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Impact of Charred Palm Kernel Shell on the Calorific Value of Composite Sawdust Briquette

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Abstract: Impact of charred Palm Kernel shell on the calorific value of composite sawdust briquette is discussed in this study. Composite sawdust briquettes were produced by mixing screened sawdust waste and palm kernel shell of grades 1.18, 2.00 and 2.36 mm in percentage ratios of 90:10, 80:20, 70:30, 60:40 and 50:50, respectively and starch gel was used to bind the mixtures, respectively in their ratios. Calorific tests were carried out on the samples using the Gallenkhamp Calorimeter to determine the energy contents. The results indicates that the addition of palm kernel shell in various proportions increases the average calorific values when compared to the briquette produced from 100% pure sawdust material. It was observed that the finer the grade (i.e., 1.18 mm) of palm kernel shell in the briquette, the higher is the calorific value up to a percentage by weight of 30%. Furthermore, from the results of the Analysis of Variance (ANOVA) carried out, the effect of variation of the different grades of palm kernel shell on the calorific value is highly significant at both 0.05 and 0.01 level of significance. Also with respect to the effect of percentage composition, there is a significant added variance component on the calorific value at 0.05-level of significance but not at 0.01-level of significance. This indicates that both the grade of charred palm kernel shell and percentage composition have effect on the calorific values. There is no significant interaction between the two factors A and B at any level of significance. This indicates that the two factors are not dependent on each other.

Key words: Composite sawdust briquette, calorific value, charred palm kernel shell and analysis of variance

INTRODUCTION

The role and impact of natural resources in the functioning of an economic system can never be over-emphasized. In view of these, energy which, is usually obtained when all these natural resources are harnessed plays a vital role in the overall development planning of any nation[1]. Energy has been the central cross-sectoral issue, which affects all human activities either directly or indirectly. It is a vital input to economic growth and development of any economy developed or developing.

According to Bansal[2], energy has been seen to be a crucial input in the process of economic, social and industrial development. Apart from the other three classical factors i.e., land, capital and labour, the role of energy cannot be underestimated when it comes to development.

Energy resources are generally classified into two namely renewable and non-renewable. The renewable are thought to be a better option since the non-renewable such as kerosene, diesel, gasoline etc. have a capability not to be replenished and could be exhausted. For example, experts have forecasted that petroleum resources will be exhausted by the year 2025[3,4]. Renewable energy sources are more environmentally friendly and are thus better candidates for use in achieving some measure of technological development under a sustainable environment both in the developed and the developing nations[5]. Out of the various types of renewable source of energy, biomass is one of the most versatile. It includes all the living or dead organic materials in form of wastes or residues. Plants, animals and their wastes are not only regarded as biomass. Materials, which originate through a conversion process like paper, cellulose, organic residues from food industry and organic waste materials from industries and houses i.e. Municipal Solid Wastes (M.S.W.) constitutes a larger part of biomass[3]. Wood from commercial forestland is the largest potential source of biomass when compared to others. Most of this potential lies in wood processing by- products otherwise known as wood wastes such as sawdust, spent paper-pulping liquor, forest management by-products such as thinning and logging residues[6]. Out of all the various kinds of wood wastes, sawdust is of high importance. Sawdust, a wood waste is always obtained from forest waste or manufacturing waste. The largest quantity is often obtained through manufacturing process. Sawdust constitutes a major source of residues of small particles of wood waste available in sawmill industries, wood processing and pulp plants. It has been observed that the forestry and wood-based industries is usually characterized by the production of large volumes of residues without any economic utilization. In the past, these residues were left in the field to be wastefully burnt away. However, in recent years, burning of wood residues in the open has been discouraged because of environmental problems associated with this practice. It has been found that there is a potential for utilizing forestry and wood residues especially sawdust for energy[7]. It has been affirmed that the volume of sawdust generated in some parts of the developing countries like Nigeria is quite high[8]. This is due mainly to the increasing number of operating sawmills. The presence of these wastes in large quantity poses disposal problems for the industry. These sawdust wastes can be converted to a useful form by briquetting process. Briquetting is a process of converting loose wastes into a dense compact and consolidated unit through the application of high temperature and pressure with or without a binding agent.

The sawdust wastes having been briquetted can be utilized as a high-grade solid fuel by improving the calorific value and ensuring a clean and bluish smoke free flame suitable for cooking. This could be a way of turning wood waste to wealth. According to Adegoke[5], sawdust briquetting has been found to be a better way of releasing and controlling the amount of heat during the combustion process when used for cooking applications. When sawdust is briquetted, chemical pollutants are eliminated and with enough supply of oxygen complete combustion of the fuel is guaranteed. The lack of control of heat was the shortcoming of the locally produced stove called Abacha stove in 1997 during the kerosene scarcity in Nigeria. In the construction, sawdust is rammed into the stove and aided with a small amount of firewood at the base and then the sawdust is burnt as cooking fuel[9]. On the other hand, agricultural residue such as palm kernel shell in its raw form is generally not good quality fuel. In its raw form when burnt, palm kernel shell produces too much smoke and not much heat[10]. When palm kernel shell is charred i.e., by burning, it could be added as an additive to sawdust briquette and this turns them into good quality fuel otherwise known as composite sawdust briquette.

