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UTILIZATION OF FALCATA SAWDUST BRIQUETTES AS AN ALTERNATIVE SOLID FUEL

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ABSTRACT

In this study, the falcata sawdust was utilized to produce briquettes. The samples were produced using a single mold manual briquetting device. The falcata sawdust was mixed with three binders namely cassava starch, paper pulp and molasses at 70:30, 60:40 and 50:50 sawdust-to-binder ratio and were then evaluated in terms of its calorific value, boiling time and durability. Results showed that the calorific value of briquettes decreased as the sawdust-to-binder ratio is increased. Briquette samples with 70:30 sawdust-to-binder ratio can boil water in a shortest period. Meanwhile, the durability of briquettes increased as the sawdust-to-binder ratio is increased. Among the binders considered, cassava starch has the highest durability followed by paper pulp. Further, a manually-operated briquetting machine that can produce 25 briquettes with an average production time per batch of 5 minutes was fabricated. The said machine can produce 300 briquettes per hour.

Keywords: boiling time, briquetting machine, calorific value, durability, falcata sawdust briquettes.

INTRODUCTION

Briquettes are made from waste materials like old newspaper, sawmill wastes (sawdust) or partly compressed biomass waste. The compression leads to a product of higher bulk density, uniform size and shape. Biomass briquettes can also be used as an energy source for cooking purposes and in some industries that uses boiler for wood kiln drying. In addition, briquetting is the process of transforming a granular or powdery substance into a larger, more convenient size. Traditionally, firewood and charcoal have been the major fuels used. Briquettes can be a substitute to these conventional forms of fuel.

Falcata sawdust is an abundantly available solid waste in Barangay Natumolan, Tagoloan, Misamis Oriental. The weekly production of sawdust in one saw mill enterprise is about 500-700 sacks per week which can be used to produce the energy products. If these residues are burnt directly, it results in very poor thermal efficiency and may create a lot of air pollution and contributing to global warming. Saw dust can be a solid biofuel in which it is convenient way to energetically recover the waste.

The need for alternative sources of energy has been a sensitive issue for the past years. In the Philippines, the harnessing and utilization of renewable energy has been a significant part of the government's strategy to supply the energy needs of the country (Department of Energy 2011a). To minimize the dependence on imported fuel and to solve problems on energy shortage, considerable efforts have been made to utilize the country's available resources. The use of the several forms of renewable energy such as the geothermal, wind, and solar are studied and researched upon to maximize the benefits that can be harnessed for the country (Gatmaitan, RA., *et al*, 2012).

MATERIALS AND METHODS

Materials

The materials needed to produce the briquettes include: sawdust, cassava starch, paper pulp and molasses.

Production of Briquettes

The falcata sawdust was collected from sawmills at Tagoloan, Misamis Oriental, Philippines. It was sieved with a 2mm mesh and sun dried before mixing it to the binders. The sawdust was mixed to the binders at a ratio of 70:30, 60:40 and 50:50 (sawdust-to-binder ratio). The compression of the mixture (sawdust and binder) took place at constant pressure and the pressure was held constant at 1500 psi (10.34Mpa) to produce a briquette of the same sizes in each of the type of binder used. Figure-1 shows the experimental set-up used in producing the briquettes samples. It was driven by a hydraulic jack with a capacity of twenty tons installed with a pressure gauge.



Figure-1. Single mold manual hydraulic briquetting device.



Evaluation of Briquettes Properties

After the production of briquettes samples, it was evaluated in terms of its calorific value, boiling time of water and durability.

Calorific Value

A known amount of the sample was burnt in a sealed chamber (Bomb). The air was replaced by pure oxygen. Sample was ignited electrically. As the sample was burnt, heat is produced. The rise in temperature was measured. Since barring the loss of heat, the amount of heat produced by burning the sample must be equal to the amount of heat absorbed by the calorimeter assembly. A knowledge of the water equivalent of the calorimeter assembly and of the rise in temperature enables one to calculate the heat of combustion of the sample.

$$\text{Calorific Value of Sample (PER GRAM)} = \frac{W \times (T_2 - T_1)}{\text{gram of sample taken}}$$

where:

W = Water equivalent of calorimeter
 T1 = Initial temperature before firing
 T2 = Highest temperature after firing

Water equivalent in 'G' =

$$\frac{\text{Benzoic acid calories} \times \text{gram of sample weight taken cal/gr}}{T_2 - T_1}$$

Note: Benzoic acid calories = 6318 cal.

The heat capacity of the calorimeter can also be determined by burning an exactly known amount of a standard substance, whose enthalpy of combustion has been determined. Benzoic acid, $C_7H_6O_2$, is one such standard. The standard test has to be performed as per IP-12, IS-1350 (PART II) and ASTM D-4809. Figure 2 shows the bomb calorimeter used in determining the calorific value of the briquettes samples.



