

SOLID FUEL FROM EMPTY FRUIT BUNCH FIBER AND WASTE PAPERS PART 5: CRACK TEST FOR TRANSPORTATION AND STORAGE PURPOSE

YUHAZRI¹, M.Y., HAERYIP SIHOMBING², YAHAYA³, S.H., SAID⁴, M.R., UMAR NIRMAL⁵, SAIJOD LAU⁶ and PHONGSAKORN PRAK TOM⁷

^{1,2,3} Faculty of Manufacturing Engineering

⁴ Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, MALAYSIA

¹yuhazri@utem.edu.my

²iphaery@utem.edu.my

^{5,6} Faculty of Engineering and Technology

Multimedia University

Jalan Ayer Keroh Lama, 75450, Melaka, MALAYSIA

³nirmal@mmu.edu.my

⁴twlau@mmu.edu.my

⁷ Nuclear Power Division

Malaysia Nuclear Agency

Bangi, 43000, Kajang, MALAYSIA

⁵phongsakorn@nuclearmalaysia.gov.my

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 crack test for transportation and storage purpose. This solid fuel prepared by manual compression technique and tested using drop test equipment. This analysis important to know the capability of the solid fuel to sustained/maintained the physical shape after transportation and storage activities. Experimental work shows that most samples of solid fuel have good performance for the test.

Keywords: Empty Fruit Bunch Fiber, Waste Papers, Transportation, Storage.

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), compression test at lateral position (Yuhazri *et al.*, 2012d), durability, immerse and crack, but in this paper (part 5) only discuss on the crack test for transportation and storage purpose.

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).

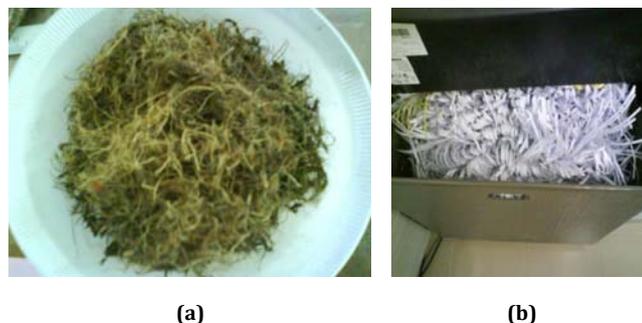


Figure 1: (a) EFB in fibrous form, (b) Shredded paper in shredder machine.

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	<212 μ m	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.

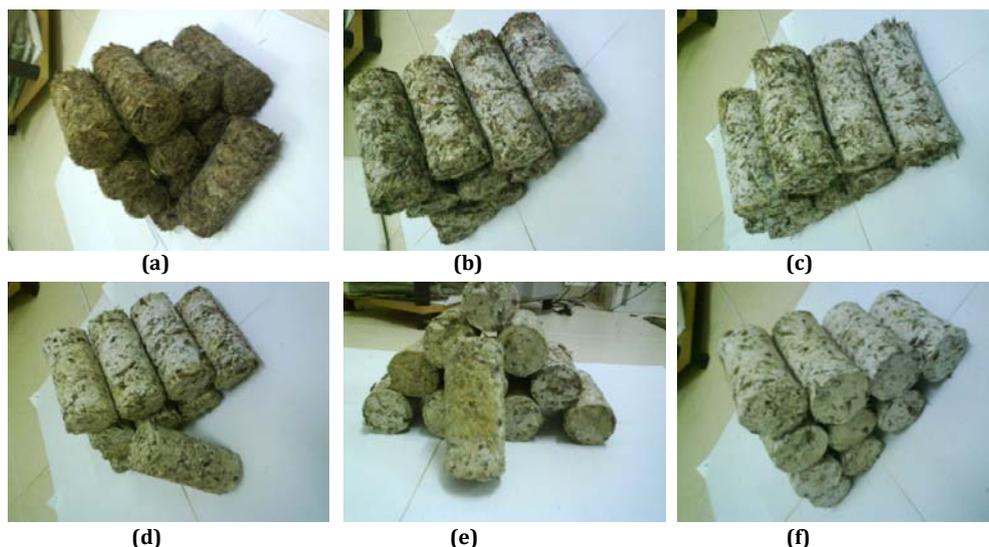


Figure 2: Samples of solid briquettes in different ratios; (a) S/N 1, (b) S/N 2, (c) S/N 3 (d) S/N 4, (e) S/N 5 and (f) S/N 6.

