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Agglomeration of Wood Dust and Charcoal Powder for Solid Fuel Production.

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ABSTRACT
Briquette which is a block of solid fuel was obtained from the compaction of charcoal powder, wood dust, with three different binders. Cassava starch, wood tar and molasses. Briquette is a common coal used as a source of fuel in industrial boilers, and commercial purposes. Charcoal is material without plasticity and cannot be mould into shape without adding a binding material which helps to hold the particles together. Briquettes was formed using charcoal dust, an agglomerating material such as wood dust is added to the charcoal powder, starch from cassava was prepared and served as the binding agent for the two materials. Pressure was then applied to the mixture to form a solid fuel called briquette.

KEYWORDS: ***Agglomeration, Charcoal, Plasticity, Solid fuel, Wood dust***

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I. INTRODUCTION

Nigeria has an abundant supply for biomass resources, particularly from agro-forestry residues and some solid waste. Briquette is a block of compressed coal dust, charcoal dust, sawdust, wood chips or biomass, and is used as a fuel in stoves and boilers. Charcoal is a material without plasticity and cannot be mould into shape without adding a binding material. To form charcoal dust into briquettes, an agglomerating material is added to the charcoal dust and then pressure is applied to the mixture to form a briquette.

Fig 1: Briquettes from charcoal, wood dust and binder

Making fuel briquettes is a tedious and messy work. If one is seeking for high-paying dirty jobs, then, one may consider making charcoal briquettes to sell to one's neighborhood. The demand for briquettes is high. Once the charcoal briquettes have been made, they are cleaner and smokeless than the lump charcoal; - that is the reason many people prefer using it. A lot of income can be generated by making fuel briquettes for use in home and in addition by selling excess briquettes to other people in the city.

Other sources of energy that is environmentally friendly and also cheaper is needed as an emerging trend in the growing environmental concerns, particularly climate change resulting from the use of non-biodegradable fossil fuels and the needs for renewable energy supply to sustain economic development. Biomass resources are readily available source of renewable energy and equally environmentally friendly than fossil fuel. These resources are obtainable from wood tar from sawmills, charcoal powder, etc. This made it necessary to look into the problem and result into a meaningful way of re using these resources.

II. LITERATURE REVIEW

Agricultural and forestry biomass residues have the potential for the sustainable production of bio-fuels and to offset greenhouse gas emissions [1,2]. Due to its high moisture content, irregular shape and size, and low bulk density, biomass is very difficult to handle, transport, store, and utilize in its original form[3].

The quality of fuel pellet is usually assessed based on its density and durability. High-density of pellet represents higher energy per unit volume of material, while durability is the resistance of pellets to withstand various shear and impact forces applied during handling and transportation. High bulk density increases storage and transport capacity of pellets. Since feeding of boilers and gasifiers generally is volume-dependent, variations in bulk density should be avoided [4].

Carbonization is a way to increase energetic density (when compared the char heating value with that of raw biomass) and hydrophobicity that results in a decrease of moisture content and that of microbiological growing [5-8]. A bulk density of 650 kg/m3 is stated as design value for wood pellet producers [9]. Low durability of pellets results in problems like disturbance within pellet feeding systems, dust emissions and an increased risk of fire and explosions during pellet handling and storage [10]. This problem usually caused by carbonization of the biomass that results in formation of products that are friable and lead to generation of dust. The problem can be overcome by milling and pelletizing the carbonization products with adequate binder

Preprocessing is usually done before densification(pellet formation) of biomass. Through density, durability, impact resistance and compact resistance can be increased by preprocessing process. Steam conditioning and preheating (direct or indirect) can be done to increase the binder properties. However, cost on preprocessing makes the fuel pellets cost ineffective during pelletization. Selection of binder can play the important role to achieve the same desired properties of pellets including strength, durability and compact resistance as achieved by preprocessing that leads to economical pellet production without steam conditioning and preheating of biomass material. Biomass resources have been known to be important sources of renewable energy[11]. The biomass may be obtained directly from forestry plantation or indirectly as residues(by-products)from processing of former. This contributed to large losses of covered area as a result of deforestation which affect climate change. The situation may be compounded by emission of greenhouse gasses from indiscriminate burning of the biomass resources. Due to the huge quantities of residues that are produced and accumulated as sawdust (from irregular-shaped pieces of wood)and indiscriminate burning of the residues that are not environmentally friendly it necessitates that the residues could be used as a raw material in the production of energy [12].

In this work, the agglomeration of charcoal produced from sawmill waste with three different binders (wood tar, molasses sand starch) was studied. Different binders have been used in order to achieve particle agglomeration and good cohesion properties [13-14].

III. MATERIALS AND METHODS

Materials

i) 50 kg charcoal dust/fines
ii) 4 kg sawdust
iii) 5 kg starch
iv) 5 kg molasses
v) 5 kg wood tar
vi) 200 µm sieve,
vii) 500 ml beaker

Methods

The pellets used for the research were prepared by mixing and compacting the raw materials together manually. The binder used was wood tar with a mass ratio charcoal/tar wood/ dust of 1:1:1.Cold compression was used to produce rectangular pellets of mass 0.56-0.65 g, with length 1.5cm, breadth 1.0 cm and a height 0.7 cm. Samples were cured in an oven at 105 °C over a period of 24 hrs. This is to obtain adequate durability and uniformity in the pellets produced. Pellets were cured and stored in a desiccator.

