Fuel Characterization of Briquettes Produced from Corncob and Rice Husk Resides.

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ABSTRACT

The selection or choice of agro-waste briquettes for domestic and industrial cottage applications depends on the fuel properties. In this work, investigations were carried out on properties of briquettes produced from corncob and rice husk residues with a view to finding out which of the two residues examined can be used more efficiently and rationally as fuel. Ultimate and proximate analyses were carried out to determine the average composition of their constituents. A simple prototype briquetting machine was fabricated to facilitate densification of these residues into briquettes.

The results of this work indicate that briquettes produced from these two residues would make good biomass fuels. However, findings show that corncob briquette has more positive attributes of biomass fuel than rice husk briquette. It has a moderate moisture content of 13.47%, higher density of 650 kg/m^3 and lower relaxation ratio of 1.70. Other positive attributes of corncob briquette over rice husk are long after glow time of 370 seconds and slow propagation rate of 0.12 cm/s. It also has higher volatile matter of 86.53%, higher heating value of 20,890 kJ/kg and compressive strength of 2.34 kN/m^2 compared to rice husk which are 67.98%, 13,389 kJ/kg, and 1.07 kN/m^2, respectively.

(Keywords: corncob, rice husk, briquette, biomass fuel, agricultural residues)

INTRODUCTION

The availability of energy for domestic use in Nigeria continues to pose a formidable challenge, especially with the high cost of cooking gas and 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 agro wastes such as rice-husk and corncob as alternatives.

Numerous 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 rice husks and corncobs are produced annually and these residues are left to rot away or they are burned like other agricultural wastes. These residues could however, be used to generate heat for domestic and industrial cottage applications (Fapetu, 2000b).

Among several kinds of biomass, agricultural residues have become one of the most promising choices. Some agricultural wastes such as wood can be directly utilized as fuels. Nevertheless, a majority of them are not suitable apparently because they are bulky, uneven, and have low energy density. All these characteristics make them difficult to handle, store, transport, and utilize in their raw form. Hence, there is the need to subject them to conversion processes in order to mitigate these problems. One of the promising solutions to these problems is the application of briquetting technology (Wilaipon, 2007). The technology may be defined as a densification process for improving the handling characteristics of raw materials and enhancing volumetric calorific value of the biomass.

Appreciable studies have been carried out on briquetting process. Such agro-residues already studied include maize cob (Wilaipon, 2007), maize cob + coal particles, (Wilaipon, 2008a), groundnut and melon shells, (Oladeji et al. 2009), rice husk, (Musa, 2007), waste paper + admixture of coconut husk, (Olorunnisola, 2007), and banana peel (Wilaipon, 2008b), among others.

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 hydrogen, and substantial heating value.

The fuel properties of agro waste briquettes vary from one type to another, so corncob and rice husk briquettes are expected to vary in properties. Since briquettes can be made from wide varieties of agro-residues, selection of the best briquettes has to be made based on the one that has better fuel properties or positive attributes. This will go a long way to ensure judicious use of these wastes.

The broad objective of this work was to convert corncob and rice husk which are two popular agricultural residues in Nigeria into biomass briquettes. This was followed by determination of mechanical and combustion properties of the briquettes produced. Furthermore, the results obtained were compared so as to determine which of the two residues would produce better briquettes.

MATERIALS AND METHODS

Corncob and rice husk that were utilized in this experiment were obtained from farm waste dumps. The residues were chosen because they are produced in large quantity in the country and most often they are dumped or flared resulting in widespread fire hazards and environmental pollution.

The two residues were individually chopped into small pieces using a hammer mill and 0.6mm particle size was utilized for the purpose of this work. The procedure as highlighted in accordance with ASAE 424.1 (2003) was followed to determine the chosen particle size. In this work, 5% by weight of starch was used as binding agent in line with works of Musa, (2007) and Olorunnisola, (2007). The starch was made into gel and added to 1 kg each of samples of corncob and rice husks separately. The blend of cassava starch gel and the residues were stirred vigorously to ensure a proper mix, which was fed into the mould of a briquetting machine and compressed by a hydraulic press.

Meanwhile, the briquetting machine used was an existing one, which was redesigned and modified (Figure 1).The machine was based on hydraulic principle and consists of four moulds, where biomass feed stocks were fed. According to the design of the moulds, four briquettes were produced per batch (Figure 2 and Figure 3). The briquettes were later ejected after the holding time (i.e., duration of load application of five minutes) was observed as suggested by Olorunnisola (2004).

