SOLID FUEL FROM EMPTY FRUIT BUNCH FIBER AND WASTE PAPERS PART 4: COMPRESSION TEST AT LATERAL POSITION

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ABSTRACT

This research discussed on the results obtained for each sample that have been conducted to the solid fuel briquettes made of empty fruit bunch fiber and waste papers from view of mechanical performance which is compression test at lateral position test. This solid fuel prepared by manual compression technique and tested using universal testing machine. This analysis important to know the capability of solid fuel to sustained external force because of mechanical activities. Experimental work shows that, the larger amount of paper in the ratio, the higher the maximum load it can withstand before failure, therefore briquette S/N 6 gives the highest compressive strength.

Keywords: *Empty Fruit Bunch Fiber, Waste Papers, Ash Content.*

1.0 INTRODUCTION

Producing energy from renewable biomass is only one of the various ways of responding to the challenges of the energy crisis. Since the oil crisis in 1970's the use of biomass as a source of energy is a topic of growing interest and debate as agreed by Gómez-Loscos (2012), Tong and Li (2012), Arias (2011), Vaclav (2010), Fernando (2009), Kaygusuz and Keles (2008).

Corley and Tinker (2008) in their book discuss in detail about oil palm in Malaysia. In 2004, Malaysia had about 3.87 million hectares of land under oil palm cultivation. Currently, more than 80 percent of the oil palm produced is used for food applications like cooking oil, frying oil and many others. Oil palm is a perennial crop. It has an economic life span of about 25 years. Traditionally, oil palm is grown for its oil example like palm oil, palm kernel oil, and palm kernel cake as the community products. Besides palm oil and palm kernel, oil palm industry generates large quantity of biomass residue which is side products as stated before like fronds, trunks, EFB, palm oil mill effluent, palm fibre and shell that have not been fully commercially exploited.

Through concerted research and development efforts by many research organizations including Malaysian Oil Palm Board, this co – products from palm oil industry have been found to be good resources for many application such as palm oil fuel ash a biomass residue (Brown *et al.*, 2011), oil palm as a viable concrete pozzalanic material (Foo and Hameed, 2009), Oil palm ash as partial replacement of cement for solidification/stabilization of nickel hydroxide sludge (Chun *et al.*, 2008), oil palm ash in concrete (Tangchirapat *et al.*, 2007).There are many competitive uses of these materials. One of them is to utilize them as a fuel for energy production but in term of biodiesel fuel. In fact, Malaysian government has identified biomass as fifth fuel resource to compliment the petroleum, gas, coal, and hydro as energy resources, while palm biomass has been identified as a single most important energy source as stated by Sumiani (2006). On the other hands, the main sources of biomass in Malaysia are domestic wastes, agricultural wastes, effluent sludge and wood chips (Yuhazri *et al.*, 2011) and (Yuhazri *et al.*, 2010).

Biomass energy systems can be based on a wide range of feedstock like food and garden wastes (Romeela and Ackmez, 2012), solid wastes and sewage sludge (Despina *et al.*, 2012), cellulosic ethanol (Gonzalez, 2011), coal and cattle biomass (Carlin *et al.*, 2011) and many more. They use many different conversion technologies to produce solid, liquid, and gaseous fuels. These can then be used to provide heat, electricity and fuels to power vehicles; using burners, boilers, generators, internal combustion engines, turbine or fuel cells. Power can be generated by co – firing a small portion of biomass on existing power plant, burning biomass in conventional steam boilers, biomass gasification and anaerobic digestion.

Converting palm biomass into a uniform and solid fuel through briquetting process appears to be an attractive solution in upgrading its properties and add value as reported by (Sławomir, 2012), (De *et al.*, 2012), (Nasrin *et al.,* 2011), (Chuen-Shii, 2009). Biomass briquette is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. Biomass briquette plant is of various sizes which converts biomass into a solid fuel. Briquettes are ready substitute of coal or wood in industrial boiler and brick kiln for thermal application. Biomass briquettes are non conventional source of energy, renewable in nature, eco – friendly, non polluting and economical. Process of converting biomass into solid fuel is non polluting process. It involves drying, cutting, grinding, and pressing with or without the aid of a binder.