3.0 RESULTS AND DISCUSSION

Crack test is carried out to observe whether the briquettes can withstand fracture when it is subjected to drop during transportation and storage. The testing is conducted by releasing all briquettes from a height of two meters and the formation of crack is observed. The figure of briquettes after crack test is illustrated in Figure 3.

From Figure 3, it can be seen that the entire sample did not scattered after subjected to crack test, but there a formation of wear and surface crack on sample briquettes after the crack test done on it. From figure it can be explained that sample S/N 1 formed a fraction after subjected to a crack test. Meanwhile S/N 2 and S/N 3, there are no fraction, crack, wear or tear observed on it after subjected to crack test. As for sample S/N 4, large crack formation on the surface of the sample is observed. Finally, sample S/N 5 and S/N 6, small crack and wear formation on the surface of the samples are observed during the crack test. Sample S/N 4 formed the most obvious crack and wear formation after it is subjected to crack test. Meanwhile for S/N 1, small amount of the briquette has tear out but the whole briquette does not scatter and the formation of crack is smaller compared to other sample briquettes.

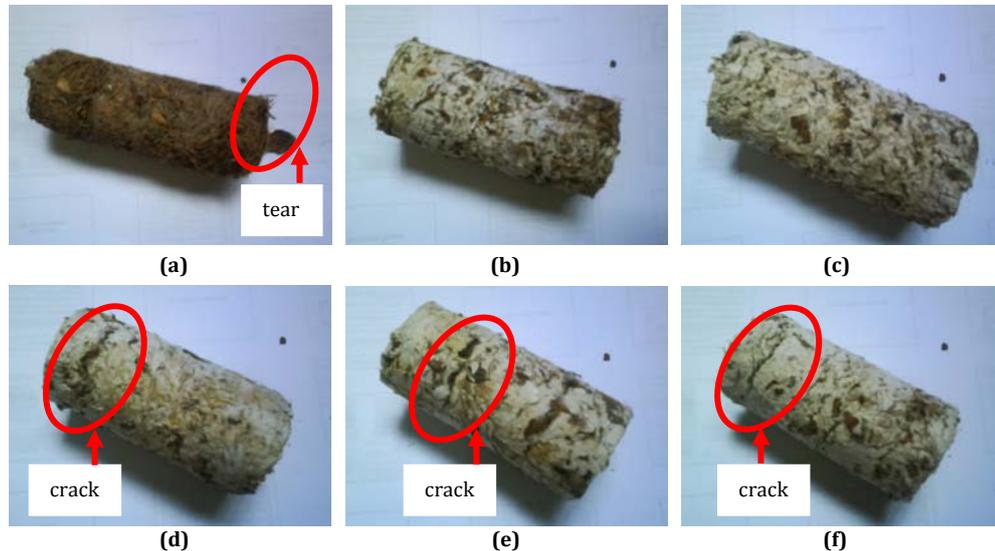


Figure 3: Crack test on sample briquettes; (a) S/N 1, (b) S/N 2, (c) S/N 3 (d) S/N 4, (e) S/N 5 and (f) S/N 6.

Another reason may be due to the condition of the EFB fiber which is fibrous and cellulose that helps to binds and hold the mixtures strongly thus protecting the briquettes from crack. Compared to a crack analysis carried out by Husain *et al.*, (2002), crack analysis is done on a densified biomass briquette to observed the formation of crack by releasing the briquette from a height of 1 to 2 meter to observed whether the briquette can sustain cracking or breaking. The test was made after keeping the briquettes for four days at atmosphere condition. Form the test it is observed that the crack length in the axial direction increases with diameter of briquettes. The briquettes managed to sustain a cracking and breaking when released from 1 to 2 meter of height. This is same with the sample briquettes produced which also released form height of 2 meter for four times and the results observed that all sample briquettes manage to sustain breaking and cracking without scattering, but some of the sample did formed a crack on its surface.

