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EFFECTS OF PROCESSING PARAMETERS 0N THE MECHANICAL PROPERTIES 0F BRIQUETTES PRODUCED FROM CORN COBS, GROUNDNUT SHELLS AND CASSAVA PEELS: A COMPARATIVE ANALYSIS.

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Abstract - Indiscriminate dumping of refuses along major roads, in drainage systems and (or) streams and rivers have been a major challenge to developing countries, especially Nigeria. The densification and conversion of these wastes to useful products such as briquettes have reduced the handling, transportation, storage as well as the pollution problems encountered in the management of these wastes. The purpose of this work is to evaluate and compare the effects of process parameters (biomass concentration, dwell time and pressure) on the mechanical properties of briquettes produced differently, from corn cobs(COB),groundnut shells(GNS) and cassava peels(CSP)with cassava starch as binder. The mechanical property investigated was the shattering index. Five different blends each of COB,GNS and CSP and cassava starch binder, in the ratios of 50:50, 60:40, 70:30, 80:20 and 90:10, were separately mixed to produce briquettes of various constitutions. The results of the analyses showed that the shattering indices for the biomass concentrations of 50:50, 60:40 and 70:30 ratios for COB, GNS and CSP, ranged from 0.997 to 0.999. For the dwell time between 30 to 50 mins., the shattering index ranged between 0.925 (GNS) to 0.978(CSP).The result also showed that at pressure 38KPa, the shattering indices increased for all the biomass briquettes with GNS and CSP being highest at 0.999.These showed that GNS and CSP, in the ratios of 50:50, 60:40 and 70:30, would be suitable for production of high quality stable and durable briquettes and that biomass concentration and pressure are paramount parameters that determine the stability and durability of biomass briquettes.

KEYWORDS: Corncobs, Groundnut shells, Cassava peels, Cassava starch, Briquettes, Shattering Index, Biomass concentration, Pressure.

1.INTRODUCTION

The management and recycling of wastes have been major problems facing the developing countries. Developing countries such as Nigeria, do little or nothing as regards the recycling of agricultural waste products into useful products. This has led to environmental problems such as pollution, resulting from indiscriminate dumping of refuse on the streets, in the drainage systems and water ways, causing blockages of water ways on rainy days. This practice has also led to the outbreak of epidemics (Yahaya et al., 2012).

Biomass as an alternative fuel source is introduced to meet the ever-increasing energy demand and to avoid the overall dependency on fossil fuel. The use of biomass according to research is a better alternative because of its renewability, abundance and environmental friendliness which includes no release of carbon dioxide and very low sulphur content (Karunanity et al, 2011). Biomass in its primary form is difficult to handle, transport, store and utilize because of its high moisture content, irregular shape and size and low bulk density. One of the major limitations of biomass for energy purposes is its low bulk density typically ranging from 80-100kg/m³ (Sokhansanj and Fenton 2006; Mitchel et al. 2007). The low bulk densities also present challenges for technologies such as coal firing, because the bulk density difference causes difficulties in feeding the fuel into the boiler and reduces burning efficiencies.

Biomass densification is one of the promising options for overcoming the bulk-density challenges or difficulties experienced in the handling of biomass. This is because biomass in its original form is bulky, wet and dispersed. Biomass densification involves technologies for converting plant residues into fuel. The mechanical compression of the biomass during densification increases its density to about ten folds. These densification technologies include pelletizing, briquetting or agglomeration to improve the handling characteristics of the biomass materials.

In this study, corn cobs, groundnut shells and cassava peels were used as the feed stocks for the production of briquettes. The aim was produce stable and durable briquettes which would be used as alternative energy sources as well as to reduce the pollution problems these wastes (feed stocks) pose to the environment. Cassava starch was used as a binder.

