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PRODUCTION OF SOLID FUEL BRIQUETTES FROM AGRICULTURAL AND WOOD WASTE (SAW DUST AND RICE HUSK)

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ABSTRACT:- Fibrous agricultural and wood waste materials have been compressed with suitable adhesive into solid fuel briquettes in a compressing machine, which was designed and constructed for this purpose. Nine samples of fibrous waste materials were prepared into different categories:- Category A (100% saw-dust, 100% rice-husk, 50-50% rice-husk/sawdust using starch as adhesive). Category B (100% saw-dust, 100% rice-husk, 50-50% rice-husk/ saw dust using gum arabic as adhesive) and category C (100% saw-dust, 100% rice husk, 50-50% rice-husk/saw dust using bentonite as adhesive). The solid fuel briquettes in category C had the lowest average moisture content of 9.1%, categories A and B solid fuel briquettes had 10.5% and 13.0%, respectively. The results from a water boiling test (WBT), involving comparsion of the burning abilities of the solid fuel briquettes and fire wood of the same quantity (200 grammes) in boiling 1.5 litres of water showed that the solid fuel briquettes bound with each of the three adhesives; bentonite, gum arabic and starch; boiled water within a period of 14 to 22 minutes, while firewood did so within a period of 22 to 27 minutes. The open flame test showed that the solid fuel briquettes bound with starch burnt with bluish yellow flame with little black smoke indicating that the stoichiometric (air-fuel) ratio was almost correct. The solid fuel briquettes bound with gum arabic and bentonite burnt with yellow flame with moderate black smoke., indicating incomplete combustion due to poor air-fuel ratio. The reason for this cannot be ascertained.

INTRODUCTION

Many countries of the world are endowed with wood. Wood, which is obtained from trees, contains the natural polymer cellulose, which is also the basis of other natural materials such as cotton. Wood is highly anisotropic, that is, its properties, vary with direction, because of its fibrous nature. The tensile and compressive strengths are much greater along the grain than across the grain (Ibhadode, 1997). However, the shear strength along the grain is much lower than the shearing strength across the grain. The low shear strength along the grain makes it difficult to use wood for tension members of a structure (Ibhadode, 1997). It is however a good material for compression members.

The wood from felled trees is sawn into timber for buildings and other construction purposes. The waste product from this process is called sawdust. Popular wood for timbers are obtained from the rain forest all over the world, for example in Nigeria popular wood for timber include iroko (chlorophora excelsa), mahogany (Khaya invorensis), obeche (Triplochiton Saderoxylon), black and grey afora (Terminalia invorensis and Terminalia superba) and others. Wood all over the world, was the dominant fuel in the 1850's (Ruedisill, 1974). However, it had lost about 20 percent of the market to coal by the year 1900. It still forms the bulk of energy requirements of the rural populace of third world countries, primarily for domestic heating. Firewood is now being consumed more rapidly than it is grown (Vaclar, 1980). In many countries, the result is the elimination of trees from around cities. This trend has a great influence on the environment.

Rice is an edible food which is common all over the world. It is typically a swamp plant which is well adapted to growing in naturally flooded places such as river banks, valleys and the brackish and fresh water mangrove swamps. It can also be successfully cultivated using controlled irrigation. Many varieties also thrive under rain-fed conditions at fairly high altitudes. Under these conditions rice is grown without irrigation, but has a shorter growing period and also produces lower yields than swamp varieties. Therefore, there are two types of rice, swamp rice and upland rice. After harvesting and threshing of the rice, it is milled and the waste product from this process is the rice husk.

Both saw dust and rice husk as waste products could be briquetted into a solid form. The technique of briquetting waste materials is well known and well established.

Briquetting of saw-dust and other waste materials has long been practised in Europe, Asia and the America (Kishimoto, 1969). The briquetting of lignites using calcium and ammonium sulphites liquoirs (both by-products of paper-making) as binders has been reported (Saglam et al., 1990), and strong and water-resistant briquettes were obtained. Also Afonja (1972 and 1975) was able to briquette sub-bituminous coals using various binders. Recently, (Akpabio et al. 1995) successfully briquetted solid fuel from sugar cane waste, using starch as a binding agent. The ever increasing demand for fuelwood in third world countries, which in turn causes a serious threat to environmental protection, has motivated this work which is aimed at finding ways to utilise the waste products of wood and rice, which otherwise would have been an enviromental nuisance, marring the beauty of the landscape.

The aims of this work are to compress these waste materials into solid fuel briquettes, and use them as an alternative to fuelwood in domestic and industrial applications and also to compare their burning characteristics with that of fire wood.