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. From the result, it can be said that the sample briquettes produced is high durable as it does not scatter but only form wear and tear on the surface of the sample. This is suitable for the end application of the briquettes which required high durability during handling, transportation and storage. The reason for durable briquettes may be due to the good compaction process of the briquettes resulting in high compacted briquettes which hard to crack when subjected to abrasive environment.

REFERENCES

- [1] Arias, N.C. (2011): Production of Biomass From Short Rotation Coppice for Energy Use: Comparison Between Sweden and Spain, Master thesis at Department of Energy and Technology, Faculty of Natural Resources and Agricultural Science, Swedish University of Agricultural Science.
- [2] Brown, O.R., Yusof, M.B.B.M., Salim, M.R.B. and Ahmed, K. (2011): Physico-chemical Properties of Palm Oil Fuel Ash As Composite Sorbent in Kaolin Clay Landfill Liner System. *Clean Energy and Technology (CET)*, 2011 IEEE First Conference (June), pp.269-274, 27-29.
- [3] Carlin N.T., Annamalai, K., Oh, H., Ariza, G.G., Lawrence, B., Arcot V.U., Sweeten, J.M., Heflin, K. and Harman, W.L. (2011): Co-Combustion and Gasification of Coal And Cattle Biomass: A Review of Research and Experimentation (*Green Energy - Progress in Green Energy*). Springer London Publisher. Vol.1, pp.123-179.

