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Determination of Chemical Compositions, Heating Value and Theoretical Parameters of Composite Agricultural Waste Briquettes

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Abstract - In spite of the numerous advantages agricultural waste briquettes, have over loose agricultural waste; there are needs to further improve on the fuel properties and combustion parameters. This improvement was done by briquetting composite agricultural waste in the percentage ratio of 50:50 to form composite ricehusk/groundnut shell, ricehusk/sawdust and groundnut shell/sawdust briquettes. The ultimate analysis and the determination of the heating values of the composite briquettes carried out revealed improvement in the percentage composition of carbon, Hydrogen and the heating value of the composite briquettes. These are strong indications of more effectiveness of the composite agricultural waste briquettes, when used to fire heating devices such as cook stove, boiler, heating and melting furnaces.

Keywords; Agricultural waste, Composite agricultural waste briquettes, heating value, homogenous agricultural waste, theoretical air-fuel ratio, ultimate analysis, weight of dry flue gas,.

1 INTRODUCTION

Energy resources are 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 the capability not to be replenished and would be exhausted [1]. More so, the environmental impacts as a result of emissions of CO_2 ,SO_2 , NO_x etc during combustion of the non-renewable resources, prompted the use of renewable for cooking and heating purposes .Out of the renewable sources of energy, agricultural waste is one of the most versatile. Energy from biomass which includes agricultural waste, has made the greatest contribution to national energy consumption in both developed and developing countries [2].

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The burning of the agricultural waste in loose form results in loss of fuel and widespread air pollution. However, briquetting the agricultural waste forestall the aforementioned problems. Agricultural waste briquettes have the following advantages over the loose ones, there is increase in the net calorific value per unit volume, the fuel is easy to transport and store, uniform in size and quality.

Agricultural waste covers a wide range of different species which show large variation in composition and fuel characteristics [3]. However, the percentage composition of the combustible elements in the agricultural waste whether in loose form or briquette form are very low compare to fossil fuels [4]. Hence the low emissions of the oxides of the combustible elements. The emission of CO_2 form the combustion of biomass (agricultural waste) is equivalent to the amount of CO_2 absorbed during its growing cycle, so the net CO_2 released is approximately zero by mass [5], [6], [7].

It is evidently clear that the emissions from the burning of agricultural waste briquettes contribute little or nothing to global warming.

Composite agricultural waste briquettes may show variation in composition and fuel characteristics, when compared with homogenous agricultural waste briquettes. So knowledge about their ultimate analysis, heating values, and theoretical parameters such as theoretical air-fuel ratio and theoretical weight of dry flue gas have become imperative. The aim of this research work is to determine the aforementioned fuel properties and theoretical parameters of the composite agricultural waste briquettes with a view to finding out whether there are significant increase or decrease in them, when compared with homogenous agricultural waste briquettes.

2 MATERIALS AND METHODS

2.1 Agricultural Waste Selected for Study

Rice husk, groundnut shell and sawdust were selected for study.

2.2 Preparation of the Composite Briquette Samples

The composite briquette sample with ratio of their percentage compositions as shown in Table 1 were individually produced, using the briquette making machine developed by [8].Starch was used as the binding agent. After production, the composite briquettes were oven dried to reduce the moisture content.

Table 1 Percentage compositions of composite agricultural waste briquette

Composite briquette sample	Ratio of percentage composition
Ricehusk and groundnut shell	50:50
Ricehusk and sawdust	50 :50
Groundnut shell and sawdust	50:50

2.3 Ultimate Analysis of the Composite Agricultural Waste Briquette Samples.

The chemical compositions of composite agricultural waste briquettes include carbon, hydrogen, oxygen, nitrogen and sulphur among others. The ultimate analysis or the determination of their percentage compositions were carried out using standard methods. Thus, ASTM D5373-02 method was used for the determination of percentage composition of carbon, hydrogen and nitrogen, ASTM D4239-02 method was used for the determination of percentage composition of sulphur and ASTM D5142-02 method was used for the determination of percentage ash content of individual composite briquette samples. The percentage oxygen content of the individual composite agricultural waste briquette was determined by difference

as follows

$$\%O = 100 - \%(C + H + S + N + Ash)\,. \quad (1)$$

Where C, H,S, N ,O and Ash are the carbon, hydrogen, sulphur , nitrogen, oxygen and ash content of the composite agricultural waste briquettes respectively.

2.4 Determination of Heating Value of the Composite Agricultural Waste Briquettes

The heating value of the individual composite agricultural waste briquette was determined, following the procedure in accordance with the standard method (ASTM E711-87).

2.5 Determination of Theoretical Air-Fuel Ratio for the Composite Agricultural Waste Briquette.

The theoretical air required for complete combustion of 1kg composite agricultural waste briquette, being a solid fuel was determined using the following equation given by [9].

$$W_T = 11.5C + 34.5\left(H - \frac{O}{8}\right) + 4.3S \quad (2)$$

Where W_T is the theoretical Air-Fuel ratio of the composite agricultural waste briquette.

2.6 Determination of Theoretical Weight of Dry flue gas per kilogram of Composite Agricultural Waste Briquette.

The total theoretical weight of dry flue gases per kilogramme of the composite agricultural waste briquette was determined, using equation (3).

$$W`_{dfg} = \frac{28}{12}C + \frac{44}{12}C + \frac{64}{32}S + 0.768 W_T + N \quad (3)$$

Where W_{dfg} is the theoretical weight of dry flue gas per kilogram of composite agricultural waste briquette.