Malaysia has involved in palm oil industry over the last four decades and since then it has generated vast quantities of palm biomass, mainly from milling and crushing palm kernel. Empty fruit bunch is the main solid waste from oil palm obtained from milling process. This biomass can be used as an alternative energy for combustion purposes especially in industry. Unfortunately, due to its poor physical properties EFB is not normally utilized as fuel. However, it can be use in optimise by upgrading and treating its properties. The method that can be used is the briquetting technique. Briquetting is the alternative method in upgrading biomass into a useful solid fuel that can be done through various technologies. In this research, EFB material will be mixed up with the recycled papers and it will be turned into solid briquette through the briquetting process. The used of recycle papers in this research is to utilized the abundant papers into something useful, thus helps in reducing the number of municipal wastes generated every year. Papers are selected as a material to be used compared to the other types of recycled wastes such as glass and plastic because it is known to be a good material for a combustion ignition. As for plastics, it may be compatible to papers to be used as ignition material in combustion, but it will spread a toxic gas while it is burn.

The scope of this research is mainly focusing on the mixing of the empty fruit bunch, EFB and the recycled papers. All these palm oil mills is to be obtained, mixed up and to be develop as a fuel briquette at a certain ratio or percentage with the EFB as the major element. This fuel briquette is to be carried out with the performance tests and comparison tests in terms of its calorific values (Yuhazri *et al.,* 2012a), gas emission (Yuhazri *et al.,* 2012b), ash content (Yuhazri *et al.,* 2012c), stability and durability, immerse and crack, but in this paper (part 4) only discuss on compression test at lateral position.

2.0 MATERIALS AND METHODS

Empty Fruit Bunch (EFB) supplied by Malaysian Palm Oil Board (MPOB) from one of plantation in Malaysia was used as reinforced material in this green composites fabrication. The EFB used in the composites was in a chopped strand form. The EFB type used was shown in the Figure 1(a) and the Table 1 is the basic properties of EFB used for the fabrication of the composites based on study done by (Nasrin *et al.*, 2008).

(a) **(b)**

Figure 1: **(a)** EFB in fibrous form, **(b)** Shredded paper in shredder machine.

Recycled papers are use as a matrix material in the solid fuel briquette fabrication. The reason to choose papers as recycled waste in this research is because due to the properties of papers which can provide good properties for combustion. Furthermore, it can act as a binder during the blending of papers and EFB during fabrication stage. The papers are obtained from waste papers of the paper shredder machine. This is because the crushing papers have a standard size and dimension after is shredded inside the crushing machine. The standard size and dimension helps to ensure that the blending of papers and EFB is uniform.

Table 1: Properties of EFB as raw materials. (Nasrin *et al.*, 2008).

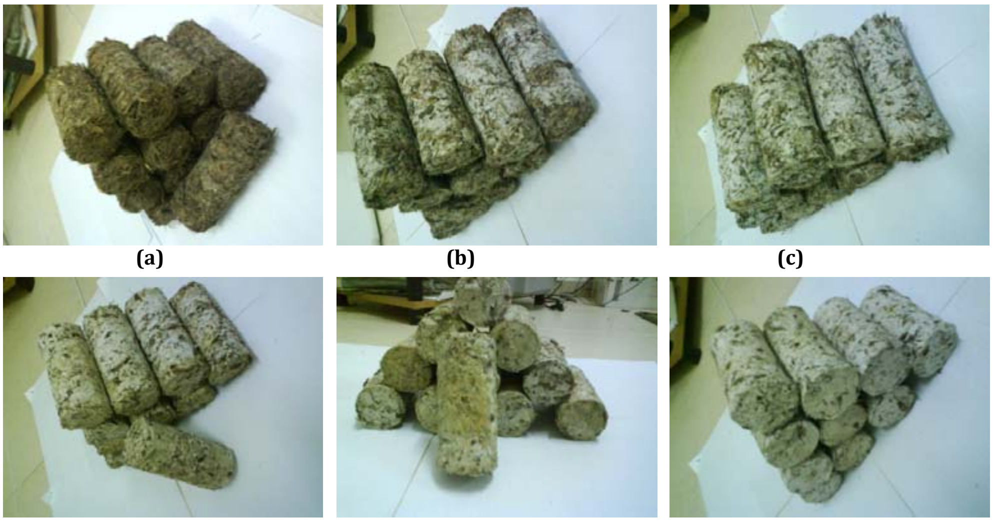
Raw Material	Average size of Materials	Calorific Value kJ/kg	Moisture Content %	Ash Content %
Pulverized EFB	<212μm	17000	12.0	2.41
EFB Fibre	3 cm	16641	16.0	4.70
EFB Fibre	2.5 mm	16641	14.0	4.60

The dimension of sample briquette produced during sample preparation is 40 mm in diameter and 73 mm in length with average weight about 67.64 grams. The ratio of briquette produced is presented in Table 2 and Figure 2 is actual specimens.

Table 2: Sample ratio and its serial number.

