DENSIFICATION OF DURIAN PEEL WASTE AS A SOLID BIOFUEL: EFFECT OF BINDER RATIO

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant & Maintenance)"

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This thesis is submitted in partial fulfilment of the award of Bachelor of Mechanical Engineering (Plant & Maintenance) With Honours

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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

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DEDICATION

For my beloved

Parents and Siblings

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ABSTRACT

Since long ago, the non-renewable energy such as fossil fuel had been consumed for the benefits of human. The continuous of fuel consumption can lead to depletion of fuel's resources and environment issues. There is an alternative ways to reduce non-renewable energy consumption by using biomass conversion into biofuel. In this project, solid biofuel will be highlighted due to its advantages in term of storage, transportation and usage. The source of solid biofuel (biomass) that will be used is durian peels because the availability of durian fruit to grow even when off season with the help of technology. Besides, there will be an investigation about the binder ratio to the durian peel briquette. There are six processes need to be done in order to convert the durian peel into briquette. First, durian peel was gone through drying process for reduce it moisture. Second, crushing process was done to obtain small pieces of durian peel. Third, milling process where the process made the durian peel in form of powder. Fourth, the powder of durian peel undergone through carbonization process which changes the powder into carbon. Fifth, the powder of durian peel only and containing carbon were mixed with two types of binders which are tapioca starch and calcium hydroxide. Sixth, densification process was done in order to give density to the powder of durian peel which is known as briquette. There were ten types of durian peel briquette produced in this project which are NC, NCS 1:4, NCS 1:8, NCS 1:12, NCC, C, CS 1:4, CS 1:8, CS 1:12 and CC. All of briquettes were undergone through four analysis; proximate, calorific value (theoretical), compressive and FTIR. The proximate analysis was done by follow the standard of ASTM of coal and coke. The proximate analysis have four parameters which are moisture content (10.42 – 14.24 %), ash content (4.23 – 15.66 %), volatile matter (41.55 – 72.09) and fixed carbon (9.44 – 33.00 %), while the calorific value was found to be 12.40 – 20.41 MJ/kg. The compressive strength for all briquettes has a range from 17.32 – 130.19 MPa. The spectrum of the briquettes has a result of O-H stretching at region of 3200 – 3400 cm^{-1}. This region also represent as cellulose. At region of 1000 – 1100 cm-1, are indicating of C-O bonding which group of alcohol. Based on the result obtained, briquette CC is considered has the best characteristic of briquette because it has high calorific and medium value of compressive strength which are 20.41 MJ/kg and 17.32 MPa, respectively.

ABSTRAK

Sejak zaman dahulu lagi, tenaga yang tidak boleh diperbaharui seperti bahan api fosil telah digunakan untuk kegunaan manusia. Penggunaan bahan api secara berterusan boleh mengurangkan sumber bahan api dan boleh mencemarkan alam sekitar. Terdapat satu cara alternatif untuk mengurangkan penggunaan tenaga yang tidak boleh diperbaharui ini dengan menggunakan penukaran biojisim kepada biofuel. Projek ini akan fokus kepada biofuel pepejal sahaja kerana kelebihannya dari segi penyimpanan, pengangkutan dan penggunaan. Sumber biofuel pepejal (biojisim) yang akan digunakan adalah kulit durian kerana pada masa sekarang, buah durian boleh didapati di mana-mana dan bila-bila masa sahaja walaupun di luar musimnya. Terdapat enam proses yang akan dilakukan untuk menukar kulit durian kepada briket. Pertama, kulit durian akan melalui proses pengeringan supaya kelembapan kulit durian dapat dikurangkan. Kedua, kulit durian akan melalui proses penghancuran untuk memperolehi serpihan-serpihan kulit durian. Ketiga, proses pengisaran dilakukan untuk menjadikannya dalam bentuk serbuk. Sesetengah serbuk akan melalui proses karbonisai. Kelima serbuk yang mengandungi karbon dan tidak mengandungi karbon akan dicampur dengan bahan pengikat iaitu kanji ubi kayu dan kalsium hidroksida. Dalam projek ini, terdapat sepuluh jenis briket kulit durian iaitu NC, NCS 1:4, NCS 1:8, NCS 1:12, NCC, C, CS 1:4, CS 1:8, CS 1:12 dan CC. Kesemua jenis briket telah melalui kesemua proses analisis; proksimat, nilai kalori, ujian mampatan dan FTIR. Proksimat analisis dilakukan dengan merujuk kepada piawaian ASTM arang batu. Proksimat mempunyai empat parameter iaitu kandungan kelembapan (10.42 – 14.24 %), kandungan abu (4.23 – 15.66 %), jirim meruap (41.55 – 72.09) dan karbon tetap (9.44 – 33.00 %), manakala nilai kalori adalah 12.40 – 20.41 MJ/kg. Kekuatan briket pula adalah 17.32 – 130.19 MPa. Berdasarkan keputusan yang diperolehi, briket C dianggap sebagai briket yang paling terbaik diantara briket yang lain kerana ianya mempunyai nilai kalori yang cukup tinggi dan nilai kekuatan mampatan juga tidak terlalu tinggi dan tidak terlalu rendah dimana nilainya adalah sebanyak 20.41 MJ/kg and 17.32 MPa mengikut masing-masing.