Corn cob is the central core of an ear of maize (Zea mays sp. mays). It is the part of the ear where the kernels grow. The inner most part of the cob is white and has a consistency similar to foam plastics (Roth et al, 2014). Groundnut, also known as, peanut or goober is of the family Arachis hypogeal. It is a legume crop grown mainly for its edible seeds. The fruit (pod, nut) of peanut consists of external husk (hull or shell) (21-29%) surrounding the nut 79-71% (Van, D. 2013). Peanut husks are the by-products of peanut processing. The shelling of the peanuts comes immediately after cleaning of the peanut for the production of peanut oil and other peanut products which are mainly edible. Groundnut or peanut husks/shells usually consist of fragmented hulls with variable amounts of whole or broken kernels (Hill, 2002).Peanut hulls are a bulky waste generated in large amounts. In the recent past, environmental concerns have led to an interest in using peanut shells for a variety of purposes (Henzé et al, 2017).

Cassava, also known as tapioca, is of the species Manihot esculenta (Euphor -biaceae). Cassava peels represents 5 to 15% of the root (Aro et al., 2010). They are obtained after the tubers have been cleaned with water and peeled. Fresh cassava peels contain phylates and large amounts of carcinogenic glycosides. Oyelaran et al (2015) in their work titled "Performance Evaluation of the Effects of Waste Paper on Groundnut Shell Briquettes", studied the combustion characteristics of binder-less briquettes produced from waste paper and groundnut shells in the ratios of 10:90, 20:80, 30:70, 40:60 and 50:50 respectively. Oladeji (2010) in his research titled "Fuel Characterization of Briquettes Produced from Corncobs and Rice Husks", studied the properties of briquettes produced from the above named biomass residues.

2. MATERIALS AND METHODS.

The corn cobs (COB) and groundnut shells (GNS) were collected from various refuse sites in Enugu State while the cassava peels (CSP) and cassava starch were gotten from garri-processing farms in Anambra State, both in South-Eastern Nigeria. The samples were sundried for one week to a moisture content of about 12%, then milled separately using an electric milling machine and then sieved with a sieve shaker of 2.5mm mesh size to obtain the desired particle size. The biomass samples were separately mixed with binders in the ratio of 50:50, 60:40, 70:30, 80:20 and 90:10 with the addition of water.

Productions of the briquettes were done by loading 100gms of charges of the three different biomass samples (separately) into the moulds of the 30-tons hydraulic briquetting machine for compression. Compression pressures of 19KPa, 23KPa, 28KPa, 33KPa, 37KPa and dwell times of 10, 20, 30, 40 and 50 minutes were used.

The durability (shattering indices) of the COB, GNS and CSP were measured after fourteen days of formation. This is the ability of the briquettes to remain undamaged when handling during transportation and storage. This was done in accordance with the ASTM D440-86 (2002) standard. 50gms of each of the briquette samples were put into a polythene bag and dropped from a height of 2m onto a concrete floor three times. The briquettes and fragments were screened and sieved using a mesh. The durability of the briquettes is computed as:

$$\frac{weight\ of\ briqutte\ after\ dropping}{weight\ of\ briqutte\ before\ dropping} \quad \textbf{2.1}$$

The process variables considered in this study were biomass concentration, dwell time and compaction pressure. The design of experiment was done using the Response Surface Methodology to optimize the production of the briquettes.

3. RESULTS AND DISCUSSIONS

Effects of biomass concentration on shattering index

The effect of biomass concentration on the shattering index of the briquettes was conducted. It was seen that the shattering index reduced as biomass concentration increased and this could be as a result of reduction in binder proportion. It could be deduced that the quantity of biomass used greatly affects the durability rating of the briquettes. The values of shattering index for the biomass concentration of 80 and 90% for the different biomass considered were low, thus, they might not be suitable for briquettes production. Among the biomass used for the briquettes, cassava peel briquette has higher shattering index and this could be that the binder has high influence on it than other binder ratios. Therefore, shattering index of biomass concentration of 50, 60 and 70% for all the biomass falls within the acceptable range of Kaliyan and Morey (2006) for production briquettes. This implies that they are the suitable biomass concentration levels required to produce high quality briquettes that can survive mechanical handling and movement from one location to another, with cost-effective feasibility and environmental friendliness. Similar result was obtained by Davies and Davies, (2013).

