UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SOLID FUEL FROM EMPTY FRUIT BUNCH FIBER AND RECYCLED MATERIAL

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) with Honors.

By

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) with Honors. The member of the supervisory committee is as follow:

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ABSTRACT

This research purpose is to study and analyze the effect of different ratio from the mixture of Empty Fruit Bunch Fiber (EFB) and recycled material briquettes towards the combustion properties. This research also aims to utilize the abundant materials such as palm biomass and waste papers into a useful product to minimize the quantity of wastes produced in this country. The main raw materials used in this study are EFB fiber and waste papers. Basically, these two materials were mixed up and turned into solid fuel briquettes by briquetting technology. The mixtures were compacted into a solid briquette using a hydraulic compression machine. The typical pressure applied to compress the briquette is 12 000 lb. After that, the briquettes have undergone two types of testing which is chemical testing and mechanical testing. All the testing conducted were referred according to the standard test methods provided by ASTM standard. Types of chemical testing tested onto the fuel briquettes are moisture content test, ash content test, combustion test, gas emission test and combustion analysis. As for the mechanical testing, types of testing that have been conducted are crack test, stability test, water resistance test, durability test and compression test. From the testing, the best ratio of the biomass briquettes were observed and selected. From the analyses of both chemical and mechanical testing, it was found that sample briquette with ratio 60:40 has given a highest value of heat released which is 162.77 kJ, whereas sample with ratio 40:60 has good burning time, and better compressive strength. Meanwhile, sample ratio of 50:50 has produced lowest ash content and sample ratio 90:10 has given the lowest gas emission of carbon, nitrogen and sulfur and the best sample that sustained its dimensional stability.

ABSTRAK

Kajian ini dijalankan adalah bertujuan untuk mengkaji dan menganalisa kesan tenaga pembakaran yang berlaku terhadap campuran dua bahan mentah iaitu *Empty Fruit Bunch* (EFB) dan bahan yang boleh dikitar semula pada kadar nisbah yang berbeza – beza. Kajian ini juga turut dihasilkan dengan matlamat untuk menggunakan bahan – bahan terbuang seperti hasil buangan kelapa sawit dan bahan terbuang pada tahap yang optimum bagi mengurangkan kuantiti bahan terbuang yang dihasilkan dalam negara pada setiap tahun. Bahan utama yang akan terlibat dalam projek ini ialah EFB dan kertas terbuang. Secara keseluruhannya, EFB dan kertas terbuang tersebut akan dihancurkan dan dicampurkan menjadi satu adunan bagi menghasilkan sampel berbentuk pepejal yang dikenali sebagai "*briquette*". Hasil campuran tersebut akan dimampatkan ke dalam bentuk pepejal menggunakan mesin mampatan pada tekanan 12 000 lb. Selepas pepejal *briquette* berjaya dibentuk, ia akan melalui dua jenis ujian iaitu ujian kimia dan ujian mekanikal. Ujian kimia yang akan dilakukan adalah seperti ujian kelembapan, ujian isipadu abu yang dihasilkan selepas pembakaran,ujian pembakaran, ujian pembebasan gas dan ujian analisa pembakaran. Manakala ujian mekanikal yang terlibat adalah seperti ujian keretakan, ujian kestabilan, ujian ketahanan, uijan ketahanan pada air, dan akhir sekali ujian mampatan. Berdasarkan ujian – ujian tersebut, nisbah 60:40 telah memberi nilai haba pembebasan yang paling tinggi iaitu sebanyak 162.77 kJ, manakala nisbah 40:60 telah memberikan masa pembakaran yang paling lama dan nilai kekuatan tekanan yg paling baik. Sementara itu, nisbah 50:50 telah menunjukkan nilai abu yg paling rendah selepas pembakaran dah nisbah 90:10 merekodkan nilai pembebasan gas paling rendah disamping mampu mengekalkan kestabilannya dengan baik.

DEDICATION

For my beloved family especially my parents Abd Muin B. Ahmad and Kalthom Binti Hasan and friends

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° C	-	Celcius
e.m.c	-	electromagnetic compatibility
g/min	-	gram per minute
GPa	-	giga pascal
kJ/kg	-	Kilo Joule per kilogram
kN	-	Kilo Newton
kW	-	kilo watt
MPa	-	mega pascal
µm	-	micro meter
mm	-	millimeter
N/m^2	-	Newton per meter
%	-	Percentage
lb	-	Pound
S/N	-	Serial Number
w.t %	-	Weight Percent

