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SOLID FUEL FROM EMPTY FRUIT BUNCH FIBER AND WASTE PAPERS PART 2: GAS EMISSION FROM COMBUSTION TEST

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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 gas emission content during combustion test. A good and quality briquette is the one that contained high oxygen and small amount of carbon monoxide, carbon dioxide, nitrogen and sulphur gases which released during the combustion. This is because, all these gases can cause air pollution and it is hazardous to human health. Low sulphur content is desirable in order to make this form renewable energy more environments friendly as compared to combustion of fossil fuels because combustion of agricultural wastes types will emit less sulphur oxide and react with water, oxygen and oxidants in forming the acidic compound that formed acid rain. Hence, the possibility result in this research is the development of solid fuel briquette by mixing the empty fruit bunch with a waste paper can be one sources of fuel energy. From the combustion analysis showed sample briquette of S/N 1 was found to be the best ratio as the amount that met the good environmental friendly aspects.

Keywords: *Empty Fruit Bunch Fiber, Waste Papers, Gas Emission 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.,* 2012), stability, and durability, proximate, ultimate, immerse and crack, but in this paper (part 2) only discuss on gas emission released after combustion test.

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)

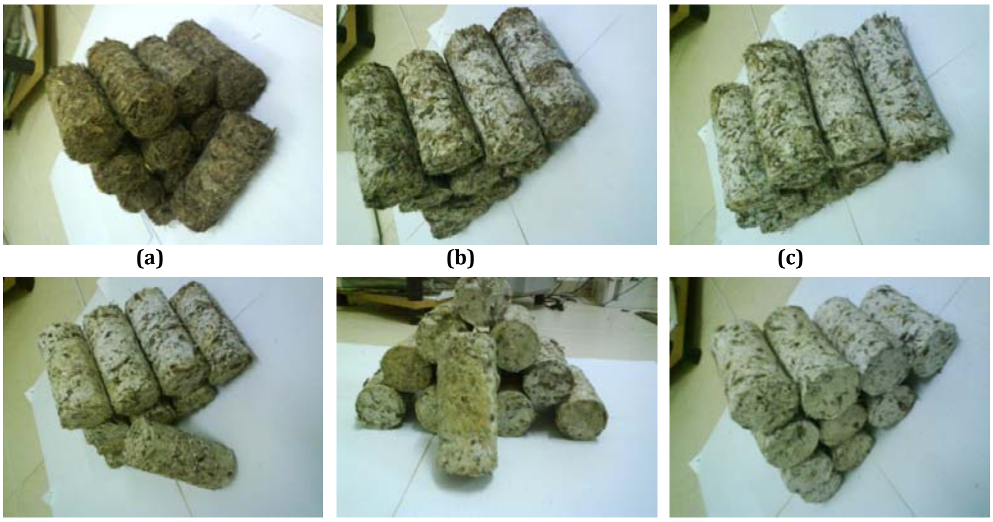
Raw Material	Average size of Materials	Calorific Value kJ/kg	Moisture Content %	Ash Content %
Pulverized EFB	<212μm	17000	12.0	2.41
EFB Fibre	3 cm	16641	16.0	4.70
EFB Fibre	2.5 mm	16641	14.0	4.60

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

During the combustion process, gas emission from each sample can also be recorded by using equipment called gas analyzer. The gas emission for each sample is taken during the combustion takes place until the sample burn completely. The purpose to record the gas emission for the sample is to obtain the composition of material in terms of carbon, oxygen, nitrogen and sulphur. The value of each element can be presented in the Table 3.

Table 3: Amount of gas emission in sample briquettes

Sample Ratio	Gas Emission					
	O_2 (%)	CO (ppm)	CO_2 (%)	NO(ppm)	NO_2 (ppm)	SO_2 (ppm)
S/N 1	20.90	283.00	0.33	6.00	0.5	10.00
S/N 2	20.80	376.00	0.40	10.00	0	24.00
S/N 3	20.00	770.00	0.80	9.00	0	18.00
S/N 4	20.70	755.00	0.20	11.00	0	21.00
S/N 5	20.80	79.00	0.80	7.00	0	16.00
S/N 6	20.80	446.00	1.00	4.00	1.0	10.00

Table 3 shown a data on the amount of gas emission of sample briquettes in term of oxygen, carbon monoxide, carbon dioxide, nitrogen oxide, nitrogen dioxide and sulphur dioxide. From the table, it can be deduce, briquette with a ratio of 40:60 released the highest percent of carbon dioxide which is 1.00 percent followed by sample with ratio 70:30 and 50:50 with percentage of carbon dioxide 0.80 percent for both samples. Sample briquette that released the least amount of carbon dioxide in percentage is sample ratio of 60:40 with a value of 0.20 percent. This can be further understood by referring to the histogram in Figure 3.