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LIST OF ABBREVIATION

ASTM	American Standard Testing Method
Mtoe	Million tons oil equivalent
GHG	Green house gas
MC	Moisture content
VM	Volatile matter
FC	Fixed carbon
FTIR	Fourier transform infrared spectroscopy
NC	Non-carbon
NCS	Non-carbon starch
NCC	Non-carbon calcium hydroxide
C	Carbon
CS	Carbon starch
CC	Carbon calcium hydroxide
NHV	Net heating value/Calorific value
MJ/kg	Mega Joule per kilogram
kN	Kilo Newton
MPa	Mega Pascal
mm	Millimeter
Cm	Centimeter
m	meter
RPM	Rotation per minute
G	Gram
Kg	Kilogram
Y	Years

Min	Minute
cal	calori
MT	Mega Tons
Mol	Molecule
UTeM	University Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Energy can be defined as something that can do work or the capacity of a system to do work and produce change (Frank, 2014). In other words, energy is the amount of force or power when applied can move an object from one position to another and can come in various forms and from many different sources. That is why it is very important for human development and human life. There is a need for a control and accessible supply of energy for the sustainability of modern societies. Nowadays, energy has become an integral part of human life for almost every activity such as transportation, industrial, domestic and the others. Thus, there is a need to maintain the energy for the sustainability of the growing world population. There are two categorizes of energy sources which are renewable and non renewable energy. Renewable energy is an energy source that can be unlimited and can be use to produce energy again and again. For examples are solar energy, wind energy, water energy and bio energy. While non renewable energy are limited and cannot be replaces as quickly once they are used. For examples are fossil fuels, petroleum and the other (Chauhan, 2007).

For over many years, human's kind rely on non renewable energy which is fossil fuels such as coal, oil and natural gas for their needs. This can be seen in Table 1.1 where it shows the non renewable energy is the largest source of energy consumed around the world. In fact today, non renewable energy source still being used especially petroleum, coal and natural gas.

Table 1.1: Energy consumption around the world at 2005

Energy source	Total (%)
Petroleum	40
Natural gas	23
Coal	23
Nuclear energy power	8
Renewable energy	6
Total	**100**

Source: Demirbas, 2008

The continuation of the use of fossil fuel will lead into a depletion of fossil fuels reserves, global warming, and continuing fuel price rise. These problems will create an unsustainable situation. One of the solutions is using renewable energy resources due to unlimited and environmentally friendly. Hence, renewable energy sources will play an important role as energy supply in the future. Estimation was made where in the year of 2040 almost half of energy source will come from renewable energy as shown in Table 1.2 where it shows an enhancement of energy supply from year to year. There are many source come from renewable energy sources but only one will be focused which is biofuel.

Table 1.2: Estimation of global renewable energy scenario 2040

Energy	2001	2010	2020	2030	2040
Total consumption (million tons oil equivalent)	10,038	10,549	11,425	12,352	13,310
Biomass (Mtoe)	1,080	1,313	1,791	2,483	3,271
Large hydro (Mtoe)	22.7	266	309	341	358
Geothermal (Mtoe)	43.2	86	186	333	493
Small hydro (Mtoe)	9.5	19	49	106	189
Wind (Mtoe)	4.7	44	266	542	688
Solar thermal (Mtoe)	4.1	15	66	244	480
Photovoltaic (Mtoe)	0.2	2	24	221	784
Solar thermal electricity (Mtoe)	0.1	0.4	3	16	68
Marine (tidal/wave/ocean) (Mtoe)	0.05	0.1	0.4	3	20
Total renewable energy sources (Mtoe)	1,365.5	1,745.5	2,694.4	4,289	6,351
Renewable energy sources contribution (%)	13.6	16.6	23.6	34.7	47.7

Source: Demirbas, 2008

Biofuel comes from biomass. Biomass is a matter that can be either inorganic (non living) or organic (living). Biomass consists of any organic material, living or recently dead that produced by photosynthesis (Hall et al., 1993 in Demirbas 2009). Carol, (2013) stated that during photosynthesis, energy from sunlight is stored in the roots, stems and leaves of plants. Some of this energy is used by the plants, and some is transferred through the food web to animals. When plants and animals die, fungi and microorganisms break them down. Thus, these organisms also depend on photosynthesis energy which means all living material from the smallest micro organisms to the largest tree is biomass. Biomass can produce clean and abundant energy. The key is by choosing beneficial and sustainable biomass sources while avoiding from destroying ecosystems or pollute atmosphere. Initially, biomass may seem unimpressive due to it looks such as a pile of garbage, sawdust, field of grass, even animal manure, but, with the right technology, those things can generate exciting ways to meet energy needs like providing heat, fuel or power as well

without affecting environment. Based on David (2008), the derivation of biomass used for transportation purposes is called as biofuel. Besides, the derivation of biomass into biofuels requires several steps, which are thermochemical and biochemical conversion. By doing these conversion, they can supply energy such as heat, electricity and fuels as shown in Figure 1.1. The conversion of biomass to biofuel can be categorized into three types which are solid, liquid and gas. In this project, solid biofuel that came from durian will be highlighted due to the problem created by the fruits of durian.