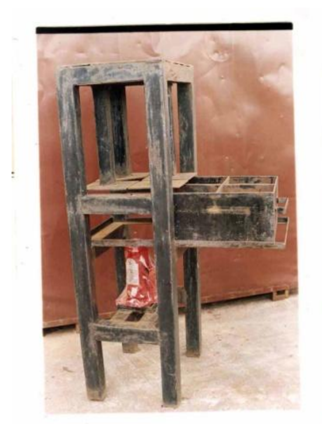

Figure 1: Briquetting Machine.

Figure 2: Briquette from Rice Husk.

Figure 3: Briquettes from Corncob.

DETERMINATION OF PHYSICAL AND COMBUSTION CHARACTERISTICS OF THE BRIQUETTES PRODUCED

The density of briquettes from each residue was determined immediately after ejection from the mould and this was calculated from the ratio of the mass to the volume of briquette. The mass was obtained by using a digital weighing scale, while the volume was calculated by taking the linear dimensions (length, breadth and thickness) of the briquette by means of a Vernier caliper.

The relaxed density of the briquettes from the two residues was determined in the dry condition after nineteen days. It was calculated simply as the ratio of the briquette's weight to the new 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.

Equilibrium moisture content of the briquettes produced was determined in accordance with ASAES 269-4 (2003), while the % carbon, hydrogen, oxygen, nitrogen, and sulfur were determined in accordance ASTM standard D5373-02 (2003).

Proximate analysis of the briquette samples was carried out to determine the percentage volatile matter content, % ash content, and % content of fixed carbon. The procedure of ASTM standard D5373-02 (2003) was adopted.

The flame propagation rates of the briquette samples were determined as highlighted by Musa, (2007). To do this, one piece of the oven-dried briquette was graduated in centimeters and ignited over a Bunsen burner in the laboratory environment until the fire extinguished itself. The flame propagation rate was estimated by dividing the distance burnt by the time taken in seconds.

The afterglow time was estimated and determined. This became necessary in order to estimate how long the individual briquette will burn before restocking when they are used in cooking and heating. The procedure of Musa, (2007) was also used. One piece of oven-dried briquette was ignited over a Bunsen burner and after a consistent flame was established, the flame was blown out. The time in seconds within which a glow was perceptible was recorded.

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

The compressive strength of the briquettes was investigated by using a universal testing machine. Compressive strength was determined in accordance with ASTM 1037-93 (1995).

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

$$\text{Density Ratio} = \frac{\text{Relaxed Density}}{\text{Maximum Density}} \quad \textbf{(1)}$$

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

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

$$\text{Relaxation Ratio} = \frac{\text{Relaxed Density}}{\text{Maximum Density}} \quad \textbf{(2)}$$

Finally, compaction ratio which is defined as the density of the in-die briquette divided by the initial density of the residue was determined and calculated.

RESULTS AND DISCUSSION

The results of the determination of physical and combustion characteristics of rice husk and corncob briquettes are shown in Tables 1 and 2, while the result of burning characteristics of the two residues examined is presented in Table 3.

From the result of ultimate analysis, the moisture content of rice husk briquette was 12.67 %, while the moisture content of corncob briquette was 13.47 %. These results are within the limits of 15 % recommended by Wilaipon, (2008a), and Grover and Mishra, (1996), for briquetting of agro-residues. Other results of ultimate analysis for rice husk gave 42.10%, 5.8%, 51.67%, 0.38%, and 0.05% for contents of carbon, hydrogen, oxygen, nitrogen, and sulfur, respectively, while the corresponding values for corncob briquette in the order listed above were 19.72%, 15.56%, 62.12%, 0.38%, and 0.82%, respectively.

Table 1: Physical and Fuel Characteristics of Rice Husk and Corncob Briquettes.

Parameter	Unit	Briquettes	
		Rice Husk	Corncob
Length of the briquette	m	0.075	0.075
Breadth of the briquette	m	0.075	0.075
Thickness of the briquette	m	0.008	0.006
Weight of the briquette	kg	0.025	0.024
Compaction pressure	MPa	2.10	2.10
Carbon content	%	42.1	19.72
Hydrogen content	%	5.8	15.56
Oxygen content	%	51.67	62.12
Sulphur content	%	0.05	0.82
Ash content	%	18.60	1.40
Nitrogen content	%	0.38	0.38
Volatile matter	%	67.98	86.53
Fixed carbon	%	13.4	12.07

Table 2: Combustion Characteristics of Rice Husk and Corncob Briquettes.

