K.andStephen, J. M. (2012).Physico-chemical characteristics and market potential of sawdust charcoal briquette. International Journal of Energy and Environmental Engineering.3:20.

ASTM Standard D5373 –02. (2003). Standard Test Method Instrumental Determination of Carbon, Hydrogen and Nitrogen in Laboratory Samples of Coal and Coke". ASTM International: West Conshohocken, PA.

ASTM E711 –87.(2004). Test Method for Gross Calorific Value of Refine-Derived Fuel by the Bomb Calorimeter. ASTM International: West Conshohocken, PA.

El-Saeidy, E.A. (2004)."Technological Fundamentals of Briquetting Cotton Stalks as a Biofuel".An Unpublished Ph.D.Thesis. Faculty of Agriculture and Horticulture, Umboldt Germany Pp 56-70.

Enweremadu, C.C, Ojediran, J.O., Oladeji, J.T., and Afolabi, I.O. 2004."Evaluation of Energy Potential of Husks from Soy-beans and Cowpea".Science Focus. 8:18-23.

Francis, W. and M. C. Peters (1965).Fuel and Fuel Technology, Pergamon Press Publishing, United Kingdom pages 101-106.

Grover, P. D., Mishra, S. K., Clancy, J. S. (1994).Development of an appropriate biomass briquetting technology suitable for production and use in developing countries. Energy Sustain. Dev.1(1),45–48.

Husan, Z., Z. Zainacand Z. Abdullah (2002). Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil.Biomass and Bioenergy. 22:Pp505-509.

Jenkins, B. M., Baxter, L. L., Miles, Jr., T. R, Miles,T. R.(1998). Combustion properties of biomass. Fuel Process Technology.54:17–46.

Loo, S. V., Koppejan, J. (2008).The Handbook of Biomass Combustionand Co-firing.Earthscan, London.

Musa, N.A. 2007. "Comparative Fuel Characterization of Rice Husk and Groundnut Shell Briquettes".NJREDl. 6(4):23-27.

Oladeji J.T. (2011). Pyrolytic Conversion of Cow Dung into Medium-Grade Biomass Fuels International Journal of Pure and Applied Sciences 2011a Volume 4 number 2, pp173-178.

Rajvir, S., R. C. Maheshwari and T.P. Ojha (1980). Development of Husk fired furnace. J. of agric. Engr. Res. 25 pp109-120.

Wilaipon, P. (2008). "Density Equation of Bio-Coal Briquette and Quantity of Maize Cob in Phitsanulok, Thailand".American Journal of Applied Sciences. 5(2):1808-1811.

Yang, Y. B., Ryu, C., Khor, A., Yates, N. E., Sharifi, V. N., Swithenbank, J. (2005). Effect of fuel properties on biomass combustion. Fuel 84;2116–2130.