MATERIALS AND METHODS

Materials

Sawdust and rice-husk were obtained from timber sheds and rice mills. Three adhesive materials were used, namely, gum arabic, starch and bentonite. A fibrous waste compressing machine which was designed and constructed (Inegbenebor and Malachy, 1998) was used.

Methods

(1) Briquetting Process

(2) The briquetting treatments are summaried in Table 1.

Table 1. Briquetting treatments showing the various combinations of solid waste materials and binding agents.

	Fibrous waste Materials		Binder		
Treatment No.	Saw Dust %	Rice Husk %	Starch	Gum Arabic	Bentonite
1	100	-	1	-	-
2	-	100	1	-	-
3	50	50	1	-	-
4	100	-	-	1	-
5	-	100	-	1	-
6	50	50	-	1	-
7	100	-	-	-	1
8	-	100	-	-	1
9	50	50	-	-	1

Treatment one began by weighing out 300 grammes of saw dust. The adhesive (starch) was prepared by dissolving 100 grammes of starch in cold water, to produce a paste. Hot water (1.25 litres) was poured on the paste and it was stirred vigorously until a milky homogenous solution was formed. This was allowed to cool for 10 minutes and it was then mixed with 100% sawdust (300g) in a separate container for 2 minutes. The material was put in the mould of the compression machine for the briquette to be made. The briquette, after compression, was removed and weighed. Then it was left in the open air to dry for 6 days.

Treatment two began by weighing out 300 grammes of rice-husk. The adhesive (starch) was prepared as in treatment one. The same procedure was used to obtain briquette of rice-husk.

Treatment three also began by measuring 50% rice husk (150g), 50% sawdust (150g), and 100 grammes of starch. The preparation of starch paste was made as previously described. The briquette of 50% saw dust and 50% rice husk was obtained as previously described.

Treatment four which was from 100% saw dust was prepared as in treatment one. However, the adhesive was gum arabic and this was prepared by dissolving 160 grammes of gum arabic in 1.25 litres of cold water for a day. The 100% saw dust briquette of gum arabic adhesive was achieved as previously described for the other treatments. Treatments five and six followed similar procedures. Treatments seven, eight, and nine, which used bentonite adhesive, followed similar procedures as the previous treatments. However, 120 grammes of bentonite was dissolved in cold water (the same quantity of water as in the other samples). The solution was stirred continously until a homogeneous solution was formed.

2 Moisture Contents Measurement

The moisture content of the briquette has an impact on its heat value since some amount of heat energy is required to expel the mositure contained in the briquettes, thereby reducing the heat values of the briquettes.

The moisture content of the briquette was determined as follows:

A weighing container (tin) was cleaned, dried and weighed to the nearest 0.01g (M_1). A sample of dried briquette was taken and crumbled and then placed in the container. The container and the content were weighed to the nearest 0.01g (M_2). The container was then placed in an oven at a temperature of 105°C for 24 hours. Thereafter, the container and its content were weighed again to the nearest 0.01g (M_3).

The moisture content of the briquettes (W) was calculated as a percentage of the dried briquettes, using the following formula

$$W = \frac{M_2 - M_3}{M_3 - M_1} \times 100$$

Where M_1 is mass of the container (g)
M_2 is mass of container + the compressed briquette.
M_3 is mass of container + dried briquettes in the oven.

3. Water boiling test (wbt)

The water boiling test (WBT) is a simple laboratory test which measures the time it takes a given quantity of fuel to get a given amount of water to its boiling point. This is a well-developed test which has been used before (Akpabio et al. 1995).

Two hundred grammes each of briquettes and firewood, accurately weighed, were stacked in 2 local improved-fuel stoves. Two galvanised aluminium pots fitted with thermometers were each filled with 1.5 litres of water. As soon as ignition was underway, a stop watch was activated. Temperatures were recorded at 5 minute intervals until the water boiled, noting the initial temperature in each case.

4. Open Flame Test (OFT)

This test will enable one to know the type of flame and type of smoke emitted from the briquette. Smoke is finely divided carbon which results from the decomposition of carbonaceous materials evolved during the process of combustion (Rhys-Jones, 1963).

The briquettes were ignited after sprinkling some kerosine to start the combusion and the nature of flame and smoke emitted by the briquettes were observed.

Table 2. Sample weight before and after drying and the moisture content of the briquette.

RESULTS AND DISCUSSION

From the table below, the following observations were noted. The samples prepared from 100% saw dust with various binders (samples 1,4,7) showed the lowest values in the weight of saw dust (low density). Samples prepared from 100% rice husk with various binder (sample 2,5,8) had higher values because of the particle sizes of the fibrous waste. Samples prepared from 50-50% saw dust and rice husk had the highest values of wet and dry weight which could be attributed to the initial weight of the various binders.