Parameter	Unit	Briquettes	
		Rice Husk	Corncob
Moisture content	%	12.67	13.47
Compressive strength	kN/m^2	1.07	2.34
The heating value	kJ/kg	13,389	20,890
Initial density	kg/m^3	138.0	155.0
Maximum density	kg/m^3	524.0	650.0
Relaxed density	kg/m^3	24.0	385.0
Density ratio	-	0.45	0.59
Compaction ratio	-	3.80	4.19
Relaxation ratio	-	2.22	1.70

Table 3: Burning Characteristics of Rice Husk and Corncob Briquettes.

Parameter	Unit	Briquettes	
		Rice Husk	Corncob
After glow time	s	354.0	370.0
Flame propagation rate	cm/s	0.10	0.12

The amount of carbon and hydrogen content in the two residues examined is very satisfactory as they contribute immensely to the combustibility of any substance in which they are found, (Musa, 2007). The low sulfur and nitrogen contents in both specimens are welcomed development as there will be minimal release of sulfur and nitrogen oxides into the atmosphere and that is an indication that the burning of briquettes from the two specimens examined in this work will not pollute the environment, (Enweremadu, et al., 2004).

For the proximate analysis, the % content of fixed carbon, ash content and volatile matter for rice husk briquette were 13.40%, 18.62%, and 67.98%, respectively. The corresponding values for corncob briquette in the order listed above were 12.07%, 1.40%, and 86.53%, respectively. The values of volatile matter and ash content are good and acceptable. This is because higher percentage of the briquettes from the two residues would be made available for combustion. However, the briquette from corncob is better than rice husk briquette, because the briquette from corncob has higher value of volatile and lower percentage of ash content.

The higher heating value calculated for briquette produced from rice husk was 13,389 KJ/kg while that of corncob briquette was 20,890 KJ/kg. These energy values are sufficient enough to produce heat required for household cooking and small scale industrial cottage applications. They also compare well with most biomass energy. For examples, 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) The heating value of briquette produced from corncob is higher than that of rice husk, which shows that briquette from corncob is better than its rice husk counterpart.

The values of 524 kg/m^3, 240 kg/m^3, and 2.22 were obtained for maximum density, relaxed density and relaxation ratio for rice husk briquette respectively while the corresponding values for corncob briquette were 650 kg/m^3, 385 kg/m^3, and 1.70, respectively. The two densities obtained in this work compare well with density of notable biomass fuels such as coconut husk briquette-630 kg/m^3 (Olorunnisola, 2007), banana peel-600 kg/m^3 (Wilaipon, 2008b), groundnut shell briquette-524 kg/m^3, and melon shell briquette-561 kg/m^3 (Oladeji,et al.,2009).

As with previous result, here also, corncob briquette appears better than rice husk briquette. The relaxation ratios obtained are also good enough and they are close to the values obtained by Olorunnisola (2007), where a relaxation ratio of between 1.80 and 2.25 was achieved for briquetting of coconut husk and Oladeji, et al., (2009), where values of 1.97 and 1.45 were obtained for groundnut and melon shell briquettes, respectively. The lower relaxation ratio of corncob briquette is an indicator to the superiority of corncob briquette over its rice husk counterpart.

The compressive strengths for the two feed stocks were found to be reasonable with the briquette from corncob having the higher value of 2.34kN/m^2. The implication of this is that, briquette from corncob will suffer damage during transportation and storage than rice husk briquette.

The afterglow times of 354 sec. and 370 sec. were recorded for rice husk and corncob briquettes, respectively, while the propagation rates of 0.10 cm/s and 0.12 cm/s were obtained for briquettes of rice husk and corncob, respectively. The longer afterglow time and slow propagation rate for corncob briquette imply that corncob briquette will ignite more easily and burn with intensity for a long time than rice husk.

CONCLUSIONS

The findings of this study have shown that, the briquettes produced from rice husk and corncob would make good biomass fuels. However, from the study, it can be concluded that, briquette from corncob has more positive attributes of biomass fuel than rice husk briquette.

Finally, the study also concluded that, both briquettes will not crumble during transportation and storage because the values obtained for their relaxed densities are closed to the maximum densities of the briquettes from the two residues.

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