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ASSESSMENT OF THE EFFECT OF PARTICLE SIZE AND BRIQUETTE TYPE ON THE BULK DENSITY AND RESISTANCE TO HUMIDITY OF SOME SOLID BIOMASS BRIQUETTES

Omojogberun Yele Veronica*

* Department of Mechanical Engineering, The Federal Polytechnic, Ado-Ekiti, Nigeria

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ABSTRACT

Many developing countries generate millions of tons of agricultural wastes and forest residues every year. Handling and transportation of these materials which is difficult due to their low bulk density can easily be address through briquette production. Briquette quality which is greatly influence by its bulk density, calorific value and resistance to humidity is very important when deciding the materials and the particle size that will produce briquette of good quality. This research work centers on the assessment of particle size and biomass type that will give good bulk density and resistance to humidity. Three type of biomass materials with various particle sizes were selected viz: maize stalk (0.6, 1.0, 2.36, 4.75, 8.0, 9.5 and12.5mm), rice husks (0.6, 1.0, and 2.36mm), and sawdust(0.6, 1.0, 2.36, 4.75, 8.0, 9.5 and12.5mm). The bulk density and resistance to humidity was determined and it was discovered that rice husks briquette with particle size 0.6mm and 3% starch content have the best bulk density while maize briquette with particle size 4.75mm and 9% starch content give the best result for resistance to humidity therefore, for the purpose of packaging and transportation rice husks briquettes of size 0.6mm and 3% starch is recommended while for resistance to humidity, 4.75mm, 9% starch content of maize stalk briquette is recommended.

KEYWORDS: briquettes, starch content, bulk density and resistance to humidity.

INTRODUCTION

Many developing countries produce huge quantities of agro residues which are used inefficiently causing extensive pollution to the environment. The major residues are rice husk, coffee husk, coir pith, jute sticks, bagasse, groundnut shells, maize stalk, saw dust, mustard stalks and cotton stalks etc. [1]. Every year, millions of tons of agricultural wastes and forest residues are generated and are either wasted or burnt inefficiently in their loose form causing air pollution. Also, handling and transportation of these materials is difficult due to their low bulk density [2]. Biomass briquettes are a sustainable fuel made from biomass materials such as saw dusts, wood shavings, straws, rice husks, abandoned furniture etc. which are used to replace fossil fuels by households and industries. The quality of these briquettes is a very significant factor that is mostly influence by briquette calorific value, briquette density and resistance to humidity [3]. Densification of biomass can address handling, transportation and storage problem and has provided a great boost to the utilization of wood and other agricultural waste for domestic and industrial fuel [4]. However the processes involved in the production of these briquettes fuel makes it more expensive than fossil fuel [5].

Briquetting technology is yet to get a strong foothold in many developing countries because of the technical constraints involved and the lack of knowledge to adapt the technology to suit local conditions. Overcoming the many operational problems associated with this technology and ensuring the quality of the raw material used are crucial factors in determining its commercial success [6].

MATERIALS AND METHODS

The raw materials used for this work are maize stalk, rice husk, sawdust, paper pulp and starch (cassava extract).

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Preparations of Briquettes

Maize stalks were collected, cut into small pieces, soaked for 7days, pounded and dried for another 14 days due to the season. The dried maize stalks were grounded and rubbed over a sieve of 0.6mm, 1mm, 2.36mm, 4.75mm, 8mm, 9.5mm, 12.5mm in order to have various sizes. Rice husks and sawdust were collected and dried for 14 days to reduce the moisture content and then sieved. The dried rice husks were sieved using a sieve of particle size of 0.6mm, 1mm, 2.36mm through which three different particle size of rice husks were obtained while the dried saw dust was sieved using a sieve of particle size of 0.6mm, 1mm, 2.36mm, 4.75mm, 8mm, 9.5mm, 12.5mm through which seven particle size of sawdust were obtained.

Briquette from maize stalk, sawdust and Rice husks were produced using starch as binder and paper waste as an additive in the proportion of 80% (Maize stalk, sawdust and Rice husks) to 20% paper pulp additive. 3% and 4.5% of starch as binder were used for sawdust and rice husks briquette while 6% and 9% was used for maize stalk briquettes.