Ratio of EFB to Paper	Serial Number
90:10	S/N 1
80:20	S/N 2
70:30	S/N 3
60:40	S/N 4
50:50	S/N 5
40:60	S/N 6

There are several steps involved in producing a single briquette according to its ratio. Firstly, the waste papers need to be immersed in water for 24 hours and then it is blended using a blender to mash up the waste papers. Then, the blended papers it weighed again to get the weight of mashed papers with water. After dividing the EFB and shredded papers according to their ratios, the EFB fiber is mixed up with the shredded paper. Then, the compacting step takes place by compacting the mixing of EFB and waste paper into a solid briquette by using hydraulic press machine and cylinder mold. The size of the mold is 100 mm in length and 40 mm in diameter. The mixing is compressed into the mold until it gets to the desired length which is 73 mm. The amount of pressure applied during compacting process is 3 bars. Finally, the solid briquette is placed inside a drying oven at temperature 100 °C for 24 hours to remove the water obtained during the compacting process.



(a) **(b)** **(c)** **(d)** **(e)** **(f)**

Figure 2: Samples of solid briquettes in different ratios; **(a)** S/N 1, **(b)** S/N 2, **(c)** S/N 3 **(d)** S/N 4, **(e)** S/N 5 and **(f)** S/N 6.

3.0 RESULTS AND DISCUSSION

Compression test is carried out in order to obtain compressive strength of fuel briquette. In this test, each sample will be tested five times to get an accurate result. The sample is tested using UTM tensile machine in lateral position. The compression test conducted on the sample can be illustrated in Figure 3.


(a) (b) (c)

Figure 3: **(a)** Position of sample briquette in lateral, **(b)** Compression of sample briquette, **(c)** Sample briquette after compressed.

Figure 3 (a) shows the position of the briquette on the testing machine. The briquette is tested in lateral direction. Then the sample will be compressed until it failed under the load subjected to it during the compression. The speed rate used is 1.3 mm/min. the process of compression on the sample briquette is shown in Figure 3 (b). A sample briquette is considered to be failed after it has been compressed by half of its diameter. The maximum load set on the machine is 140 kN. A figure of sample briquette which has failed after in is compressed is presented in Figure 3 (c). A comparison of compression test results on the overall briquettes can be further illustrates in a Figure 4.

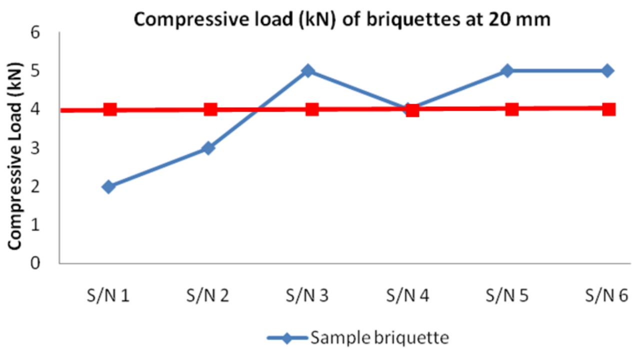


Figure 4: Comparison of Compressive load on sample briquette.

From Figure 4, it can be deduce that the average compressive load at the fracture of the briquettes is around 4 kN which represented by a red line in the figure. The gap between the values of compressive load sustained between each sample is not too large, and this means that each briquette is compatible with each other in terms of its compressive strength. A data for maximum load, compressive strength and modulus for each briquette tested is presented in Table 3.

Table 3: Maximum load, compressive strength and modulus of the sample briquette in each ratio.

Sample Ratio	Maximum Load (kN)	Compressive Strength (MPa)	Modulus (GPa)
S/N 1	56.71	45.13	0.33
S/N 2	63.85	50.81	0.36
S/N 3	62.17	49.48	0.30
S/N 4	65.22	51.90	0.35
S/N 5	64.18	51.07	0.31
S/N 6	65.96	52.49	0.36

Referring to Table 3, sample briquette S/N 6 is the highest sample that can withstand a maximum load of 65.96 kN and followed by sample S/N 4 with a maximum load of 65.22 kN. Sample briquette S/N 1has the lowest maximum load which is 56.71 kN. In the other hands, sample briquette S/N 6 also has recorded the highest compressive strength value which is 52.49 MPa compared to sample briquette S/N 4 and S/N 5 which recorded a compressive strength of 51.90 MPa and 51.07 MPa respectively. This is followed by sample briquette S/N 2 and S/N 3 with a compressive strength of 50.81MPa and 49.48 MPa. Sample briquette S/N 1 is recording the least amount of compressive strength with a value of 45.13 MPa. This can further understand by referring to Figure 5.

