CO-PROCESSING OF COCONUT SHELL AND SUGARCANE RESIDUE AS SOLID BIOFUEL

MOHD NUR SHAFIQ BIN AHMAD RAZIMI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CO-PROCESSING OF COCONUT SHELL AND SUGARCANE RESIDUE AS SOLID BIOFUEL

MOHD NUR SHAFIQ BIN AHMAD RAZIMI

This report is submitted to the Faculty of Mechanical Engineering to fulfil the partial requirement for awarding the Bachelor of Mechanical Engineering (Thermal- Fluids)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka (UTeM)

JUNE 2013

SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)".

Signature: ……………………………………………

Supervisor: DR. NONA MERRY MERPATI MITAN

Date: 28th JUNE 2013

DECLARATION

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

Signature: ………………………………………
Student: MOHD NUR SHAFIQ BIN AHMAD RAZIMI
Date: 28th JUNE 2013

ACKNOWLEDGEMENT

Alhamdulillah. I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. Firstly, I would like to thank my parent for their continuous encouragement. A special gratitude I give to my final year project supervisor, Dr. Nona Merry Merpati Mitan, whose contribution in stimulating suggestions and encouragement, helped me to coordinate my project especially in doing research and writing this report. Furthermore I would also like to acknowledge with much appreciation the crucial role of the staff of Fakulti Kejuruteraan Mekanikal and Fakulti Kejuruteraan Pembuatan, who gave the permission to use all required equipment and the necessary materials to complete the task “Co-processing of coconut shell and sugarcane residue as solid biofuel”. A special thanks goes to my team mates, who helped me a lot in this final year project.

ABSTRACT

This report is based on co-processing of coconut shell and sugarcane residue as a solid biofuel. This study covers the briquette from co-processing of coconut shell (*Cocos nucifera*) and sugarcane bagasse (*Saccharum officinarum L*). The solid biofuel briquettes were formed into cylindrical shapes 35 mm diameter, 10 mm in thickness Experiments were performed on both non-carbonized and carbonized briquettes made from various ratios of sugarcane to coconut shell 1:1, 1:3, 1:5 by weight. This research was conducted to determine the optimum mixing ratio for solid biofuel produced by hydraulic press of from co-processing of coconut shell and sugarcane baggasse. Proximate analysis and compressive test are determined to study the characteristic of the produced briquette. The carbonization process takes place in furnace at 370℃. Carbonized briquette are compared to non-carbonized to differentiate and to study the combination of coconut shell and sugarcane. The value of moisture content, volatile matter, ash content, fixed carbon, calorific value and compressive strength for carbonized and non-carbonized samples are then compared to investigate the best co-processing. The experimental results indicated that calorific value increased with increasing ratios of coconut shell for NC 1:1, NC 1:3, NC 1:5, C 1:1, C 1:3 and C 1:5. The non-carbonized ratio NC 1:5 have the lower moisture content, higher calorific value and did not fail by compressive test.

ABSTRAK

Laporan ini adalah berdasarkan bersama pemprosesan tempurung dan sisa-sisa tebu sebagai bahan api bio yang kukuh. Tempurung kelapa (*Cocos nucifera*) dan tebu hampas tebu (*Saccharum officinarum L*). Briket bahan api pepejal berbentuk silinder yang berdiameter 35 mm dan ketebalan 10 mm dihasilkan menggunakan mesin penekan hydraulic. Briket yang mepunyai peratusan 1:1, 1:3 dan 1:5 dihasilkan daripada campuran tempurung kelapa dan hampas tebu. Kajian ini telah dijalankan untuk menentukan nisbah pencampuran yang optimum untuk biofuel pepejal yang dihasilkan oleh mesin penekan hidraulik dari campuran tempurung kelapa dan hampas tebu. Analisis proksimat dan ujian mampatan ditentukan untuk mengkaji ciri briket yang dihasilkan. Proses karbonisasi berlaku dalam relau pada suhu 370℃. Briket arang dibandingkan dengan briket mentah untuk membezakan dan mengkaji gabungan tempurung kelapa dan tebu. Nilai kandungan lembapan, gas meruap, kandungan abu, karbon tetap, nilai kalori dan kekuatan mampatan bagi sampel arang dan mentah kemudiannya dibandingkan untuk mengkaji hasil campuran yang terbaik. Keputusan eksperimen menunjukkan bahawa nilai kalori meningkat dengan peningkatan nisbah tempurung untuk NC 1:1, NC 1:3, NC 1:5,C 1:1, C 1:3 dan C 1:5. Briket arang NC 1:5 mempunyai kandungan lembapan yang lebih rendah, nilai kalori yang lebih tinggi dan tidak gagal dengan ujian mampatan.