Figure-2. Bomb calorimeter.

Boiling Time of Water

Stopwatch was used as the measuring device to get the time. Half litre of water was provided via a kettle (0.5mm thickness), which was then placed on the stove (charcoal fired) and the briquettes were lighted for combustion. The initial temperature of water was 29°C and the time it took each sample to boil water was recorded. The kettle was equipped with a thermometer as shown in Figure-3.



Figure-3. Kettle installed with thermometer.

Durability of Briquettes

In performing the shatter resistance of briquettes, drop height of six feet (1.8 meters) was used and each sample was dropped twice. There were three replicates in each binder and in each ratio. The briquettes weight (in grams) before and after dropping was recorded using a top loading balance. The percent weight loss and percent shatter resistance were calculated using the following formulas (Ghorpade, 2006):

$$\% \text{ weight loss} = \frac{w_1 - w_2}{w_1} \times 100\%$$

% shatter resistance = 100 - % weight loss
 where:

w_1 = Weight of briquette before shattering
 w_2 = Weight of briquette after shattering

Design and Development of Briquetting Machine

After the evaluation of falcata sawdust briquettes, a manually-operated briquetting machine was designed and developed to produce twenty five (25) briquettes at a time. The displacement analysis of the cover plate was simulated using Solid works 2014 as shown in Figure-4.

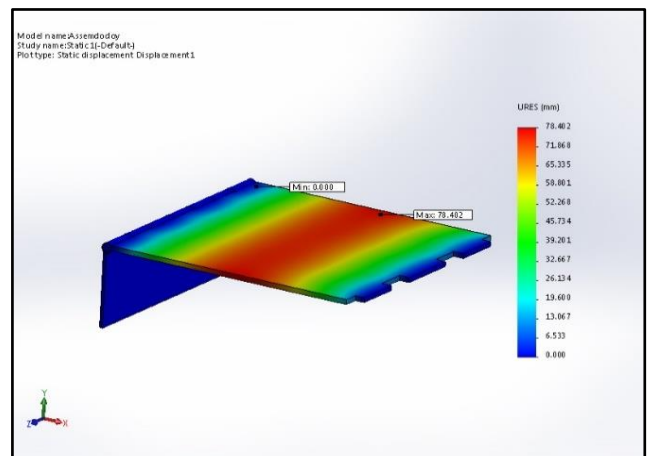


Figure-4. Displacement analysis of the cover plate.

The briquetting machine is composed of twenty-five mold with internal diameter of 38.1mm and depth of 175mm welded to 10mm mild steel plate at the top and



bottom and 6.35mm at the middle. The height of the design is 950mm using a channel bar with a dimension of 4x2x1/4 in. The die or mold is equipped with a hydraulic jack at the bottom and closing plate at the top. Both piston and closing plate should withstand the high pressure applied by the hydraulic jack. The machine was designed using Autocad 2015 as shown in Figure-5.

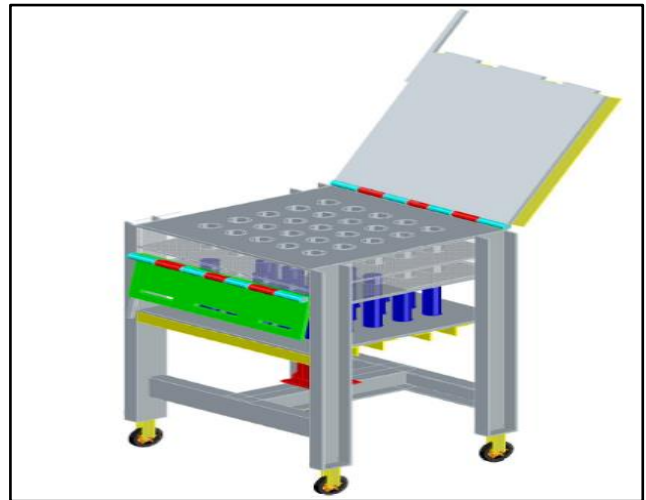


Figure-5. Design of briquetting machine.

RESULTS AND DISCUSSIONS

Calorific Value

Figure-6 shows the calorific value at various sawdust to binder ratio and binders. It could be observed that as the volume of cassava starch binder increased from 30% to 50%, the calorific value decreased, with an increase ash content after combustion. Similar results were observed when paper pulp and molasses binders were used.