The aim of this study is to study the impact of charred palm kernel shell on the calorific value of composite sawdust briquette. According to Akachukn[11], the most important fuel property is its calorific or heating value. The calorific value test is one of the major tests to determine the energy content of a fuel. It is a property of a biomass fuel that depends on its chemical composition and moisture content.

MATERIALS AND METHODS

Composite sawdust briquettes were produced by mixing screened sawdust waste and palm kernel shell of grades 1.18, 2.00 and 2.36 mm in percentage ratios of 90:10, 80:20, 70:30, 60:40 and 50:50, respectively and starch was used to bind the mixtures respectively in their ratios. The sawdust waste was collected from one of the sawmills in Akure in South West of Nigeria. In addition, the charred palm kernel shell was bought from a local market and the starch was obtained from a cassava-processing factory. The starch was later made into non-viscous gel. The Gallenkhamp bomb calorimeter and oven were used in the course of the experiment.

In determining the calorific value of the briquette, the Gallenkhamp bomb Calorimeter was first calibrated using a standard sample of Benzoic acid whose known calorific value is 6.32 kcal g^{-1}. A known mass of sample of small quantity, 0.5 g of the different compositions was placed in the crucibles. Small quantities of the sample material i.e. sawdust, palm kernel shell and starch binder were weighed individually in the stated ratios. They were thoroughly mixed before being placed in crucible since they do not form a complete homogenous mixture. The samples were put inside an oven to ensure dryness One end of a cotton thread strand of length 50 mm was inserted between the coil of ignition wire and the other end dipped into the centre of the sample in the crucible.

The thread enhances the combustion of the sample inside the crucible. The bomb body was placed and tightly screwed in position. The thermocouple wire was plugged into the hole on top of the bomb body. The pressure release valve was closed and oxygen was admitted into the bomb until the pressure rose to 25 bars. The light spot index was set to zero using the galvanometer zero knob ensuring a stable temperature before the firing knob was depressed and released to fire the bomb. Heat is released and the maximum deflection of the galvanometer scale was recorded after which the burnt gases were released from the apparatus with the aid of the pressure release valve.

The maximum deflection obtained in the galvanometer was converted to energy value of the sample material by comparing the rise in galvanometer deflection with that obtained when a sample of known calorific value of benzoic acid is combusted. The whole experiment was repeated and for each sample of different grade of palm kernel shell, 3 different readings were obtained.

The data collected were computed and analysed statistically using the Analysis of Variance (ANOVA). The experiment was arranged in a 2-factor factorial in a Complete Randomised Design (C.R.D). For the Calorific Value Test, a 3×5 factorial experiment can be designed. The factors taken into consideration are the grade of Palm kernel shell and Percentage composition of Palm kernel shell in samples. The effects of these factors on the calorific values of the briquettes were studied.

Data analysis:

- The following steps were taken in obtaining the calibration constant for the bomb calorimeter used when determining the calorific values of the samples.

Mass of Benzoic, m_b = 0.384
Calorific value of Benzoic = 6.32 kcal g^{-1}
Galvanometer reflection without sample, θ_1 = 1 division
Galvanometer deflection Benzoic acid θ_2 = 6.3 divisions
Calibration constant,

$$\gamma = 6.32\, m_b/\theta_2 - \theta_1 \quad (3.1)$$
$$\gamma = 0.46$$

Having known the calibration constant, the calorific values of the various samples can now be obtained as follows
Let mass of sample = Z g
Galvanometer deflection with sample, = θ_3 divisions
Heat releases from sample, Q = $(\theta_3 - \theta_1)\,\gamma$ kcal.
Therefore calorific value of sample = $(\theta_3 - \theta_1)\,\gamma/Z$ kcal g^{-1} can now be multiplied by a factor of 4.2 to obtain the final calorific value result in MJ kg^{-1}.

- The following hypotheses were set up under ANOVA to justify the factorial experiment:

Factor A: grade of palm kernel shell: Null hypotheses, H_0: The effect of the grade of charred palm kernel shell on the calorific value is not significant
Alternative hypotheses, H_a: The effect of the grade of charred palm kernel shell on the calorific value is significant.

Factor B: Percentage composition of palm kernel shell in samples: Null hypotheses, H_0: The effect of the percentage composition of palm kernel shell on the calorific value is not significant.
Alternative hypotheses, H_a: The effect of the percentage composition of palm kernel shell on the calorific value is significant.