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF EQUATION

ABBREVIATION

Cs	=	Coconut shell
S	=	Sugarcane
HHV	=	High heating value
LLV	=	Low heating value
CO_2	=	Carbon dioxide
SO_2	=	Sulphur dioxide
NO	=	Nitrogen oxides
RE	=	Renewable energy
MC	=	Moisture content
VM	=	Volatile matter
FC	=	Fixed carbon

TABLE OF CONTENT

CHAPTER II LITERATURE REVIEW

CHAPTER III METHODOLOGY

CHAPTER I

INTRODUCTION

1.1 Background

Since the energy crisis in the mid-1970s, biomass energy has received attention from entire world. The research and development regarding this type of energy had done widely. Biomass is also categorized as stored sun energy. Furthermore, biomass energy usage gives economical and environmental benefits.

According to Fernandez et al., (2011), the utilization of biomass is needed to meet the energy demand because biomass considered neutral because it released the same amount of carbon dioxide (CO_2) during combustion. Biomass has lower sulphur and nitrogen content and generating lower emission compared to traditional fossil fuel. Biomass utilization is a perfect solution to global warming and to reduce dependency on fossil fuel. Agricultural residue like coconut shell and sugarcane contain a high amount of hemicelluloses, cellulose and lignin which is made it suitable in form of biofuel.

Government of Malaysia had introduced several schemes such as National Green Technology Policy 2009 and National Renewable Energy 2010 which is are the policies that focused on the biomass to support the renewable energy scheme. One of the objectives of National Renewable Energy is to increase renewable energy contribution such as biomass in the national power generation mix.

Due to the growing of industries day by day, the energy consumption demands are increase proportionally. Furthermore, due to the limitation of fossil fuel and increases in energy demand, the conversion technologies of biomass to fuel is seen as a great solution to decrease the dependency on fossil fuel. The usage of electricity received from national grid can increase the emission of carbon to the atmosphere which is can give environmental impact. Hence, the agriculture residue such as coconut shell and sugarcane is the one of the alternative source of energy that need to be modified in order to lower the dependency on fossil fuel and as well as the emission of fossil fuel usage.

1.2 Problem Statement

Due to the growing of industries day by day, the energy consumption demands are increase proportionally. The dependency on fossil fuel should be decrease because of the limitation of the natural resources. Biomass as a source of renewable energy and can be used to generate heat and electricity or as a transportation fuel. Agricultural residue such as coconut shell and sugarcane baggasse can be utilized for energy generation.

Coconut shell and sugarcane residue are seen as one of sustainable source for renewable energy source due to hemicelluloses, cellulose, and lignin compositions that contain in biomass agricultural material make it suitable for solid fuel application. The availability of resources of coconut shell and sugarcane residue makes it suitable as a topic of study.

1.3 Objectives

This study of co-processing coconut shell and sugarcane covers several objectives:

1. To produce a solid biofuel in term of briquette from coconut shell and sugarcane residue.
2. To investigate moisture content, volatile matter, ash content and fixed carbon of briquette from co-processing coconut shell and sugarcane.
3. To study the calorific value of briquette from coconut shell and sugarcane.
4. To investigate the effect of mixture ratio between coconut shell and sugarcane to the mechanical properties of the briquette.