Mechanical resistance tests were carried out for further experiment. Following same processes, molasses was employed as a binder for a better agglomeration. Weight ratio of1:3:3 molasses/charcoal/wood dust were used to produce rectangular pellets of mass 0.55-0.65 g, length of 1.5cm, breadth of 1.0 cm, and height 0.7 cm. samples produced were cured in the oven between 162 -179 °C for 24 hrs. The temperature range used were chosen from (standard temperature gradient) TG data. This ranges are standard and does not allow molasses combustion and also gives a proper caramelization. Starch was also used as another binder. This was achieved by carefully dissolving 3kg powdered starch into 500ml of cold water. 3000ml of water was allowed to boil and then poured into the cold mixture of starch to obtain a gelatinous mixture which makes up the binder. 50 g of 30-50 mesh preheated charcoal were added while stirring slowly. Also, 5 kg of wood dust was also added and stirred continuously to obtain the required texture. The mixture obtained was cooled and shaped into rectangular pellets. This was further cured at 105 °C for 24 h.

IV. ANALYSIS OF RAW MATERIALS

The raw materials were analyzed. Test conducted on the raw materials include the proximate analysis and elemental analysis, heating value, density and energetic density.

Table 1: Energetic Densities.

Sample	Energetic Density ED K (GJ m-3)	Packed Energetic Density PED (GJ m-3)
Wood Residue	13.6	3.7 – 5.3
Sawdust	-	5.3
Charcoal	9.6	3.5
Charcoal Dust	-	6.4
Tar Pellet	17.1	9.1
Molasses Pellet	13.9	7.4
Starch Pellet	10.9	5.7

Table 2: Proximate and Elemental analysis of raw materials (%, dry basis).

Sample	Proximate Analysis				Elemental Analysis (ash free)			
	Moisture Content	Ash content	Volatility	Fixed Carbon	C	H	N	Oa
Wood residue	9.4	0.3	87.6	12.0	46.3	5.6	< 0.1	43.5
Molasses	19.1	5.6	82.4	6.2	40.5	3.6	0.8	50.5
Wood tar	12.6	4.1	66.0	26.1	38.2	6.0	< 0.1	51.6
Tar pellet	9.1	2.6	42.0	49.1	71.9	3.4	0.4	19.5
Starch pellet	3.0	1.3	25.0	73.3	80.1	2.8	< 0.1	17.0
Starch	12.1	0.5	96.1	1.5	44.7	5.4	0.4	45.3
Charcoal	6.1	1.2	17.0	77.4	75.1	2.2	< 0.1	18.2
Molasses pellet	1.7	5.1	32.5	59.4	65.7	3.1	0.5	26.6

Table 3: Heating values, and densities of raw materials.

Sample	High heating value (MJ kg-1)	Low heating value (MJ kg-1)	Apparent density (g cm-3)	Bulk density (g cm-3)
Wood residue	16.8	15.4	0.623	0.20- 0.26
Sawdust	16.9	15.5	-	0.26
Charcoal	27.5	27.3	0.23	0.12
Charcoal dust	29.7	29.3	-	0.23
Wood tar	21.5	20.3	1.18	0.30
Molasses	15.1	11.8	1.49	0.31
Starch	17.0	16.0	0.56	0.19

V. DISCUSSION OF RESULTS

Differences among wood residue and charcoal values can be explained by the de-volatilization during carbonization, which produces an increase in ashes content, fixed carbon and carbon content, as well as a decrease in oxygen content as a consequence of CO and CO_2 formation. Molasses and starch showed low fixed carbon content as expected. For charcoal and charcoal dust, their heating values are the highest for all the samples and their apparent and bulk densities are the lowest. The low value of charcoal bulk density is the justification for a densification attempt.

Auto-ignition temperatures of about 300 °C, 270 °C and 380 °C were found in wood tar, starch and charcoal, respectively. For all the graphs but that of charcoal two main peaks are shown: one at low temperatures, corresponding to volatile ignition, and a second one close to 500 °C, corresponding to char combustion. In the case of molasses, a peak beginning at 120 °C with maximum at 140 °C appears; it is attributable to molasses caramelization. At 177 °C volatile matter combustion begins, reaching a maximum at 200 °C. At 440 °C charcoal combustion starts.

VI. CONCLUSION

Briquettes-based fuel remains one of the most important form of fuel. It is useful for industrial applications and laboratory use. The conclusion drawn from this study is that good quality and highly storable/durable briquettes can be produced from a mixture of saw dust charcoal, and binders. Briquetting reduces landfill; briquette reduces wastes, it also gives considerable employment opportunities because it turns unused materials into valuable energy products). This means that there will be an income increase for households as lesser amount of money will be required to acquire energy. Lastly the energy or heat produced by the briquettes is equal to that of fuel wood and kerosene. Hence it can be used in place of fuel wood and kerosene.

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