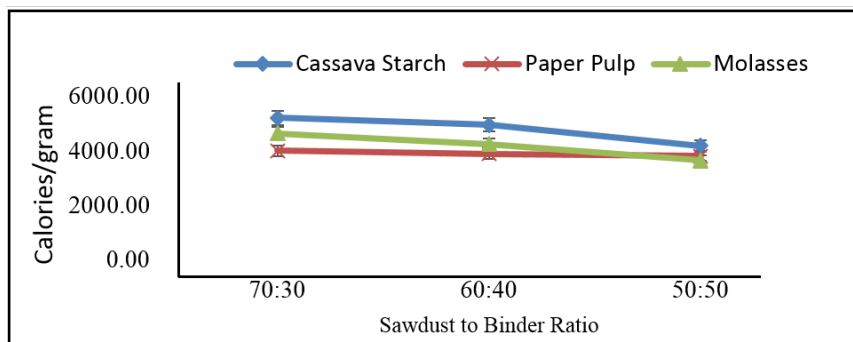


Figure-6. Calorific value at various sawdust to binder ratio and binders.

Boiling Time

Figure-7 shows the boiling time of water at various sawdust to binder ratio and binders. As the ratio of cassava starch, paper pulp, and molasses is increased, the boiling time correspondingly increased. The shortest

boiling time (8.72 minutes) was observed at 70:30 while highest boiling time (15.03 minutes) was observed at 50:50 sawdust to molasses ratio. It was observed that samples with 50:50 sawdust to molasses ratio have high moisture content.

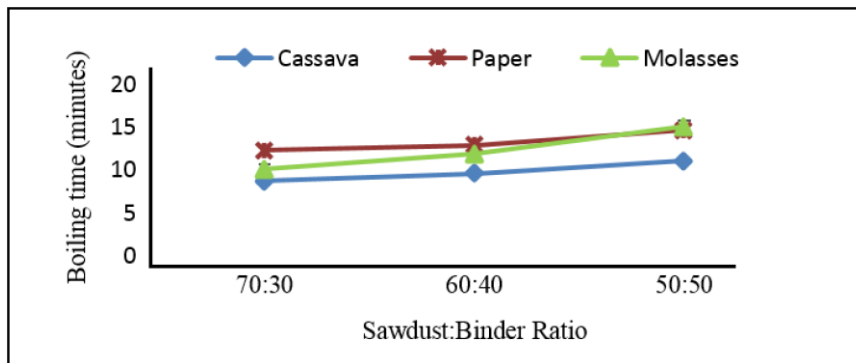


Figure-7. Boiling Time at various sawdust to binder ratio and binders.

Durability

Figure-8 shows the results of durability test of the briquette samples. As the binder proportion is increased from 30% to 50%, the durability (Percent Shatter

Resistance) of briquettes is increased. Molasses binder has recorded the lowest durability among the three binders. Cassava starch and paper pulp binders have excellent durability and are suitable for briquette production.

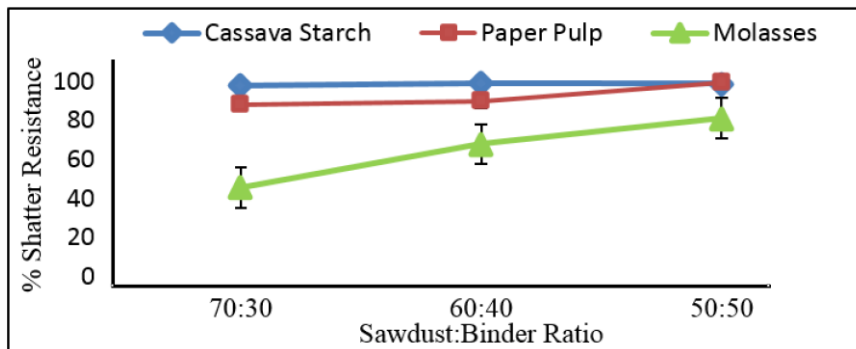


Figure-8. Percent shatter resistance at various sawdust to binder ratio and binders.

Fabricated Briquetting Machine

Figure-9 shows the actual manually operated briquetting machine. This machine can produce twenty-five (25) briquettes at a time, with an average production time of 5 minutes per batch. Table-1 shows the capacity of machine in 1 hour. In Figure-10, samples of briquettes produced by the machine are shown.

Table-1. Machine capacity in one-hour.

| Type of Binder Used | Total produced, per hour |
|---------------------|--------------------------|
| Cassava Starch | 300 |
| Paper Pulp | 300 |
| Molasses | 300 |



Figure-9. The manually-operated briquetting machine.



Figure-10. Production of briquettes.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the present study, the following conclusions were derived:

a) The calorific value of briquettes decreased as the sawdust-to-binder ratio is increased. Briquettes sample with 70:30 sawdust-to-binder ratio can boil water in a shortest period. Meanwhile, the durability of briquettes increased as the sawdust-to-binder ratio is increased. Among the binders considered, cassava starch has the highest durability followed by paper pulp.

b) The fabricated manually-operated briquetting machine can produce 25 briquettes at a time, with an average production time of five minutes per batch. The machine can produce 300 briquettes per hour. It is expected that this manually-operated briquetting machine can produce economically briquettes for alternative solid fuel application. It is recommended to increase the number of molds and injectors to increase the production and to employ automation in hydraulic system to increase the production with less effort in operating the machine.

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