Charcoal Briquette Using Leftover Firewood Fraction from Burnt-Clay Brick Production: Case Study in Thailand

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Abstract - *In Thailand, a considerable amount of firewood, which is basically made from hardwood, has been used as fuel for production of burnt-clay bricks. A previous case study conducted in a medium-size brick factory in Phitsanulok Province revealed that there were large numbers of leftover firewood fractions remaining after the brick-manufacturing process although they could be reused as materials for producing charcoal briquettes for value-added. The present study aimed to analyze the properties of the leftover fractions and calorific value. The results revealed that the calorific value of leftover firewood fractions was 27.96 MJ/kg. The fractions were briquetted by using tapioca flour as a binder at 5.5 MPa. Twelve sets of mix ratio were analyzed, and it was found that the ratio of 10:10:1 showed the most endurable quality. The test of burning properties using water heating found that charcoal briquettes which were produced with the ratio of 10:10:0.5 showed the best properties of burning and heating.*

Key Words: Biomass, Brick, Briquette, Charcoal, Fuel, Renewable energy

1. INTRODUCTION

Burnt-clay bricks are materials commonly used in Thailand's industrial sectors. They are made from clay, chaff or other materials and water, which are altogether combined and pressed until they form a mixture which is later put in a mold to make the saw shape of bricks. The bricks are then let dry for moisture reduction before being hardened in a kiln. In Thailand, burnt-clay bricks are mainly produced by small and medium-sized manufacturers using lore and knowledge passed on by predecessors. Therefore, the manufacturing process of burnt-clay bricks, which mostly uses firewood from hardwood as well as assorted plants, results in both small and large charcoal pieces which remain after the brick-burning process. These fractions are not usually reused as fuel, but they are rather sold with burnt ashes at very low prices.

The use of materials such as palm kernel shells [1], sawdust [2-3], rice husk [3-4] and wood [5] as fuel in forming processes to increase their value and to reduce environment problems has been widely researched. The forming processes can be divided into three types. First, forming with heat requires high temperature during the compressing process. The high temperature helps strengthen the mixture without need for a binder. An example of this method is the process of Caragana forming. The second type is forming process at moderate temperature with a binder, which mostly requires moderate pressure. This technique is mostly used in production of charcoal briquettes. The last type is forming process at moderate temperature without a binder, which requires high pressure. This procedure is mostly used in manufacturing sawdust briquettes.

The concept of using biomass as alternative energy has been widely discussed since it has no impact on greenhouse effect. To clarify, an amount of carbon dioxide emitted during the burning process is adsorbed in the growing process of new plants. As a consequence, such usage of biomass can increase its value and also reduce problems concerning waste management. There have been several recent studies on application of biomass including sawdust briquettes in timber industries, charcoal fractions from sugar industries, chaff and bran from rice mills, charcoal and plastic fractions as well as rice straw and sugar cane leaves after harvest. The present study adopts this notion with aim to investigating problem management of leftover firewood fractions remaining with ashes after the burning process in burnt-clay bricks production. The study also aimed to form the fractions into briquettes in order to examine the properties of firewood fractions, a proper mix ratio with binder as well as the properties of the briquettes.

2. BRICKWORKS

The present study was conducted in a medium-sized brick factory which has 3 funnel-shaped kilns in a closed type. All of the kilns are 5 meters in diameter and 7 meters in height. Each can contain 50,000 large bricks or 80,000 small ones. This factory is able to produce approximately 150,000 bricks in one production circle. The production circle here requires high temperature throughout a duration of 3 days. After that, the bricks are left dry naturally.

3. MATERIAL AND METHOD

Leftover firewood fractions and ashes deriving from the burning process in the clay production were separated by winnowing through a mesh. The isolated firewood fractions were then grinded in a hammer mill (Waco, Blender23, 2 HP, 1450 rpm) and were later winnowed through a mesh with 4-mm cavities so that they became charcoal power which was later collected to analyze its moisture, volatile matter and ash amount, respectively.