Bulk Density

The bulk density of briquette was determined by using the relation

$$BD = \frac{Bm}{Bv} \qquad (1)$$

Where:
BD = Bulk Density (kg/m^3)
Bm = mass of biomass sample (kg)
Bv = volume of measuring cylinder (m^3) [7, 8].
For this research work, the equation 1 was taken as;
BD = bulk density(g/cm^3)
Bm= mass of eight number of briquettes
Bv = volume of the container of the eight number of briquettes

Resistance to Humidity

For the resistance to humidity, the briquettes were placed in a container filled with water at room temperature (37^{0}C) for 72 hours and the changes in length and diameter of the briquettes were measured in other to determine the resistance to being humidify.
Changes in length =Final length after immersion for 72 hours – initial length before immersion
Changes in diameter = Final diameter after immersion for 72 hours – initial diameter before immersion.

RESULT AND DISCUSSION

Table 1and figure 1 is the result obtained for the bulk density of the briquettes and it showed that the briquettes made from 0.6mm, 1.00mm and 2.36mm particle sizes have better bulk density than the ones made from 4.75mm, 8.00mm, 9.50mm and 12.50mm particle sizes. It is however observed that the bulk density generally decreased as the particle sizes increased for all the briquettes produced and that rice husks briquettes of 3% starch content have the highest bulk density.

Table 1: Bulk Density of eight (8) pieces of Briquettes (g/cm^3)

			PARTICLE SIZES (MM)						
Biomass Materials	**Starch Content**		**0.6**	**1.0**	**2.36**	**4.75**	**8.0**	**9.5**	**12.5**
Maize Stalk	**6.5%**	**Bm**	464.4	339.2	176.8	348.96	326.8	354	355.2
		Bv	3131.884	3428.117	2705.04	3892.66	3488.675	3752.824	3763.0
		BD	0.14828	0.09895	0.06536	0.08965	0.09370	0.09433	0.09439
	9%	**Bm**	527.2	432.8	232.8	358.56	318.4	360	261.6
		Bv	3385.071	3201.536	3131.1	4189.14	4017.2	3505.632	4020.4
		BD	0.15574	0.135185	0.07435	0.08559	0.07925	0.10269	0.06507
Rice Husk	**3%**	**Bm**	628.4	560.24	415.2	Size not applicable			
		Bv	2706.867	3677.44	2464.46				
		BD	0.23215	0.15235	0.16848				
	4%	**Bm**	595.6	549.6	419.2				
		Bv	2828.07	3684.51	3250.033				

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		BD	0.21060	0.14917	0.12898				
Saw dust	**3%**	**Bm**	376	344.8	380.08	380.8	343.2	353.6	304.8
		Bv	3427.92	3650.722	3279.68	3572.1	2924.555	3917.848	3517.875
		BD	0.10969	0.09444	0.11611	0.10660	0.11735	0.10279	0.08253
	4.5%	**Bm**	412	345.6	525.04	384.8	376.8	394.4	379.2
		Bv	3494.884	3572.1	3351.6	3458.534	3311.937	3439.8	3692.997
		BD	0.11789	0.09675	0.15665	0.11126	0.11377	0.11466	0.10268

KEY: Bm – Bulk mass,
Bv–Bulk volume and
BD–Bulk Density.

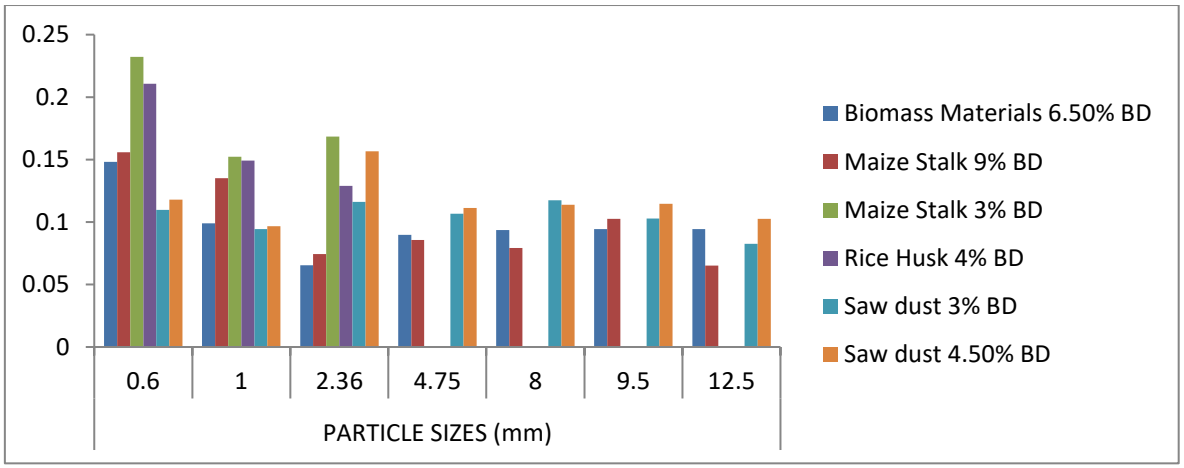

Figure 1: Chart showing the bulk density of 8 pieces of briquettes for the different composition

Also, tables and figures 2& 3 showed the result of the test carried out to determine the resistance to humidity, it was observed that briquettes produced with smaller particle sizes such as 0.6mm and 1.00mm have better resistance to humidity than the briquettes produced from the bigger particle sizes say 2.36mm, 4.75mm, 8.00mm, 9.50mm and 12.50mm.