1.4 Scope

This study covers the composition of co-processing briquette as well as the briquetting process. This study will cover the proximate analysis and hardness test of the formed briquette. Proximate analysis is used to determine moisture content, volatile matter, fixed carbon and ash of produced briquette. This study will not cover the ultimate analysis of briquette.

CHAPTER II

LITERATURE REVIEW

2.1 Bio-fuel Rationale

Due to the wake of the Energy crisis of the 70s, Government of Malaysia (GoM) had introduced the Four-fuel Diversification Strategy in 1980 in order to encourage the usage of natural gas, coal and, started to developed more hydropower stations reduce dependency on oil. Fifth-fuel strategy was introduces in 8th Malaysia Plan (2001-2005) to promote the biomass energy usage.

Hashim and Wai (2011) stated that, the concern of renewable energy (RE) such as biomass is highlighted in Fifth- fuel policy. Several policies had been introduces in order to promote the RE as an energy source. GoM had introduced several policies regarding RE such as National Bio-fuel Policy, National Green Technology Policy and National Renewable Energy Policy. In National Renewable Energy Policy the contribution of RE in national power generation mix is highlighted.

Hashim and Wai (2011) in their studies have summarized that the National Renewable Energy Policy is to facilitate the RE industry. Three principal of National Energy Policy are:

1. Supply objective
2. Utilization objective
3. Environmental objective

The most concerning problem in this world is to supply a clean energy. It is the important for all the mankind to take advantages on the natural resources in creating clean energy. In order to manipulate and maximise the usage of the natural resources and to prevent the dependency on fossil fuel, biomass is seen as the solution for this new era crisis instead it is environmental friendly.

Nowadays, energy demand is increasing due to the industries growth and home appliance. The higher demand of fossil fuel and its availability are the factor of the increasing price of the fossil fuel nowadays. The increasing price and decreasing supply of fossil fuel are the factor that driven the utilization of biomass. Moreover, the production of fossil fuel is seen to be demolished in the future. The abundant sources of biomass in tropical country are a great opportunity in energy conversion.

Arvelakis and Koukios (2012) stated that the availability of fossil fuel and greenhouse emission released from fossil fuel combustion are the factor driving the usage of the RE sources and in order to meet Kyoto protocol directives in environmental impact produced from fossil fuel sources. Furthermore, the abundant biomass resources such as forestry waste, wood waste and municipal waste should be optimize in order to generate energy and heat as well as transportation fuel.

2.2 Biomass

According to Demirbas (2001), biomass is a derivation of plant and animal matter such as sugarcane, wood, coconut shell and animals manure. McKendry (2002) stated that biomass can be categorized in four main types which are wood plants, herbaceous plants, aquatic plants and manure. Herbaceous plant is referred to the high and lower moisture content plants. Plants go through photosynthesis process and create oxygen and this is called stored sun energy. During photosynthesis process, plants capture solar radiation as fixed carbon and converts CO_2 and water to sugar, $(CH_2O)_x$.

In combustion process of biomass energy, carbon dioxide is released and used by the plant to complete the photosynthesis cycle. Biomass waste is independent fuel resource which can avoid reliance on foreign energy supply and improving the sustainable of economics. In addition, biomass is more environmental friendly compared to fossil fuel.

Fernandez et al. (2012) stated that biomass has several advantages compared to fossil fuel which is lower sulphur and nitrogen content and produce much lower NO_x and SO_2 emission to the atmosphere than fossil fuel. However, the carbon composition in biomass is lower than coal which is result in lower heating value. Furthermore, the volatile content of lignocellulosic fuels (80-90%) is twice than coal.