A compression test is conducted to observe the compressive strength that each samples can sustain before it is failed by cracking or breaking. The maximum load is 100 kN and the briquettes are compressed by two parallel plates at a speed rate of 1.3 mm per minutes. the briquettes are compressed in a lateral position. When briquettes started to compressed to half of its original diameter, the force or load will become constant value or constant plotting on the graph. This shown that the briquette has already failed and the process of compression is stopped. From the results, referring to Table 3, sample briquette S/N 6 is the best sample that can sustain maximum load subjected to it during compression. The maximum load sustained by this sample before failure is 65.90 kN. The second best ratio is sample S/N 4 with a maximum load sustained 65.22 kN. Sample ratio that sustained the least amount of maximum load before it failure is S/N 1 with a maximum load of 56.71 kN. This can be summarize that, for compression test, the larger amount of paper in the ratio, the higher the maximum load it can withstand before failure.

Based from the study conducted by Nasrin *et al*., (2008), the study is comparing the effect of EFB in two different conditions which is in powder form and fibre form with the mixing of sawdust to produce briquettes. The EFB powder is mixed with sawdust in a ratio of 50:50 and the EFB fiber is mixed with sawdust in a ratio of 40:60. From the study, the compressive strength of briquette using EFB powder is greater than briquette from fibrous form, but the presence of sawdust in both briquettes has increase the strength of the briquettes and its outer physical surface condition. The average compressive and horizontal strength for palm biomass briquettes are 7.5 MPa and 6.5 MPa respectively. It was found out that the addition of sawdust improved the strength of palm briquettes and its outer physical surface condition as well. This can be relates to the study conducted, the presence of paper in the ratio of EFB briquette has increased the strength of the briquettes. This is proven that S/N 6 shown greater compressive strength compared to S/N 1. By comparing the briquette which is S/N 5 and S/N 6 to the journal with the equal ratio, the amount of compressive strength of briquettes S/N 5 and S/N 6 is greater than the briquettes produced by the journal. The difference can be represents by Figure 5.

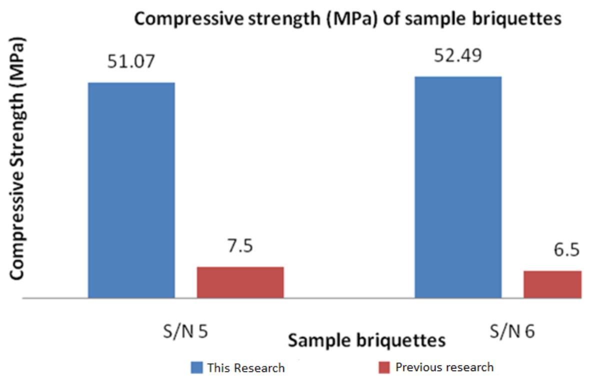


Figure 5: Comparison of sample briquette with other researcher.

From Figure 5, it clearly shown that the compressive strength of briquette obtained in this research is higher compared to the research conducted by Nasrin *et al.,* (2008). The gap between sample briquettes produced with briquettes from other research is 43.57 MPa for S/N 5 and 45.99 MPa for S/N 6. This large difference may be due to the method of compaction done or density of the briquettes produced which may be different. Meanwhile a study on mixture of waste paper and coconut husk briquette conducted by Olorunnisola (2007) have reported that briquettes produced with 100 % waste paper had the highest compressed and relaxed density whereas the compressive strength has increased slightly when it mixed with the coconut husk. This may be due to the low bulk density of coconut husk which causing the density and compressive strength decreased a bit. It proved that the presence of waste paper do increased the strength of the briquettes. Other factor that influenced the strength of a briquette is the effect of binder added into the mixtures. In this research, 2 grams of starch is added during the mixtures of sample briquette to act as a binder that help binds the mixtures together. The binder is added to all sample ratios in the same amount. In this case, starch did help increased the strength of the briquettes. This is because, when it combined with waste paper, the compaction of the briquette becomes stronger and uniform.

4.0 Conclusion

From the experiment carried out, it was generally found out that the characteristics of palm biomass briquettes produced from compaction of EFB and waste paper were satisfactory and compatible with the other researches that involved the palm briquettes. The compression test at lateral positions concluded that, the larger amount of paper in the ratio, the higher the maximum load it can withstand before failure. Analysis shows that briquette S/N 6 gives the highest compressive strength compared to other samples, and sample S/N 1 gives the least amount of compressive strength.In the nutshells it can be summarized that all samples briquettes have their own strength and weakness when they were subjected to different types of testing, but still all the briquettes were compatible with each others and it is suitable to be commercialized as a new solid fuel sources that can be utilized in many application such as camping, barbeque and for residence utilization energy. The blending of EFB fiber with waste paper can improve its physical, mechanical, and combustion properties

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