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Physical Characteristics of Briquettes Contain Mixture of Pulverized Empty Fruit Bunch and Polyethylene Plastics

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Abstract – *Physical characteristics of briquettes contain mixture of pulverized empty fruit bunch and polyethylene plastics (weight ratio 85:15) were investigated experimentally. The comparison was performed with briquettes that contain 100% pulverized EFB in terms of relaxed density and compressive strength. The briquettes were produced under various heating temperatures of 150°C, 170°C and 190°C. Meanwhile, the compression pressure was set constant at 7 MPa. The results indicate that the compressive strength of the briquettes contain mixture of pulverized EFB and polyethylene plastics is lower than that of the 100% pulverized EFB briquettes. However, the values of the compressive strength are still strong enough to resist mechanical disintegration.* ***Copyright © 2015 Penerbit Akademia Baru - All rights reserved.***

Keywords: EFB briquette, polyethylene, pulverized EFB, empty fruit bunch

1.0 INTRODUCTION

The climate change and the increase in energy demand throughout the world have driven towards the transformation from high energy dependence on fossil fuel to the utilization of inexhaustible renewable energy sources such as hydro, solar, wind, biomass and many others. In Malaysia, biomass is one of the important renewable energy sources [1], in which it can be obtained abundantly from palm oil mills. During the palm oil extraction from palm fresh fruit bunch, several types of biomass residues were simultaneously produced, that are mesocarp fibre, palm shell, empty fruit bunch (EFB). The production rate of EFB is the highest (~18 million tonnes per year), followed by mesocarp fibre (~8 million tonnes per year) and palm shell (~3 million tonnes per year) [2]. Thus, it is inevitable to utilize these biomass residues in order to prevent from just being dumped in the areas adjacent to palm oil mills.

Densification is one of the attractive methods to improve the combustion properties of the palm biomass residues by converting the residues into solid biofuel with higher energy density [3]. The advantages of this technique are handling and transportation become easier and cheaper, and reduction of formation of dust. The products from densification technique can be categorized into three types; pellet, briquette and bale. Briquette is a medium size log with a diameter of 30mm to 100mm, and with any length [4]. The log with a smaller diameter is called pellet while with a larger diameter is called bale.

In Malaysia, the research on briquette that contains palm biomass was initiated by Husain et al. more than a decade ago [5]. They have used mesocarp fibre and shell (weight ratio 60:40) for making briquettes while starch as a binder. They found that compressive strength of the briquettes produced is around 2.6 MPa, thus sufficient to resist mechanical disintegration. Then, further investigation on the various palm biomass briquettes was performed by other researchers in the following years [6-9]. For instance, Nasrin et al. have introduced the binderless 100% EFB briquettes by using piston press technology. Based on their study, it was found that average compressive strength of the briquettes produced is around 7.9 MPa [6]. In year 2010, Faizal et al. have introduced the briquettes that contain EFB fibre and mesocarp fibre in the weight ratio of 60:40 in order to utilize massive amount of EFB produced from palm oil extraction process [8]. Recently, the palm biomass briquettes that contain paper as a binder have been introduced [9]. The palm biomass used were palm shell and mesocarp fibre in the weight ratio of 60:40. It can be concluded that most of the previous studies used DIN51731 as a benchmark for comparison of performance.

However, the fast growing demand of energy throughout the world requires the maximum utilization and recovery of energy sources [10]. A technique of mixing plastics waste with other biomass sources for making a briquette has become one of the attractive ways to cope with such trend of energy demand. The polyethylene plastics, for example, has calorific value of more than 40000 kJ/kg, thus reveal the importance of harnessing such type of valuable energy source. In year 2011, Anita and Ramesh have produced the briquettes with a mixture of rice husk, polyethylene, paper and lime (weight ratio 50:25:20:5). They have concluded that the addition of plastics waste could improve the quality of the briquette especially in terms of calorific value [11]. Then, the briquettes contain biomass and various plastics waste have been introduced recently by Zannikos et al. [12]. They have produced briquettes with a mixture of high density polyethylene (HDPE) and beech sawdust in the weight ratio of 60:40. Besides, the performance of the briquettes contain mixture of HDPE:straw (weight ratio 50:50), polyethylene terephthalate (PET): polyethylene (PE): beech sawdust (weight ratio 10:25:65) and HDPE:beech sawdust:wax PE (weight ratio 48:50:2) was also evaluated. They found that the briquette made of HDPE and beech sawdust (weight ratio 60:40) has the highest calorific value.

Based on the literature review, a briquette that contain palm biomass and plastics has not been introduced yet, thus lead us for exploration of this new type of briquette. In the present study, the physical characteristics such as relaxed density and compressive strength of the new briquettes were investigated. The comparison was made with that of 100% pulverized EFB briquettes, for various heating temperatures of 150^{o}C, 170^{o}C and 190^{o}C.