Binders, such as maize flour and tapioca flour, are necessary for forming firewood fractions into fuel solids as it can strengthen the products. The present study applied tapioca flour since it is inexpensive and commonly used in Thailand. The process of producing the binders involved mixing tapioca flour with water in 12 different ratios: 10:9:0.5, 10:9:1, 10:9:2, 10:9:3, 10:10:0.5, 10:10:1, 10:10:2, 10:10:3, 10:11:0.5, 10:11:1, 10:11:2 and 10:11:3, respectively. The two raw materials were blended until it became mixture. The mixtures were then transferred into tube presses (36 millimeters in diameters and 150 millimeters in length) whose plunger is 7 millimeters in diameters and 142 millimeters in length so that the mixtures were formed into the shape of hollow cylinder, as shown in Figure 1.

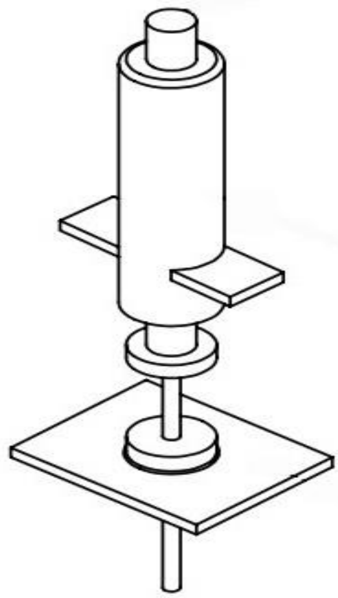

Fig -1: Briquette pressed cylinder

The tube presses employed in this study were equipped with a band heater (450 watts, 42 millimeters in diameter) with a temperature controller of PID (REX-C100) in order to stabilize the temperature at 100 degrees Celsius as shown in Figure 2. This method was conducted to generate gelatinization of the tapioca flour, as shown in the figure below. A universal testing machine (UTM: HOUNSFIELD, H50KS, 50 kN) was used as a power generator in the pressing process with the pressure of 5.5 MPa. The pressing process was done three times for each ratio.

The mixtures, which were now formed into fuel solids, were left dry in sunlight for 2 hours. They were then collected for investigating any fractures, and those without any sign of damage were gathered to analyze the calorific value with a Parr isoperibol bomb calorimeter in the standard of ASTM D 5865. They were also examined for the compressive strength with a UTM, which pressed the subjects until any damage was shown. In regard to the analysis of burning properties, 200 grams of the fuel solids in different ratios was used to boil 200 grams of water at room temperature. The durations of ignition time, boiling time and dying out time were counted. These processes were done three times for each ratio.

Fig -2: Pressed cylinder equipped with band heater

4. RESULT AND DISCUSSION

The results from testing properties of firewood fractions left from a burnt-clay industry, after the pressing process as well as analysis, revealed that the average calorific value was 27.96 MJ/kg, and the percentages of moisture, volatile matter and amount were 5.50, 32.67 and 5.67, respectively. The remaining proportion was fixed carbon.

The results after moisture reduction by sunlight were that the solid mixtures of charcoal powder, water and tapioca flour at the ratios of 10:9:0.5, 10:10:0.5 และ10:10:1 showed satisfactory adhesion and no sign of fractures or damage, as shown in Figure 3. The aforementioned ratios indicated that the proportions of tapioca flour and water should be specified properly. Furthermore, the calorific values of the three ratios above were almost the same at 28.26, 28.01 and 27.65, respectively. It is also interesting to note that these values were higher than those of briquettes made from bagasse, with 25.55 MJ/kg [6], but lower than those of specifically-made charcoal briquettes, with 32.24-33.54 MJ/kg [7].

Fig -3: Briquettes from leftover charcoal

The density values as well as compressive strength of the three ratios are shown in Chart 1 and 2. As can be seen from the graph, higher proportions of binder result in higher values of both density and compressive strength, with the maximums of 438 kg/m^3 and 2.73 MPa, respectively. In particular, the solid mixtures at the ratio of 10:10:1 showed lower values than those of the study conducted in Brazil, which employed helix formation at pressure of 5 tonnes [6]. However, when compared to chaff briquettes which was made from a clay binder at 7.74 MPa, it was found that the briquettes of the present study showed more compressive strength but less density [8]. Moreover, the present results are consistent with chaff briquettes which were produced at 4.2 MPa since they showed the compressive strength of 2.54 kN and the maximum density of 446.8 kg/m^3. When the variations in the graph are taken into account, it is however found that improper proportions of binder, both overmuch and scantily, have effect on perfection and adhesion of the products. This can be clearly seen from fractures which appeared on the solid mixtures that were comprised of the other ratios.