Effect of interaction of factors A and B: H_0: The added variance component due to the interaction of factors is not significant.
H_a: The added variance component due to the interaction of factors is significant.

The hypotheses set up were tested at 0.01 and 0.05 levels of significance using F-test. The following inferences are to be deducted from the ANOVA table; when F-calculated is greater than F-tabulated: reject H_0 and accept H_a. When F-calculated is less than F-tabulated: Accept H_0 and reject H_a.

RESULTS AND DISCUSSION

Table 1 indicates that the addition of palm kernel shell in various proportions increases the average calorific values, q_{av}, remarkably particularly when compared to the briquette produced from 100% pure sawdust material i.e. control. The finer the grade of palm kernel shell in the briquette (i.e., 1.18 mm), the higher is the calorific value up to a percentage by weight of 30%.

Figure 1 shows the graphical relationship between the average calorific value and the percentage by weight of palm kernel shell in briquette for the different grades of shell using starch as the binding agent. Furthermore, the results obtained from the factorial experiments on Table 2 reveals that with respect to factor A i.e., the effect of variation of the different grades of palm kernel shell on the calorific value is highly significant at both 0.05 and 0.01 level of significance. Hence, the null hypothesis at this point is rejected.

Table 1: Calorific value of samples

Grade of charred palm kernel shell	Percentage composition	q_1, MJ kg^{-1}	q_2, MJ kg^{-1}	q_3, MJ kg^{-1}	q_{av}, MJ kg^{-1}
1.18 mm	50/50	21.83	22.8	20.87	21.85
	60/40	20.87	20.48	21.45	20.93
	70/30	21.64	20.02	23.57	22.41
	80/20	21.02	20.48	23.18	21.89
	90/10	20.87	21.24	22.78	21.63
2.00 mm	50/50	19.32	22.02	18.55	19.96
	60/40	19.32	21.04	19.32	20.09
	70/30	21.64	20.09	22.02	21.25
	80/20	20.77	19.32	22.02	20.74
	90/10	18.16	17.77	18.93	18.29
2.36 mm	50/50	18.93	18.16	19.71	18.93
	60/40	19.32	19.32	19.32	19.32
	70/30	19.71	20.09	19.32	19.71
	80/20	18.35	17.77	18.93	18.35
	90/10	17.77	17.00	18.55	17.77
Control	100	18.35	17.58	17.00	17.64

Table 2: ANOVA table for calorific test

Source of variance	Degree of freedom	Sum of squares	Mean of squares	F-calculated	F-tabulated 0.05	F-tabulated 0.01	Comment
A	2	67.37	33.69	36.42	3.32	5.39	**
B	4	16.34	4.085	3.07	2.69	4.02	* / n.s
AB	8	10.62	1.33	1.44	2.27	3.17	*
Error	30	27.74	0.925				

**-highly significant *Significant n.s. -value not significant

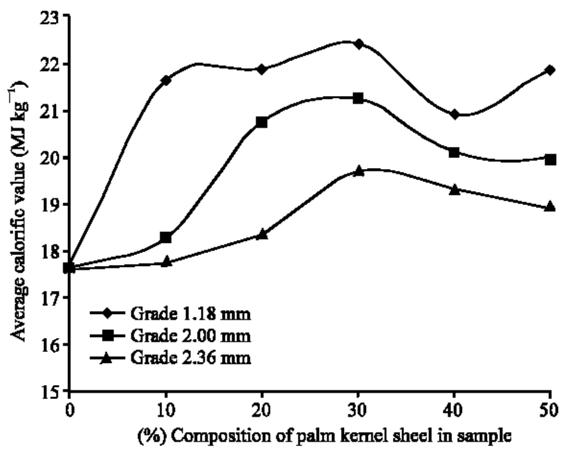

Fig. 1: Calorific values of the different compositions of the composite sawdust briquette

Also with respect to factor B (percentage composition), there is a significant added variance component on the calorific value at 0.05- level of significance but not at 0.01- level of significance. There is no significant interaction between the two factors A and B at any level of significance. This indicates that the two factors are not dependent on each other. Conclusively, the results in the calorific value show that the addition of palm kernel shell into the briquette caused an improvement in the calorific values and that the various grades of palm kernel shell and the briquette composition have a significant effect on the calorific values.

CONCLUSION

A study on the impact of charred palm kernel shell on the calorific value of composite sawdust briquette has been carried out. In this study, it has been established that the use of charred palm kernel shell as an additive in composite sawdust briquette increases the energy content of the fuel. Also the grade of the palm kernel shell and its composition has a tremendous impact on the calorific value of the fuel. Experimental analyses carried out have revealed that sawdust wastes usually generated in large uncontrolled quantities together with some other biomass additives like charred palm kernel shell can be converted to a high-grade solid fuel that will be suitable for both domestic and industrial applications.

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