LIST OF ABBREVIATION

BBQ	-	Barbeque
CPO	-	Crude Palm Oil
C	-	Carbon
CO_2	-	Carbon Dioxide
CV	-	Calorific Value
EFB	-	Empty Fruit Bunch
EPSM	-	Environment Protection Society Malaysia
FEFB	-	Fiber Empty Fruit Bunch
FFB	-	Fresh Fruit Bunch
GCV	-	Gross Calorific value
H	-	Hydrogen
HHV	-	High Heating Value
KL	-	Kuala Lumpur
LHV	-	Lower Heating Value
N	-	Nitrogen
NO_x	-	Nitrogen Monoxide
MPOB	-	Malaysian Palm Oil Board
MSW	-	Municipal Solid Waste
NCV	-	Net Calorific Value
PEFB	-	Pulverized Empty Fruit Bunch
PORIM	-	International Palm Oil Congress
RM	-	Ringgit Malaysia
SO_x	-	Sulphur Monoxide
UN	-	United Nation
UV	-	Ultra Violet
WRI	-	Water Resistance Index
WTE	-	Waste – to – energy

CHAPTER 1
INTRODUCTION

1.1 Background of study

Malaysian palm oil industry has grown tremendously over the last 4 decades, and since then it has maintained its position as the leading world's country in the production of palm oil (Nasrin, A.B., *et al*., 2008). The Malaysian Palm Oil industry recorded a mixed performance in 2005 due to continue in strong growth in production. The oil palm is the prolific producer of biomass. Oil constitutes only about 10 percent of the palm production while the rest is biomass (Yusof, B., and Weng, C.K., 2004). The prices and export earnings dipped, despite an increase in exports of all oil palm products during the year. The total oil palm planted area increased by 4.5 percent or 174,000 hectares to 4.0 million hectares in year 2005. Sabah remained the largest oil palm planted state with 1.2 million hectares or 30 % of the total planted area (Basri, W., 2006). Since the oil crisis in 1970's the use of biomass as a source of energy is a topic of growing interest and debate (Ma, A.N., and Yusuf, B., 2005). Nevertheless, the industry has also generated a vast amount of palm biomass, mainly from milling and crushing palm kernel. The types and amounts of these biomass generated in year 2005 are tabulated in Table 1.1 (Nasrin, A.B., *et al*., 2008). The oil consists of only a minor fraction of the total biomass produced in the plantation. The remainder consists of huge amount of lignocelluloses materials in the forms of fronds, trunk and empty fruit bunch (EFB). EFB is the main solid waste obtained from milling process. However, due to its poor characteristic, it has limitation to be used as fuel.

Table 1.1: Palm Biomass generated in year 2005. (Nasrin, A.B., *et al*., 2008)

Biomass	Quantity million tonnes	Moisture Content, %	Calorific Value, kJ/kg	Main uses
Fibre	9.66	19068	19068	Fuel
Shell	5.20	20108	20108	Fuel
Empty Fruit Bunches	17.08	18838	18838	Mulch
Palm Kernel Expeller	2.11	18900	18900	Animal Feed

Producing energy from renewable biomass is only one of the various ways of responding to the challenges of the energy crisis. In 2004, Malaysia had about 3.87 million hectares of land under oil palm cultivation. Currently, more than 80 % 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 (MPOB), this co – products from palm oil industry have been found to be good resources for many application. There are many competitive uses of these materials. One of them is to utilize them as a fuel for energy production. In fact, Malaysian government has identified biomass as fifth fuel resource to compliment the petroleum, gas, coal, and hydro as energy resources. Palm biomass has been identified as a single most important energy source. On the other hands, the main sources of biomass in Malaysia are domestic wastes, agricultural wastes, effluent sludge and wood chips.

Biomass energy systems can be based on a wide range of feedstock. 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 (PORIM International Palm Oil Congress, 1996).

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. (Nasrin, A.B., *et al.,* 2008). 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.

1.2 Problem statement

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 an alternative method in upgrading biomass into a useful solid fuel that can be done through various technologies. In this project, 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 project 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.

1.3 Objectives

There are several aims that need to be achieved in this project which is

(a) Determination of the best ratios of EFB and recycled papers for combustion.

(b) To develop a solid fuel from the mixing of an empty fruit bunch (EFB) and recycled papers at a different ratio/percentage.

1.4 Scopes of study

The scope of this project 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, stability, and durability, proximate, ultimate, immerse and crack. Other aspects of the material will not be covered.

1.5 Thesis Frames

The organization of this report is as follow; Chapter 1 as the beginning of the report is providing the introduction of the project. The elements that consist in Chapter 1 is background of palm oil industry and its application in industry, followed by a problem statement of the project study, an objectives that aimed in this study, scopes of project study and report organization. Chapter 2 comprised of a literature review of previous research regarding the palm biomass briquettes and types of testing that the material have gone through. Chapter 3 present the methodology of the research. In this chapter, all the equipment and type of testing that will be used in the study is stated. All the working flow during the study will be guided by using a Gantt chart. Meanwhile the result for the testing proposed in Chapter 3 is presented in Chapter 4. In this chapter, all the data regarding to the testing conducted is compiled in one

chapter. Here, a complete discussion and analyses on the data recorded is made to choose the best ratio of sample briquette to achieve the objective in this research. Finally, in Chapter 5, a conclusion on the overall project is made and a recommendation to improve the research is proposed. Gantt Chart II is used as a guidance to complete the analysis of the data.