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Determination of physical and mechanical properties of briquettes produced from carbonized rubber seed shell using local binder

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Abstract
Briquette was produced from rubber seed shell for maximum optimization of rubber seed. Rubber seed shell was carbonized to produce char and local binding agent was added in the ratio of 3:1. The mixture was poured into cylindrical mould to form briquette. The briquette produced was neat and has light weight. Mechanical test was carried out to determine the compressive strength of the briquette. Samples of the briquette were loaded longitudinally and transversely to investigate axial pressure failure and cleft failure. The test samples have average value of 1.08×10^{-3} KN/mm^2 and 2.84×10^{-4} KN/mm^2 in longitudinal and transverse loading respectfully. Briquettes produced found application in domestic cooking and as a fuel in ribbed smoked rubber sheet processing.

1. Introduction

Biomass is the only renewable source of fixed carbon and therefore it has attracted considerable attention as a renewable energy source in recent years according to Yorgun et at., 2001 as quoted by Ayhain Demirbas 2004 cited by Jaan, 2010 [1].

Table 1.1. *Household energy consumption as a percentage of total biomass consumption in a number of selected African countries*

Country	Biomass energy consumption (% of total energy consumption)	Household energy consumption (% of total biomass energy)
Burundi	94	78.5
Ethiopia	86	97
Kenya	70	93
Somalia	87	92
Sudan	84	90
Uganda	95	78.6

Source: FWD, 1992 cited in Karekezi 1998 as quoted by practical action.

Biomass is a simplest form of energy known, it produces open fire that provides heat fir cooking, warming water or warming the air in our home. More than two million people in the developing countries use biomass for the majority of their household energy needs. Table 1.1 shows household energy consumption as a percentage of total biomass consumption in a number of selected countries in Africa.

For improvement and efficient utilization of agricultural product and other biomass residues, their density must be worked on to produce pellets and briquettes. Briquetting biomass improve its handling characteristics, increase the volumetric calorific value, reduces transportation costs and makes it available for a variety of application.

Briquetting is a way converting loose biomass residues, such as sawdust, straw or rice husk, and agricultural seed shell onto high density solid blocks that can be used as a fuel [Ashden technology]. Briquetting can also be defined as the process of conversion of agricultural waste onto uniformly shaped briquettes that are easy to use, transport, and store.

The briquetting technologies can be divided (based on compaction) into, High pressure compaction, Medium pressure compaction with a heating device, and Low pressure compaction with a binder.

At present there are two high-pressure of technologies for producing briquettes; piston press, that produces a completely solid briquettes, and screw extrusion press that produces homogeneous briquette with a concentric hole, which gives better combustion characteristics due to a larger specific area, and cannot be disintegrate easily [3].

The binding materials used in low pressure compaction are to strengthening the briquettes. Binders are divided into combustible binder prepared from natural synthetic resins, animal manures or treated, dewatered sewage sludge, and non-combustible binder such as clay, cements, and other adhesive minerals [3].

The rubber seed weight is between 3.5-6.0 g, it is ovoid in shape with the ventral surface slightly flattened. The average sizes of rubber seed is 15.2 mm longitudinally and 2.0 mm transversely. The seed coat (husk) is hard and shiny, brown or grey to brown with numerous darker mottles or streaks on the dorsal surfaces, but few or none on the ventral side [4].

The average weight of the dried seed is about 4.5 g, the kernel of the rubber seed is roughly half the weight of the total seed [5]. Rubber plant grows for about 4 – 5 years before it starts to flower. In Nigeria flowering is once between February and March, while in Malaysia flowering is twice a year between March and April and between August and September [6]. Rubber fruit drops naturally when matured and dehisces to release seeds which are then picked by hand from the plantation floors for use as seedlings which are later grafted with scions as improved planting materials or for processing into rubber seed oil. Rubber seed oil and cake are extracted from the rubber seed after processing. The oil is a semi drying oil that contain 29% saturated, 23% oleic, 32.5% linoleic and 22.5% linolenic, the oil is used in production of putty, hair shampoo and also used as industrial oil (raw materials) to replace linseed oil. The rubber seed is also used in the manufacture of putty and alkyds resins, which find application in the paint and leather industry. Furthermore, rubber seed cake extracted from rubber seeds is valuable in livestock feeds [8]. The cake contains tolerable quantities of cyanogeni glucoride and can be used as livestock concentrate after drying and toasting [7]. Nigeria has a total of about 247,100 hectares of land under rubber cultivation and it is estimated to yield a total of 43,000 tonnes of rubber seeds which if properly harnessed will add value to the downstream sector of the rubber industry in the areas employment generation for seed collection and processing.