Crocker and Andrews (2010) stated that the produced sugars are store in three different polymers which is cellulose, hemicelluloses and starch. Normally, biomass composed of 65-85 wt % sugar polymers principally hemicelluloses and cellulose, and other 10-25 wt % is lignin. Other minor components composed in biomass are triglycerides, sterols, alkaloids, resins, terpenes, trepenoids, waxes and inorganic minerals. Significant amount of oil can be present mainly triglycerides in seeds and algae strains. For example soybeans (ca.20 wt % oil) and oil-palm fruit (ca.50 wt % oil) which is make it suitable for biodiesel production. Lignocellulose which is combination of cellulose, hemicelluloses and lignin is the fibrous material that forms the cell wall of plants and trees.

Crocker and Andrews (2010) stated biomass contains about 40 to 45% of cellulose which is natural, renewable organic compound and the abundant on earth. Cellulose is the polymer of glucose. Cellulose has linear polymer with more than 10000 units of glucose. Due to hydrogen bonding and possession of large number of intramolecular and intermolecular connection, cellulose is very stable, insoluble in most solvent and resistant to enzymatic soluble.

Yang et al. (2012) stated cellulose, hemicelluloses and lignin consist in biomass sources may be contribute to different yield based on the energy conversion process.

2.2.1 Coconut shell and sugarcane

According to Sarkia et al. (2011), coconut shell mainly consists of carbohydrates component such as cellulose, hemicelluloses and lignin. Coconut (*Cocos nucifera*) is a member of palm family. Coconut shell is hard lignocellulosic agricultural waste.), about 15-20% of coconut is coconut shell. Coconut husk or mesocarp is composed of fiber called coir. Shell is the inner stone or endocarp is the hardest part. The white and fleshy edible part inside the coconut with thick albuminous endosperm is the seed. Coconut shell is chosen due to the abundant resource in the tropical country. Moreover, the utilization of these types of biomass is seen as solution to reduce the waste disposal. Coconut shell has wide application instead of charcoal. There are many research studied about the activated carbon produced from the coconut shell. The higher carbon content in the coconut shell is making it suitable to use in charcoal production.

Based on Hofsetz and Silva, (2012), sugarcane (*Saccharum officinarum L.)* is a potential ethanol and sugar source. Sugarcane can be used in the production of sugar and ethanol. The by-product of sugarcane can be divided into several product namely sugar, ethanol and bagasse. Bagasse is the fibrous residue left after the juice extraction. Pith, fibre and rind are the three main component of baggasse. Typically, baggasse contains about 5 % pith, 73 % fibres, and 22 % rind by weight. The compositions of baggasse are 54.3 % cellulose, 29.7 % hemicellulose, and 24.4 % lignin. The density of baggasse is around 492 kg/m^3.

Bagasse is commonly used as a boiler fuel for electricity and steam generation, and to provide power and heat process in sugar factory. Sugarcane baggasse commonly used to a feedstock to produce ethanol. Ethanol commonly used as transportation fuel. The different conversion technologies are used to maximise the maximum yield. In this study, the pyrolysis is used in order to get higher maximum yield of char. In contrast, the fermentation process purpose is to higher the production of ethanol from the sugarcane.

2.3 Biomass energy conversion

Sjaak and Jaap (2008) stated that the energy conversion of biomass is divided by four processes which are direct combustion, thermochemical, biochemical and agrochemical. Thermochemical decomposition process is suitable for biomass sources with low moisture content such as woody and biomass residue with small grain field. Differ from thermochemical process, biochemical process is suitable for higher moisture content sources such as sugar beet, vegetables, manure, and corn. Thermochemical process is categorized by five methods which are drying, gasification, combustion, liquefication and pyrolysis.

According to Demirbas (2000), pyrolysis or devolatilization is a thermal degradation process of living material without the absence of oxygen. The product produces by pyrolysis process are mainly, carboneous charcoal, tar and lower molecular gas product. The primary produce products from pyrolysis process are char, bio-oil and fuel gas. Therefore pyrolysis may be defined as that the organic matter is degraded by thermal reaction in the absence of oxidizing agent to produce a complex volatile phase and carboneous char with inorganic component.