2.0 METHODOLOGY

2.1 Preparation of raw materials

The raw materials used in the present study were EFB and commercial polyethylene plastics bag. The EFB fibres were received from Kilang Sawit Felda Lok Heng, Kota Tinggi, Johor while commercial polyethylene plastics bags were obtained from a local supplier.

Firstly, the EFB fibres were grinded into powder form. Meanwhile, the plastics bags were cut into small pieces by a scissor and were sieved to obtain the size of 1mm to 3.35 mm. In prior to briquetting process, the basic combustion properties of the raw materials were determined by using a bomb calorimeter and performing proximate analysis. The standards used for proximate analysis on EFB powder are shown in Table 1 below.

Table 1: Standards used for proximate analysis on EFB powder

Properties	Standard Used
Moisture Content	ASTM D3173
Volatile Matter	ASTM D3175
Ash Content	ASTM D3174

The calorific values of both pulverized EFB and polyethylene plastics were determined by using IKA calorimeter system model 2000 located at Thermodynamics Laboratory, Faculty of Mechanical Engineering, UTM Skudai, and bomb calorimeter model LECO AC350 located at Plant and Automotive Laboratory, Faculty of Mechanical and Manufacturing Process, UTHM Batu Pahat.

The results of proximate analysis and calorific value are shown in Table 2 and 3, respectively. Table 2 demonstrates the moisture content of EFB powder is around 7%, thus suitable for making briquette because the fulfillment of DIN51731 benchmark (<10%). In addition, the polyethylene plastics has sufficiently high calorific value, that is around 41000 kJ/kg. Therefore, the addition of polyethylene plastics to pulverized EFB is supposed could improve the combustion properties of the EFB briquettes produced. Based on DIN51731 benchmark, the minimum calorific value of briquette for commercial purpose is 17500 kJ/kg.

Table 2: Results of proximate analysis on EFB fibres

Properties	Percentage [%]
Moisture Content	~7
Volatile Matter	~75.5
Ash Content	~3.5
Fixed Carbon	~14

Table 3: Results of calorific value

Raw Materials	Calorific Value [kJ/kg]
EFB fibres	16131
Polyethylene plastics	40792

2.2 Briquetting process

Two types of briquette were produced. The first type contained a mixture of pulverized EFB and polyethylene plastics (weight ratio 85:15) while the second type contained 100% pulverized EFB. The amount of the raw material used to make each briquette was around 41-45 g.

For briquetting process, a die set consists of plunger, die wall and base as shown by Figure 1 below was used. The die set was made of stainless steel. For measuring heating temperature during briquetting, K-type thermocouple was used. The horizontal distance between the thermocouple sensor and the inner wall of die part was set around 3mm. To control the temperature during heating, the temperature controller was connected to the thermocouple and steel coil heater. To prevent heat loss, glass wool was used as an insulator.

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To apply load during briquetting, the die set filled with raw materials was placed on the plate of Instron 600dx machine, as shown by Figure 2. Initially, the raw materials were compressed without heating for around 30 minutes and the compaction pressure applied was set at 7 MPa. Then, the die set filled with raw materials was heated for 30 minutes. After that, the briquetting system was allowed to cool down to room temperature. Finally, the briquette produced was taken out from the die set and was left under ambient condition for around 1 week to obtain stability and rigidity.

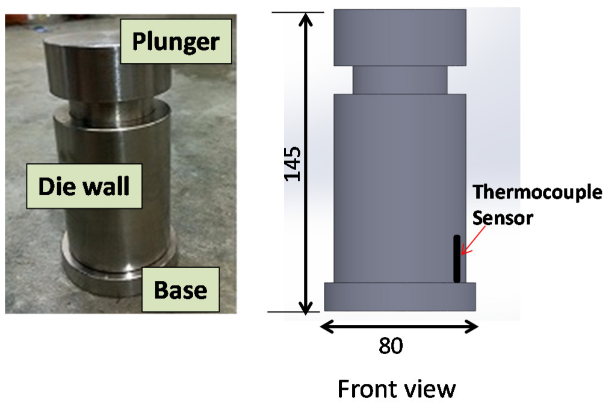

Figure 1: Die set for briquetting

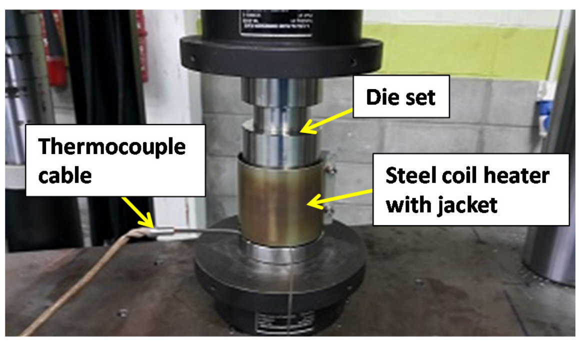

Figure 2: Briquetting process by using Instron 600dx machine

2.3 Determination of physical characteristics

In the present study, the physical characteristics were investigated in terms of relaxed density and compressive strength. The relaxed density was determined by using a stereometric technique proposed by Rabier et al. [13]. Meanwhile, Instron 600dx machine was used to determine the compressive strength. The load was applied by the machine during the test until the crack was observed. Then, the machine was stopped and the load data was collected to calculate the strength.