2. Material and Methodology

2.1. Material Collection and Preparation

Quantity of Natural rubber seeds were collected from rubber plantation at Rubber Research Institute of Nigeria, Iyanomo, Benin City. The collected rubber seed were cleaned and sun dried for 5 days to reduce moisture in other to ease dehulling process.

2.2. Shell Removal

Shells (the outer coat of the seed) were manually removed by beaten with stone and the kernels were separated from the shells by hand picking. The weight of the work sample was found to be 2.0 kg as weighed on beam balance.

2.3. Production of Char: Fabrication of Carbonizer

In production of char a carbonizer is used to provide low oxygen environment. It has an opening at the top for loading the dry rubber seed shell and an opening at the bottom for firing and removal of smokes. Generally, the carbonizer is divided into carbonization chamber and firing chamber. The carbonizer is 24 cm high and 23 cm in diameter.

2.4. Carbonization

The dry rubber seed shell is loaded into the drum through the opening at the top. Papers and the rubber seed shell inside the cylinder catches fire easily. Air enters the cylinder through the holes at the bottom and supports combustion of rubber seed shell which was allowed to burn for about 10 to 15 minutes.

After the smoke became clear, the openings at the top as well as at the bottom of the cylinder were closed to block air entrance into the drum. Then the cylinder made to rest on the ground. The side of the drum resting on the ground was covered by the soil. At the same time, top opening covered by the metal cover and sealed tightly using some soil. The drum was left undisturbed for two hours for the complete combustion of rubber seed shell (decompose) in the absence of air.

2.5. Binding Agent Preparation

Binding agent used is starch from cassava tuber because is cheaper, readily available, and support combustion.

2.6. Briquettes Composition

The samples was briquetted by mixing properly with binding agent, poured into the mould, and allowed to dry naturally under average temperature of 35 degrees centigrade for two weeks.

Figure 1. *Dry Rubber Seed*

Figure 2. *Carbonizer*

Figure 3. *Carbonization*

Figure 4. *Briquettes Produced*

Figue 5. *Axial Pressure Condition Test*

Figure 6. *Cleft Failure Conditon Test*

3. Result

3.1. Physical Properties

The briquette produced is easy to handle without fear of stay. It has light weight and average density of 6,478.78 kg/m^3.

3.2. Mechanical Properties (Compressive Test)

Longitudinal Direction

$$\text{Surface Area} = \pi r^2 \quad (1)$$

$$\text{Compressive Strength} = \frac{load\ (KN)}{surface\ area\ (mm^2)} \quad (2)$$

Table 1. *Compressive Strength under Axial Pressure Condition*

Samples	Load (KN)	Radius (mm)	Surface Area (mm^2)	Compressive Strength (KN/mm^2)
A	2	24.8	1932.46	1.034×10^{-3}
B	2	23.2	1691.15	1.183×10^{-3}
C	2	25	1963.75	1.018×10^{-3}
D	2	24.9	1948.07	1.027×10^{-3}
E	2	23.5	1735.17	1.153×10^{-3}

Average Compressive Strength on Axial Pressure Condition is $1.083 \times 10^{-3} KN/mm^2$

Lateral Compressive Strength

$$\text{Lateral Surface Area} = 2\pi rh \quad (3)$$

Table 2. *Compressive Strength under Transverse Loading*

Samples	Load (KN)	Radius (mm)	Height (mm)	Lateral Surface Area (mm^2)	Compressive Strength (KN/mm^2)
F	1.5	26.5	33.2	5523.66	2.70×10^{-4}
G	1.5	25.2	32	5067.42	2.96×10^{-4}
H	1.2	23.9	30.6	4595.74	2.60×10^{-4}
I	1.5	24.8	31.7	4940.23	3.04×10^{-4}
J	1.5	25.25	32.5	5156.81	2.91×10^{-4}

Average Compressive Strength on lateral loading $2.84 \times 10^{-4}\ KN/mm^2$

4. Conclusion

Rubber seed shell can be made into briquettes by carbonizing the shell and introducing binder. Briquettes production reduces deforestation that may leads to environmental hazards. Briquettes fuels are environmentally friend. It is used domestically using locally fabricated briquette stove. Industrially it found application as a source of fuel for steam generating system. Briquette also serves as alternative fuel in smoke house for production of ribbed smoked rubber sheet. The production of briquettes from rubber seed shell char will enable the natural rubber (trees) growing farmer's utilize rubber seed to its zero level.

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