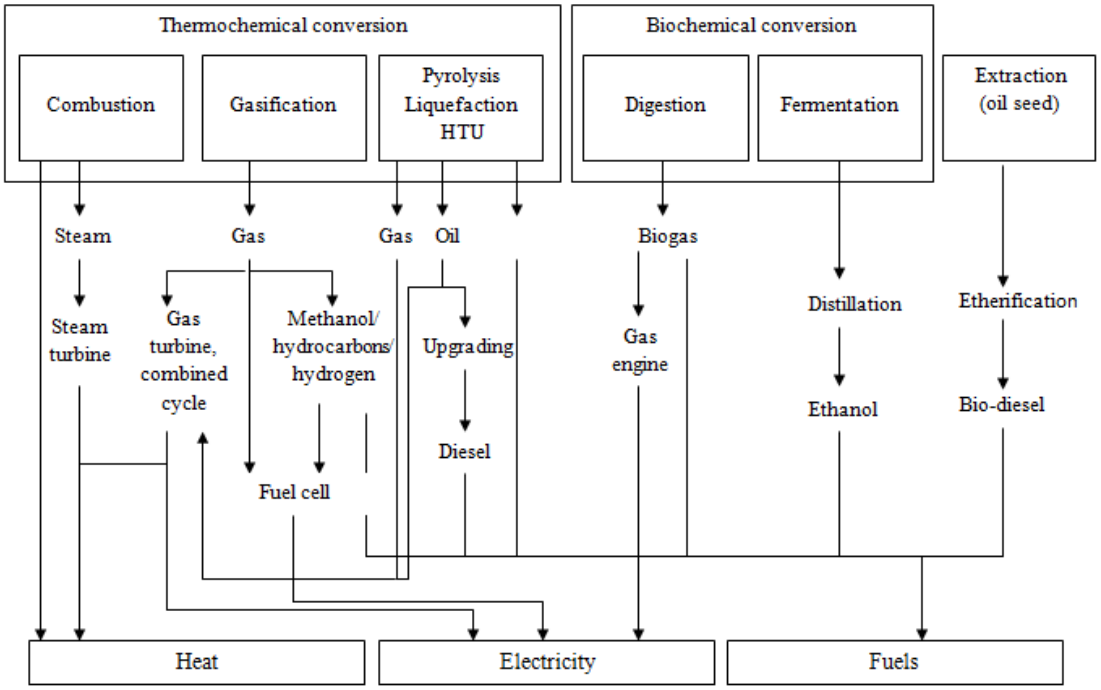

Figure 1.1: Biomass to energy conversion patterns.

Source: Turkenburg et al., 2000 in David P., 2008.

1.2 PROBLEM STATEMENT

Durian is one of the sources of biomass and durian is a seasonal fruit but lately, it can be obtained at any time even in the off-season of durian because of advance in agricultural technology. There are so many application of durian in food processing industries such as being adopted in several culinary preparations. With the availability of durian fruits in Malaysia, it not impossible this country been hampered by the massive generation of durian residues especially in form of durian peel which almost covering around 60-75 % of the entire fruit (Foo and Hameed, 2012). The presence of abundance of the durian peel residues, it can create major problems to respiratory diseases, besides of their pungent smell (Chandra et al., 2009). In order to solve this problem, a conversion of durian peel residues into briquette as a solid biofuel will be done to avoid any polluted pungent smell (Wahidin, and Anisa, 2014).

1.3 OBJECTIVES

There are several objectives on completing of densification of durian peel waste as a solid biofuel with effect of binder ratio which are:

1. To produce the briquette from durian peel waste.
2. To identify the effect of binder ratio (starch and calcium hydroxide) to the calorific value of briquette.
3. To analyze briquette product (proximate analysis, mechanical properties and functional group of briquette).

1.4 SCOPE

This project involves the preparation of durian peel waste as a raw material for briquette by drying, pulverization (crushing and milling), carbonization and densification with different binders. The binders that will be used are starch and calcium hydroxide. Furthermore, observation an analysis on calorific value, proximate analysis (moisture content, ash content, volatile matter, and fixed carbon), mechanical properties (compressive test) and Fourier Trasform Infrared Spectreoscopy (FTIR) will be performed on durian peel briquette.