Table 2: Resistance to Humidity of the briquettes for different composition (Change in length)

			PARTICLE SIZES (MM)						
Biomass Materials	**Starch Content**		**0.6**	**1.0**	**2.36**	**4.75**	**8.0**	**9.5**	**12.5**
Maize Stalk	**6.5%**	**Li**	76.0	77.0	65.0	85.0	83.0	83.5	75.0
		Lf	95.1	97.0	97.6	98.5	100.1	101.2	102.3
		ΔL	19.1	20.0	32.6	13.5	17.10	17.7	27.3
	9%	**Li**	79.0	74.0	71.0	85.0	83.0	78.0	76.0
		Lf	94.1	96.5	97.0	97.5	98.1	100.6	101.1
		ΔL	15.1	22.5	26.0	12.5	15.1	22.6	25.1
Rice Husk	**3%**	**Li**	67.0	85.0	61.0	Size not applicable			
		Lf	98.5	99.4	101.5				
		ΔL	32.0	15.5	41.6				
	4%	**Li**	70.5	85.0	73.0				
		Lf	98.5	99.4	101.5				
		ΔL	28.5	14.4	28.5				
Saw dust	**3%**	**Li**	80.0	82.0	78.5	81.0	70.0	88.0	81.0
		Lf	98.6	98.9	100.2	100.8	101.2	101.4	101.9
		ΔL	15.6	16.9	21.7	19.8	31.2	13.4	20.9
	4.5%	**Li**	83.0	81.0	76.0	81.5	73.0	78.0	77.0
		Lf	100.3	101.5	101.6	101.8	102.5	102.8	102.8

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		ΔL	17.3	20.5	25.6	20.3	29.5	24.8	25.8

KEY: Li – Length before immersion in water,
Lf – Length after immersion in water
ΔL – Change in length

Table 3: Resistance to Humidity of the briquettes for different composition (Change in diameter)

			PARTICLE SIZES (MM)						
Biomass Materials	**Starch Content**		**0.6**	**1.0**	**2.36**	**4.75**	**8.0**	**9.5**	**12.5**
Maize Stalk	**6.5%**	**Edi**	51.0	51.0	51.0	54.0	54.0	52.0	51.0
		Edf	52.1	55.0	55.0	56.0	56.5	57.0	57.5
		ΔED	1.1	4.0	4.0	2.0	2.5	5.0	6.5
	9%	**Edi**	51.0	51.0	51.0	52.0	51.0	53.0	53.0
		Edf	53.0	54.5	55.6	55.6	55.8	56.0	56.5
		ΔED	2.0	3.5	4.6	3.6	3.8	3.0	3.5
Rice Husk	**3%**	**Edi**	51.0	51.0	55.0				
		Edf	55.0	56.0	56.5				
		ΔED	4.0	5.0	1.5				
	4%	**Edi**	49.0	52.0	51.5				
		Edf	55.0	56.0	56.5				
		ΔED	6.0	4.0	5.0				
Saw dust	**3%**	**Edi**	51.0	51.5	52.0	52.0	51.0	53.0	51.0
		Edf	56.0	56.5	56.8	56.8	56.9	56.9	57.0
		ΔED	5.0	5.0	4.8	4.8	5.9	3.9	6.0
	4.5%	**Edi**	51.0	53.0	51.0	52.0	51.0	51.0	51.0
		Edf	57.0	57.5	57.5	57.8	58.0	58.5	59.0
		ΔED	6.0	4.5	6.5	5.8	7.0	7.5	8.0

KEY: Edi – Initial Diameter before immersion in water,
Edf – Final Diameter after immersion in water
ΔED – Change in Diameter