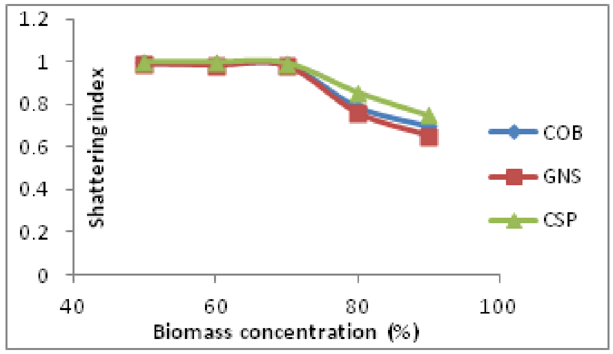

Figure 1: Effect of biomass concentration on shattering index.

Effects of dwelling time on shattering index.

Figure 2 explained the effects of dwelling time on the shattering index of the briquettes. It was observed that the shattering index increased as dwelling time increased and this could be as a result of adequate compacting period which enabled the binder to disperse uniformly. It could be noted that the dwelling time affected the stability rating of the briquettes. The values of shattering index for the dwelling time of 30 to 50minutes were high, thus, they are suitable for production of durable briquettes.

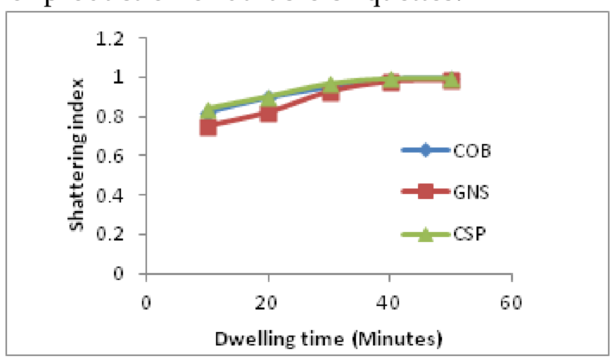

Figure 2. Effects of dwelling time on shattering index.

Effects of pressure on shattering index

Figure 3 showed the effect of pressure on the shattering index of the briquettes. The obtained values showed that increase in pressure increased the long-lasting capacity of the briquettes. The effect of pressure on the durability is massive. The mechanical interlocking as well as the increased adhesion between the particles is due to the densification of biomass under high pressure, forming intermolecular bonds in the contact area. It was seen that all the biomass samples used followed related trend. Similar result on the effect of pressure on shattering index was obtained by Davies and Abolude, (2013).

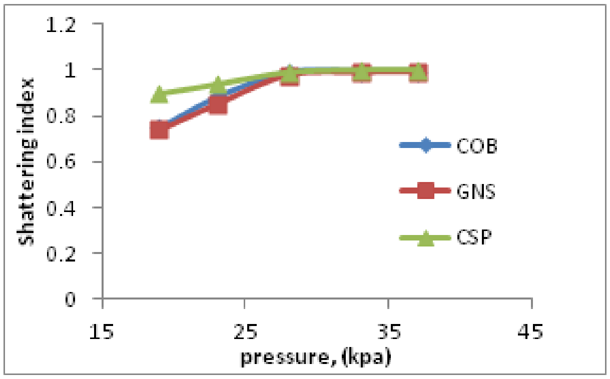

Figure 3: Effect of pressure on shattering index.

4. CONCLUSION

This comparative study was done to evaluate the effect of process parameters on the shattering indices of the three biomass briquettes produced from corn cobs, groundnut shells and cassava peels with varying biomass concentrations, dwell times and pressures. The pressure as well as the biomass concentration used had significant effects in the stability of the briquettes.

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