The moisture content is the amount of moisture present in the solid materials. A high moisture content would lead to a high waste heat value because the heat that is supposed to be liberated would be used to dry the briquette. The sample of briquettes prepared with bentonite as a binder had the lowest value of moisture content, indicating high valuefor the heat liberated. This result is in agreement with the higher caloric values found recently in using bentonite as a binder (Inegbenebor and Malacy, 1998). The moisture contents of the other binders, gum arabic and starch are higher.

Performance of the Briquettes in the Water Boiling Test (WBT):-

In order to ascertain the burning abilities of the briquettes with respect to the binder materials, the performances of briquettes in the WBT were undertaken. In this case, the performance in the WBT are presented in Figures (1-3).

It is readily seen that the briquettes bound with bentonite and starch binders boiled water in a shorter time, while firewood took much longer time. The briquettes bound with gum arabic boiled water in a longer time compared with the two other binders. The reason for this is because both bentonite and starch binders have lower moisture contents compared with gum arabic (Table 2). This might have affected the burning abilities of the briquettes bound with gum arabic. These results show that the briquettes have superior combustion characteristics over firewood.

Table 2. Sample weight before and after drying and the moisture content of the briquette.

S/No.	Materials	Binder	Weight of Sample Wet(g) Dry(g)	Moisture Content Percentage
1	100% saw dust	Starch	267.4 249.5	11.2
2	100% Rice husk	Starch	355.0 330.0	10.4
4	100% saw dust	Gum Arabic	304.8 280.5	12.8
5	100% Rice husk	Gum Arabic	385.9 352.7	12.6
6	50-50% saw dust and rice husk	Gum Arabic	408.5 370.6	13.5
7	100% saw dust	Bentonite	287.5 272.4	8.3
8	100% rice husk	Bentonite	284.5 358.5	9.7
9	50-50% saw dust and rice husk	Bentonite	394.3 368.5	9.3

In all the experiments, the firewood burnt into ash, while a large amount of all the briquettes remained, which could be reused in heating applications (Table 3). This shows that the agricultural and wood waste, can be more economical than firewood in cooking and all other burning applications, when they are compacted into briquettes with a suitable binder.

The results in Table 4 show the observation of the type of flame produced by the solid fuel briquettes of the agricultural and wood waste materials with the various adhesive materials. The solid fuel briquettes bound with starch produced a bluish-yellow flame indicating one correct air- fuel ratio. The type of flame produced by the other solid fuel briquettes bound by gum arabic and bentonite gave yellow flames, an indicator of incorrect air-fuel ratio.

Table 4: Result of the Open Flame Test

S/No.	Materials	Binder	Type of Flame	Emmision of Black Smoke
1	100% saw dust	Starch	Bluish-yellow	Low
2	100% Rice-husk	Starch	Bluish-yellow	Low
3	50-50% saw dust/ Rice husk	Starch	Bluish-yellow	Low
4	100% saw dust	Gum Arabic	Yellow	High
5	100% Rice-husk	Gum-Arabic	Yellow	High
6	50-50% saw dust/ Rice husk	Gum-Arachic	Yellow	High
7	100% saw dust	Bentonite	Yellow	Moderate
8	100% Rice-husk	Bentonite	Yellow	Moderate
9	50-50% saw dust/ Rice-husk	Bentonite	Yellow	Moderate

Comparing the smoke emitted from all the solid fuel briquettes, samples prepared with starch as a binder emitted a lower level of black smoke followed by those with bentonite as the binder. The smoke emitted from gum arabic binder solid fuel briquettes, was very black. It has been reported by (Ryhs-Jones, 1963), that smoke is a finely divided carbon which results from decomposition of carbonaceous materials evolved during the process of combustion. This could limit fuel burning capacity.

Table 3: Comparison of weight of the Briquettes and the Firewood before and after burning.

	Material Composition						
S/No	Saw dust Percentage	Rice Husk Percentage	Binder	Weight before burning Briquettes (g)	Weight before burning Firewood (g)	Weight after burning Briquettes (g)	Weight after burning firewood (g)
1	100	-	Starch	200	200	144.0	Ash
2	-	100	Starch	200	200	132.0	Ash
3	50	50	Starch	200	200	128.2	Ash
4	100	-	Gum arabic	200	200	136.4	Ash
5	-	100	Gum arabic	200	200	147.8	Ash
6	50	50	Gum arabic	200	200	140.6	Ash
7	100	-	Bentonite	200	200	148.9	Ash
8	-	100	Bentonite	200	200	160.0	Ash
9	50	50	Bentonite	200	200	151.1	Ash

CONCLUSION

The so-called agricultural and wood fibrous waste is not a waste after all. The waste can be converted into useful fuel briquettes that can be used in ovens and for cooking in the house as an alternative to firewood. These briquettes are more economical to use than firewood.