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3.0 RESULTS AND DISCUSSION

In the present study, the results of relaxed density and compressive strength were presented and discussed. Figure 3 shows the image of a briquette that contains mixture of pulverized EFB and polyethylene plastics. The figure shows that the briquette produced has a very smooth surface.

Figure 3: Briquette contains mixture of pulverized EFB and polyethylene plastics (weight ratio 85:15), produced under temperature of 190°C.

Figure 4 shows the relaxed density of the briquettes produced under various heating temperatures. The figure shows that regardless of heating temperature, the relaxed density of briquettes contain pulverized EFB and polyethylene (PE) plastics is slightly higher than that of briquettes contain 100% pulverized EFB. This is mainly due to the addition of PE plastics, that causes the tendency of the proposed briquettes to deform becomes less. Based on the figure, it can be said that the relaxed density of the briquettes contain pulverized EFB and PE plastics increases with an increase in heating temperature. This is supposed due to the increase in strength of bonding between PE plastics and EFB particles when the temperature is increased. When the strength of bonding increases, the tendency of the briquettes to deform after briquetting process becomes less.

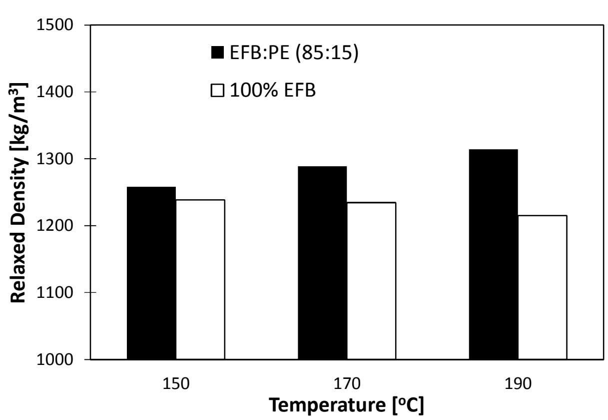

Figure 4: Relaxed density of briquettes produced under various heating temperatures

Figure 5 shows the compressive strength of the briquettes produced. It was found that the compressive strength of the briquettes contain pulverized EFB and PE plastics (weight ratio

85:15) is much lower than that of the 100% pulverized EFB briquettes. This is supposed due to the existence of bonding between EFB particles and PE plastics, which could degrade the strength of the briquettes. The values of the compressive strength of the proposed briquettes are within the range of 0.90 to 1.2 MPa. Even though the values of compressive strength are relatively low if compared to the values belong to 100% pulverized EFB briquettes, the proposed briquettes are still strong enough to resist mechanical disintegration.

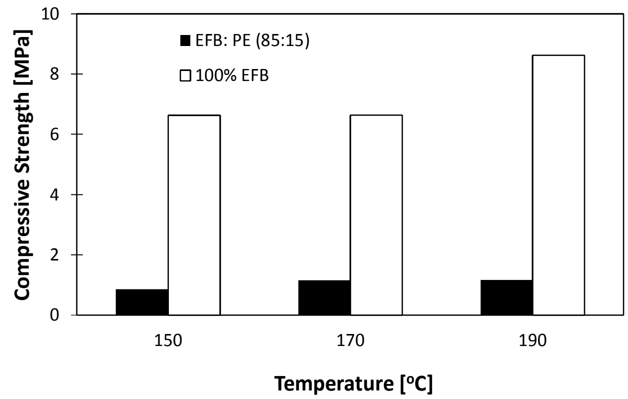

Figure 5: Compressive strength of briquettes produced under various heating temperatures

4.0 CONCLUSION

The briquettes contain new mixture of pulverized empty fruit bunch (EFB) and polyethylene (PE) plastics (weight ratio 85:15) have been successfully produced.

Even though relaxed density of the briquettes with the new mixture are slightly higher than that of the 100% pulverized EFB briquettes, the values of compressive strength belong to the briquette with the new mixture are much lower. However, the values are still considered strong enough to resist mechanical disintegration.

The combustion characteristics of the briquettes with the new mixture will be discussed in the near future.

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