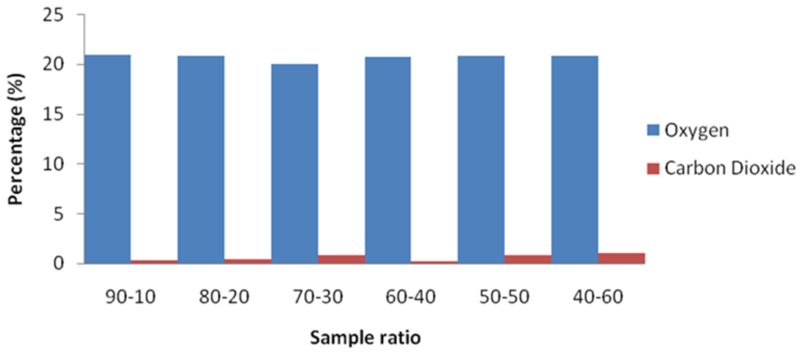


Figure 3: Percentage of Oxygen and Carbon Dioxide of sample briquettes

From Figure 3, it is clearly shown that the briquettes tested released a small amount of carbon dioxide into the air during its combustion. This shown that the briquettes does reducing the amount of carbon dioxide released from its combustion compared to conventional combustion process using fossil fuel or coal. Combustion implies the addition of air or oxygen directly to the reactor in sufficient quantity to completely or stoichiometrically oxidize the biomass, usually with the excess of oxygen to ensure burning out. During combustion of biomass, firstly it is pyrolysed to gases and organic vapors which are then burned in flaming combustion. The char burns in glowing combustion after the pyrolysed step (Bridgwater, 2007). A good and quality briquette is the one that contained high oxygen and small amount of carbon monoxide, carbon dioxide, nitrogen and sulfur gases which released during the combustion. This is because, all these gases can cause air pollution and it is hazardous to human health. Low sulfur content is desirable in order to make this form renewable energy more environments friendly as compared to combustion of fossil fuels because combustion of agricultural wastes types will emit less sulfur oxide and react with water, oxygen and oxidants in forming the acidic compound that formed acid rain. This is supported by a study on woody biomass briquette conducted by Loo and Koppejan (2008) which stated that oxygen, carbon, nitrogen, and sulfur are the main components of biomass fuels. Carbon and hydrogen become oxidized during combustion by exothermic reaction (formation of carbon dioxide and water) and therefore influence the gross calorific value of the fuel. The amounts of volatile matter also influence the combustion behavior of the solid fuels. Didar and Kashyap (1997) in the study of paddy husk briquette stated that increase in the amount of air resulted in an increased amount of carbon dioxide up to 40 to 50 % excess air, but beyond this limit, increase in excess air resulted in decrease of carbon dioxide in the combustion. The result on amount of carbon, oxygen and nitrogen obtained can be compared with the journal conducted by Yaman *et al.*, (2000) which recorded 39 % of carbon and 1.5 percent of nitrogen gases during the combustion of olive refuse and paper mill waste briquettes. Compared to the result in Table 3, the amount of gas emission obtained in the study is relatively higher. This shown that the amount of gas emission of EFB and waste paper briquettes recorded a better value of gas emission in which the value is lower compared to the journal mention previously. Meanwhile Demirbas *et al.*, (1997) in their study of waste paper and wheat straw briquettes, the amount of carbon, oxygen and nitrogen gases recorded are 45.4 %, 34.1 % and 1.8 percent respectively. These values are also higher compared to the result obtained in Table 3. This shown that the sample briquettes produced is better in terms of its gas emission in which the amount of carbon and nitrogen gases released is lower compared to the waste paper and wheat straw briquettes. From Table 3, it can be deduce that sample S/N 1 is the best sample for which is gives the highest amount of oxygen gas, and the lowest amount of carbon gases released during its combustion. The comparison can be further explained by the Figure 4.

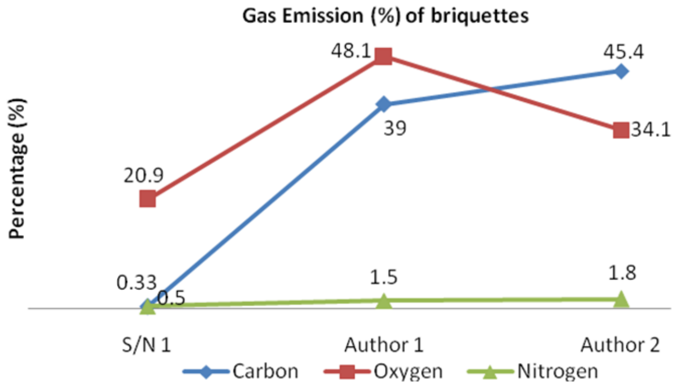


Figure 4: Comparison on gas emission of solid briquettes

4.0 CONCLUSION

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. For the gas emission released by briquettes from the combustion test, sample S/N 1 was found to produce the least amount of carbon, nitrogen and sulphur into the environment and contained high amount of oxygen. 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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