- [4] Chuen-Shii, C., Sheau-Horng, L., Chun-Chieh, P., Wen-Chung, L. (2009): The Optimum Conditions for Preparing Solid Fuel Briquette of Rice Straw by a Piston-Mold Process Using the Taguchi Method. *Fuel Processing Technology*, Vol.90, Iss.7-8, pp.1041-1046.
- [5] Chun, Y.Y., Shabuddin, W.W.A. and Ying, P.L. (2008): Oil Palm Ash as Partial Replacement of Cement for Solidification/Stabilization of Nickel Hydroxide Sludge. *Journal of Hazardous Materials*, Vol.150, Iss.2, pp.413-418.
- [6] Corley, R.H.V. and Tinker, P.B.H. (2008): The Oil Palm: *World Agriculture Series*. 4Ed. John Wiley & Sons.
- [7] De, Y.T., Xu, W. and Ai, H.X. (2012): Virtual Design and Simulation for Biomass Plane-die Briquetting Machine. *Advanced Material Research (Renewable and Sustainable Energy)*. vols.347-353, pp.2432-2437.
- [8] Despina, V., Evaggelia, K., Stelios, S. and Piero, S. (2012): Gasification of Waste Biomass Chars by Carbon Dioxide via Thermogravimetry : Effect of Catalysts. *Combustion Science and Technology*. Vol.184, Iss.1, pp.64-77.
- [9] Fernando, G. (2009): Synergy in Food, Fuels and Materials Production from Biomass. *Energy Environ. Sci.*, vol.3, iss.4, pp.393-399.
- [10] Foo, K.Y. and Hameed, B.H. (2009): Value-Added Utilization Of Oil Palm Ash: A Superior Recycling Of The Industrial Agricultural Waste. *Journal of Hazardous Materials*, Vol.172, Iss.2-3, pp.523-531.
- [11] Gómez-Loscos, A., María, D.G. and Montañés, A. (2012): Economic Growth, Inflation and Oil Shocks: Are the 1970s Coming Back?. *Applied Economics*, Vol.44, Iss.35, pp.4575-4589.
- [12] Gonzalez, R.W. (2011): Biomass Supply Chain and Conversion Economics of Cellulosic Ethanol. Ph.D. Thesis at North Carolina State University. USA.
- [13] Husain, Z., Zainac, Z. and Abdullah, A. (2002): Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil. *Journal of Biomass and Bioenergy*, Vol.22, Iss.6, pp.505-509.
- [14] Kaygusuz, K. and Keleş, S. (2008): Use of Biomass as a Transitional Strategy to a Sustainable & Clean Energy System. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, Vol.31, Iss.1, pp.86-97.
- [15] Nasrin, A.B., Choo, Y.M., Lim, W.S., Joseph, L., Michael, S., Rohaya, M.H. and Astimar, A.A. (2011): Briquetting of Empty Fruit Bunch Fibre and Palm Shell as a Renewable Energy Fuel. *Journal of Engineering and Applied Sciences*, Vol.6, No.6, pp.446-451.
- [16] Nasrin, A.B., Ma, A.N., Choo, Y.M., Mohamad, S., Rohaya, M.H., Azali, A. and Zainal, Z. (2008): Oil Palm Biomass as Potential Substitution Raw Materials for Commercial Biomass Briquettes Production. *American Journal of Applied Sciences*.
- [17] Romeela, M. and Ackmez, M. (2012): Energy from Biomass in Mauritius: Overview of Research and Applications, (Waste to Energy). Springer London Publisher. ISBN: 978-1-4471-2306-4.
- [18] Sławomir, O. (2012): Analysis of Usability of Potato Pulp as Solid Fuel, *Fuel Processing Technology*, Vol.94, Iss.1, pp.67-74.
- [19] Sumiani, Y. (2006): Renewable Energy From Palm Oil – Innovation on Effective Utilization of Waste. *Journal of Cleaner Production*, Vol.14, Iss.1, pp.87-93.
- [20] Tangchirapat, W., Saeting, T., Jaturapitakkul, C., Kiattikomol, K. and Siripanichgorn, A. (2007): Use of Waste Ash From Palm Oil Industry In Concrete. *Waste Management*, vol.27, pp.81-88.
- [21] Tong, Z. and Feng, T. (2012): A Study On Energy Saving of LEED-NC Green Building Rating System From Point Analysis. *Advanced Materials Research*, Vols.374-377, pp.122-126.
- [22] Vaclav, S. (2010): Energy Myths and Realities: Bringing Science to the Energy Policy Debate. Government Institutes Publisher.
- [23] Yuhazri, M.Y., Sihombing, H., Jeefferie, A.R., Ahmad Mujahid, A.Z., Balamurugan, A.G., Norazman, M.N. and Shohaimi, A. (2011): Optimazation of Coconut Fibers Toward Heat Insulator Applications. *Global Engineers & Technologists Review*, Vol.1, No.1, pp.35-40.
- [24] Yuhazri, M.Y., Kamarul, A.M., Haeryip Sihombing, Jeefferie, A.R., Haidir, M.M., Toibah, A.R. and Rahimah, A.H. (2010): The Potential of Agriculture Waste Material for Noise Insulator Application Toward Green Design and Material, *International Journal of Civil & Environmental Engineering*, Vol.10, No.5, pp.16-21.
- [25] Yuhazri, M.Y., Haeryip Sihombing, Umar, N., Saijod, L. and Phongsakorn, P.T. (2012a): Solid Fuel from Empty Fruit Bunch Fiber and Waste Papers Part 1: Heat Released from Combustion Test, *Global Engineers and Technologists Review*, Vol.2, No.1, pp.7-13.
- [26] Yuhazri, M.Y., Haeryip Sihombing, Yahaya, S.H., Said, M.R., Umar, N., Saijod, L. and Phongsakorn, P.T. (2012b): Solid Fuel from Empty Fruit Bunch Fiber and Waste Papers Part 2: Gas Emission from Combustion Test, *Global Engineers and Technologists Review*, Vol.2, No.2, pp.8-13.
- [27] Yuhazri, M.Y., Haeryip Sihombing, Yahaya, S.H., Said, M.R., Umar, N., Saijod, L. and Phongsakorn, P.T. (2012c): Solid Fuel from Empty Fruit Bunch Fiber and Waste Papers Part 3: Ash Content from Combustion Test, *Global Engineers and Technologists Review*, Vol.2, No.3, pp.26-32.
- [28] Yuhazri, M.Y., Haeryip Sihombing, Yahaya, S.H., Said, M.R., Umar, N., Saijod, L. and Phongsakorn, P.T. (2012d): Solid Fuel from Empty Fruit Bunch Fiber and Waste Papers Part 4: Compression Test at Lateral Position, *Global Engineers and Technologists Review*, Vol.2, No.4, pp.16-22.