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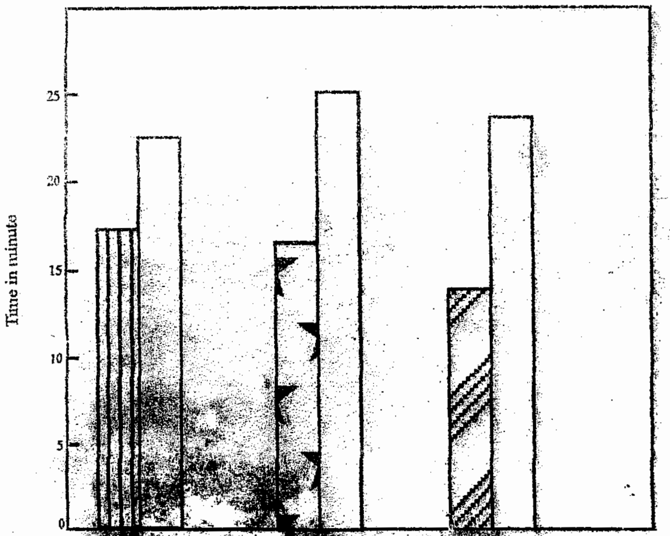

Fig. 1: Time taken by the treatment of Bentonite to boil water (100 oC)

100% Saw-dust Briquette

100% Rice-husk Briquette

50-50 saw-dusk and rice-husk Briquette

Firewood

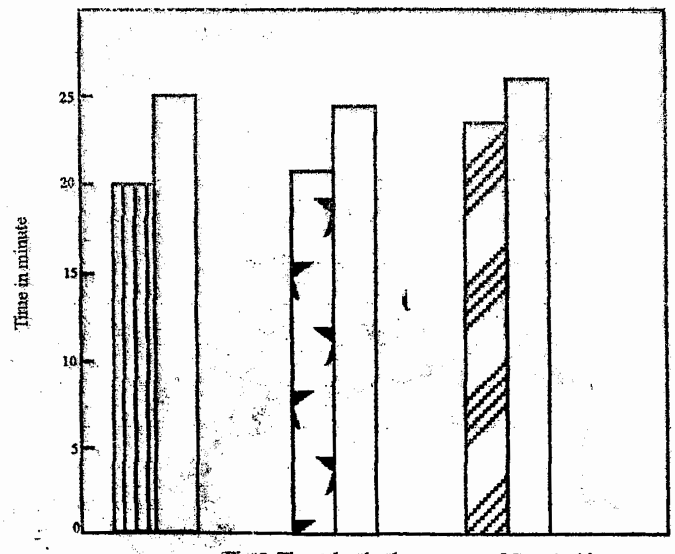

Fig. 2: Time taken by the treatment of Gum Arabic to boil water (100 oC)

100% Saw-dust Briquette

100% Rice-husk Briquette

50-50 saw-dusk and rice-husk Briquette

Firewood

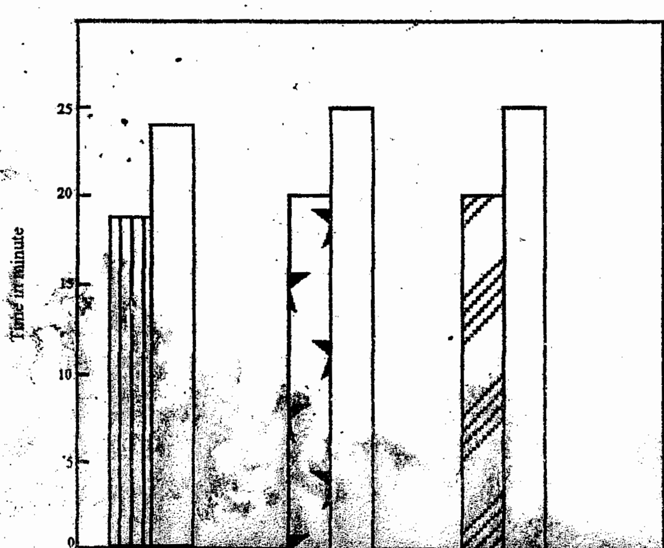

Fig. 3: Time taken by the treatment of starch to boil water (100 oC)

100% Saw-dust Briquette

100% Rice-husk Briquette

50-50 saw-dusk and rice-husk Briquette

Firewood