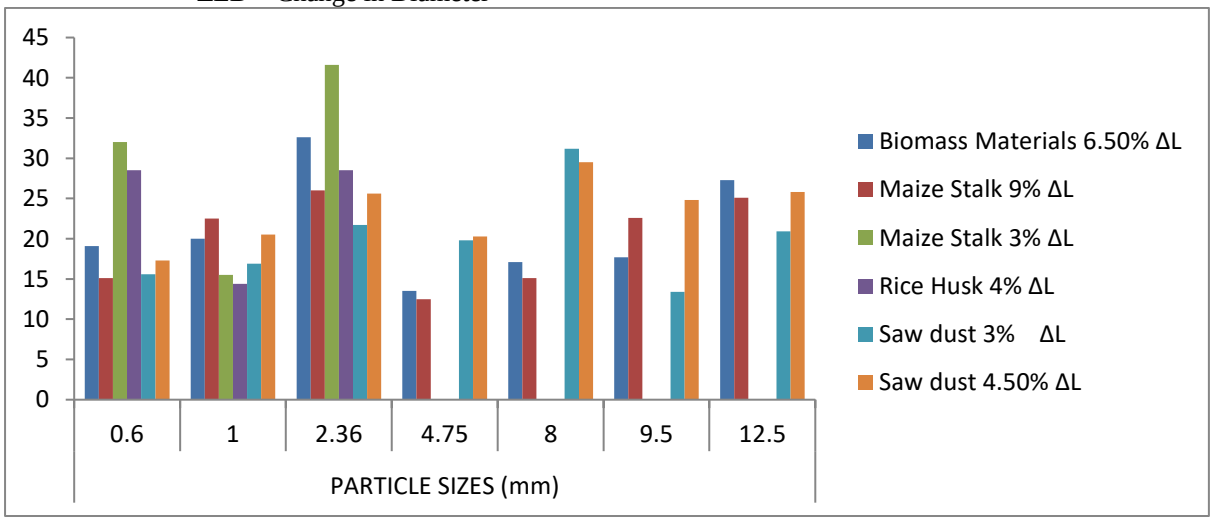

Fig 2: Chart showing the changes in length for the resistance to humidity test of the briquettes for the different composition

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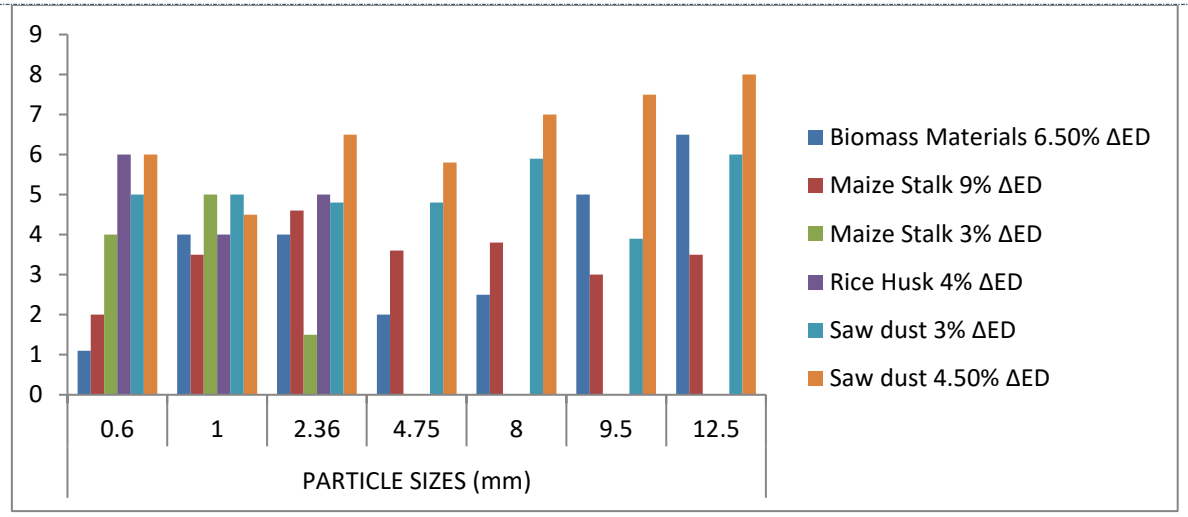

Fig 3: Chart showing the changes in diameter for the resistance to humidity test of the briquettes for the different composition

CONCLUSION

It can be concluded from the bulk density result that briquettes with smaller particle sizes and higher starch content have better bulk density than others due to better compaction of these briquettes. Also, the briquettes produced from 0.6mm particle size for the three biomass materials showed better result for resistance to humidity.

For the purpose of packaging and transporting; briquettes with good bulk density should be produced and for this study rice husks briquettes of 0.6mm particle size and 3percent starch content is recommended when considering production of briquette with good bulk density. For resistance to humidity, maize stalk briquette of particle size 4.75mm and starch content of 9percent is recommended because it offered the best resistance to humidity.

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