3 RESULTS AND DISCUSSION

The results of the ultimate analysis and the determination of the heating values of the composite agricultural waste briquettes are depicted in Table 2. The results of the determination of the theoretical air- fuel ratio and weight of dry flue gas of the composite agricultural waste briquettes are shown in Table 3.

Table 2: Ultimate Analysis Heating value of the Composite agricultural waste briquettes.

Parameters	Ricehusk/ groundnut shell briquette	Ricehusk /sawdust briquette	Groundnut shell/ sawdust briquette.
Ash content %	18.21	18.4	2.1
Carbon content%	48.7	51.6	53.1
Hydrogen ` content%	6.2	7.8	8.1
Nitrogen	0.71	0.66	0.93

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content%			
Sulphur content%	0.02	0.03	0.02
Oxygen content%	26.16	21.51	35.75
Heating value MJ/kg	17.92	19.47	19.86

Table 3: Ultimate Analysis and Determination of Heating Value of Homogenous Agricultural Waste done by Previous Researcher

	C%	H%	N%	S%	O%	Ash %	C_V MJ/kg	Source
Ricehu	42.1	5.8	0.38	0.05	51.6	18.6	13.38	[10]
sk	37.9	4.82	0.43	0.17	7	0	9	[11]
	0	5.57	0.36	0.03	34.	21.7	12.32	[12]
	38.2				*	16.4	15.15	
Groun	50.9	7.5	1.2	0.02	40.4	3.1	*	[6]
dnut	45.9	5.34	1.09	0.01	36.3	2.3	17.8	[13]
shell	*	*	*	*	*	*	15.7	[14]
Sawdu	52.2	5.2	0.47	*	40.8	1.2	*	[15]
st	48.5	3.96	0.24	0.01	27.1	7.94	*	[16]
	*	*	*	*	*	*	18.8	[17]

C_v represents heating value and * means not available.

Table 4: Theoretical Air-Fuel ratio and Weight of Dry flue gas per kilogram of the Composite Agricultural waste Briquette.

Types of composite briquettes	Air-fuel ratio	Weight of dry flue gas per kg of composite briquette
Ricehusk/groundnut shell	6.61	8.01
Ricehusk/sawdust	7.70	9.02
Groundnut shell/sawdust	7.36	8.85

It can be seen from Table 2 that, the carbon and hydrogen content of composite groundnut shell and sawdust briquettes are higher than that of composite ricehusk and sawdust briquettes and composite ricehusk and groundnut shell briquettes. When compared with the carbon and Hydrogen content of homogenous agricultural waste or briquette, that was determined by previous researchers depicted in Table 3, those of the composite briquettes are higher. The heating values of the composite briquettes were found to be higher than those of homogenous agricultural waste or briquette, as evident in Tables 2 and 3. It should however, be noted that heating value of biomass (Agricultural waste) depends on the percentage of carbon and hydrogen, because they are the main contributors to the heating values of biomass material [18], [19].

From Table 2, it can be seen that the percentage nitrogen content of the composite agricultural waste briquettes are higher than those of homogenous agricultural waste briquettes obtained by previous researchers shown in Table 3. It should be noted that the low percentage of nitrogen in the agricultural waste briquettes whether homogeneous or composite result in low emission of NO_x .The nitrogen that comes with air for combustion of agricultural waste does not oxide because it oxides at a temperature of about 1500^0C [9] and the combustion temperature of agricultural waste briquette is less than 1500^0C.

The percentage sulphur content in the composite agricultural waste briquette is very low as seen in Table 2. There are no significant increases when compared to those of homogenous agricultural waste determined by the previous researchers depicted in Table 3. However, the low sulphur content in any case will result in low emission of its oxides when the briquettes are combusted. The oxygen content of the composite briquettes is less than that of homogenous briquettes as seen in Tables 2 and 3. High amount of oxygen may lead to increase in NO_X and SO_X emission [7]. So, less emissions of the oxide of Nitrogen and Sulphur from composite briquette is expected, compare to those from homogenous briquette.

The ash content of composite Ricehusk and groundnut shell briquettes were found to be higher than that of homogenous groundnut shell briquettes. That of composite ricehusk and sawdust briquette is in an average range of the ash content of homogenous rice husk briquette and far higher than that of homogenous sawdust briquette. These are evident in Tables 2 and 3. It should be noted however, that high ash content reduces ignitibility of the fuel (briquettes) [20].

It can be seen from Table 4, that the composite Rice husk and sawdust briquette has the highest theoretical Air-fuel ratio followed by composite groundnut shell and sawdust briquette. The composite ricehusk and groundnut shell briquette have the least air fuel- ratio.

Nevertheless, in order to maximize combustion efficiency, the actual air - fuel ratio must be maintained as close as possible to the stoichometric ratio or theoretical air fuel ratio to reduce the amount of unburnt hydrocarbon in the combustion products [7].

From Table 4, it can also be seen that as theoretical air fuel ratio increased, the theoretical air flue gas increased. In actual practice, the weight of the flue gases are expected to be higher than the theoretical weight of the flue gases.This is because excess air is always used and the more the excess air is used the greater will be the weight of flue gas per unit weight of the fuel burnt [21].

4. CONCLUSION

Composite agricultural waste briquettes in the percentage ratio of 50:50 have enhanced Carbon and Hydrogen contents as well as heating value, as it is evident in this research work. So the composite agricultural waste briquettes provide better alternatives to fossil fuel for firing heating and melting devices.

Agricultural waste are produced in large quantities and are disposed indiscriminately most especially in the rural areas of developing countries, thereby causing health hazard. The increasingly use of these wastes in composite briquette form, also help in solving disposal problem apart from providing good alternatives to fossil fuel.

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