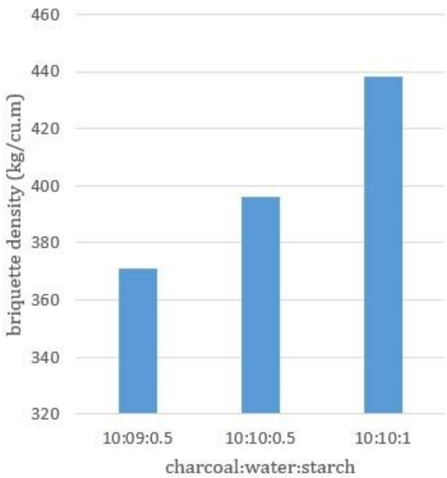

Chart -1: Briquette density

The results from testing burning properties demonstrated that the ratio of 10:10:5 showed the shortest durations of ignition and boiling time, 4.33±0.577 minutes and 15.667±1.155 minutes, respectively, as shown in Chart 3. On the other hand, the longest durations occurred with the ratio of 10:9:0.5, 6±1.732 minutes and 18.33±1.528 minutes, respectively. In addition, the ratio of 10:10:1 showed the longest period of dying out, 110.33±2.517 minutes, indicating the burning rate of 1.803±0.028 gram per minute. Furthermore, fractures, odor and soot were not found while the solid mixtures of all the three proper ratios were being burnt, and all of them were highly sensitive to ignition. The burning properties of the solid mixtures in the present study were found to be rather similar to those of 2 kilograms of bagasse briquettes which took 4.40-15.20 minutes to boil 2 liters of water. The boiling durations were also consistent, ranging from 9.50 to 18.19 minutes, but the dying-out duration of the mixtures in the present study was longer than that of the bagasse briquettes [9]. The comparison of ignition time between the present solid mixtures and chaff briquettes also showed consistency at approximately 4 minutes [8].

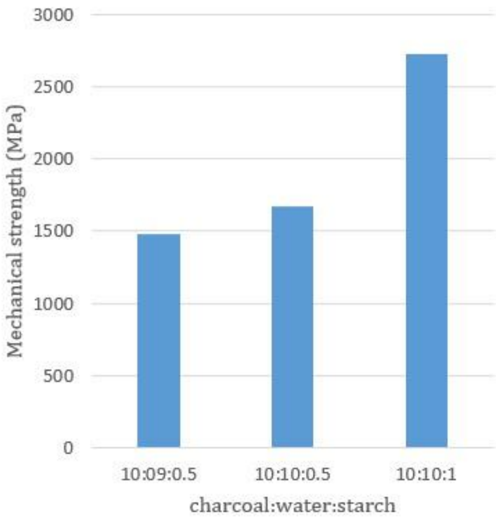

Chart -2: Briquette mechanical strength

4. CONCLUSION

Leftover firewood fractions from brunt-clay industries have potential for being produced as briquettes in order to increase their value. The briquettes which was combined with tapioca flour as a binder showed the calorific value of 27.65-28.26 MJ/kg, the density value of 438 kg/m^3 and the compressive strength of 2.73 MPa. The briquettes displayed no fractures and soot, and they were well sensitive to ignition. Their ignition time and boiling time were approximately 6 and 18 minutes, respectively.

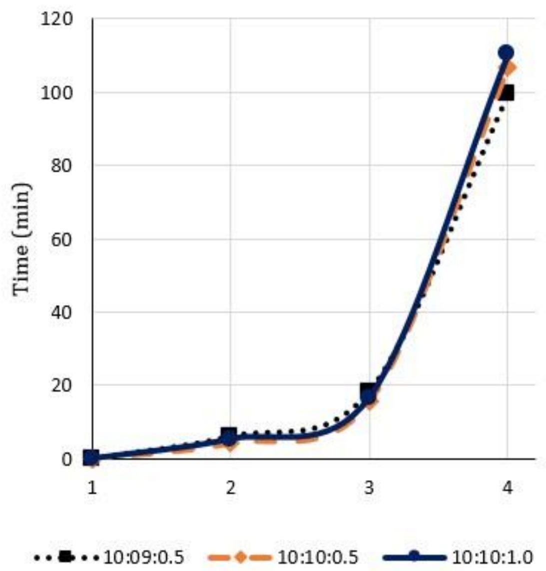

Chart -3: Burning test (1 start, 2 ignition, 3 boiling ,and 4 extinguish)

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