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BINDER EFFECT ON DENSIFICATION OF COW MANURE AS A SOLID BIOFUEL

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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 and Maintenance)"

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This thesis is submitted in partial fulfilment of the award of Bachelor of Mechanical Engineering (Plant and 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."

Signature :..

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DEDICATION

For my beloved

Parents and Siblings

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First of all, deepest thanks God because the Grace, I can complete my Final Year Project (FYP), Binder Effect on Densification of Cow Manure Briquette as a Solid Biofuel. All the challenges and trials in completing this project I faced with courage and patience until the project is completed successfully. All learning in completing this project I will make a guide to the future.

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ABSTRACT

Nowadays, researchers have shown an increased interest in study another source of energy that can be replaced of fossil fuel. Production of briquette as one of energy alternative source is capable to overcome the shortage of fuel from hydrocarbon natural resources. From the previous study, a cow manure briquette that has been produced is brittle. Therefore, this research was studied about the effect of binder on densification of cow manure briquette as a solid biofuel. The binder applied in this research is starch and calcium hydroxide. The main objective is to identify binder effect on densification of briquette production. Cow manure was collected near *Kampung Gangsa* at Malacca (U2.293806, S102.261228) as a raw material to produce briquette. It involved six processes namely drying, crushing, milling, carbonization, mix with binders and densification. Sample of cow manure separated into two types which is mix with binders and without binder. The amount of binders ratio was 4% of the weight briquette produced in 100 gram. Cow manure was carbonized at 300ºC. Analysis of calorific value, proximate analysis, compressive test and fourier transform infrared spectroscopy (FTIR) has been conducted. The calorific value for carbonization sample (29.90 MJ/kg to 39.34 MJ/kg) is higher compared to non carbonization sample (23.32 MJ/kg to 24.42 MJkg). Moreover, the proximate analysis shows the value of moisture content for non carbonization sample (10% to 11.33%) is higher compare to carbonization sample (3.33% to 8.33%). Meanwhile, the percent of ash content for cow manure briquette is (21.33% to 30.33%), volatile matter (44.67% to 62.57%) and fixed carbon (4.67% to 21.33%). All this proximate analysis is follow the standard of ASTM of coal and coke. The FTIR results indicate that at 1100 cm^{-1} was described a carboxylates group and the release of C-O structures from ethers is group of alcohol. A narrow 3900 cm^{-1} band attributed to the free stretching O-H vibration. As a result, the briquette carbon with starch 1:4 has higher compressive strength 36.34 MPa and briquette carbon with calcium has higher calorific value 39.34 MJ/kg.

ABSTRAK

Pada masa kini, para penyelidik telah menunjukkan minat yang mendalam terhadap kajian sumber tenaga lain yang boleh menggantikan bahan api fosil. Pengeluaran briket sebagai salah satu tenaga alternatif mampu mengatasi masalah kekurangan bahan api daripada sumber asli hidrokarbon. Daripada kajian yang lepas, briket najis lembu yang dihasilkan adalah rapuh. Oleh itu, kajian ini telah dikaji untuk mengetahui kesan pengikat pada pemadatan najis lembu briket sebagai bahan api bio yang kukuh. Pengikat yang digunakan dalam kajian ini ialah kanji dan kalsium hidroksida. Objektif utama adalah untuk mengenal pasti kesan pengikat terhadap pemadatan briket najis lembu. Najis lembu diperolehi dari Kampung Gangsa di Melaka (U2.293806, S102.261228) sebagai bahan mentah. Ia melalui enam proses iaitu pengeringan, penghancuran, pengisaran, karbonisasi, bercampur dengan pengikat dan pemadatan. Sampel najis lembu akan dibahagikan kepada dua jenis yang bercampur dengan pengikat dan tanpa pengikat. Jumlah nisbah pengikat hanya 4% daripada berat briket yang dihasilkan dalam 100 gram. Najis lembu telah dikarbonisasi pada 300°C. Analisis nilai kalori, analisis proksimat, ujian mampatan dan spektroskopi (FTIR) dijalankan. Nilai kalori untuk sampel karbonisasi adalah lebih tinggi (29.90 MJ/kg hingga 39.34 MJ/kg) berbanding dengan sampel tanpa karbonisasi (23.32 MJ/kg hingga 24.42 MJkg). Selain itu, analisis proksimat menunjukkan nilai kandungan lembapan bagi sampel tanpa karbonisasi adalah lebih tinggi (10% hingga 11.33%) berbanding dengan sampel karbonisasi (3.33% hingga 8.33%). Sementara itu, peratus kandungan abu untuk najis lembu briket adalah (21.33% hingga 30.33%), jirim meruap (44.67% hingga 62.57%) dan karbon tetap (4.67% hingga 21.33%). Semua analisis proksimat ini adalah mengikut piawai ASTM arang batu. Keputusan FTIR menunjukkan bahawa pada 1100 cm^{-1} digambarkan sekumpulan karboxylat dan pelepasan struktur C-O adalah dari kumpulan alkohol. Pada 3900 cm^{-1} menunjukkan getaran bebas regangan OH. Kesimpulannya, briket karbon dengan kanji 1:4 mempunyai kekuatan mampatan yang lebih tinggi 36.34 MPa dan briket karbon dengan kalsium mempunyai nilai kalori yang lebih tinggi 39.34 MJ/kg.

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ABBREVIATIONS

EPA	United State Environmental Protection Agencies
IEA	International Energy Agency
USDA	United State Department of Agriculture
FTIR	Fourier Transform Infrared Spectroscopy
NHV	Net Heating Value
NC	Non Carbon
NCS	Non Carbon Starch
NCC	Non Carbon Calcium
C	Carbon
CS	Carbon Starch
CC	Carbon Calcium
MC	Moisture Content
VM	Volatile Matter
FC	Fixed Carbon
ASTM	American Standard Testing Method

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CHAPTER I

INTRODUCTION

1.1 Background

In era globalization, the world has realized that the source of energy is no longer dependent on fossil fuels only. The increasing demand on energy resources for the next hundred years and the limitation of these resources has led the government to introduce many project based on green technology. One of the green technology projects is sustainable energy production (Gordon et al., 2009). Sustainable energy is the provision of energy that fulfilled the requirements in present generation without prejudice to their needs in the future. Renewable energy is one of the technologies that related to sustainable energy.

For Lalchand (2012), renewable energy refers to energy generated from the waste and it also mean as energy derives from natural resources that are added constantly such as sunlight, wind, rain, waves and geothermal heat.

According to official website of Ministry of Energy, Green Technology and Water, National Renewable Energy Policy 2010 was established to control the entire renewable energy program. Objectives on this plan are to facilitate the growth of the renewable energy industry, to ensure reasonable renewable energy generation costs, to increase renewable energy contribution in the national power generation mix, to enhance awareness on the role and importance of renewable energy and to conserve the environment for future generation (Hashim and Ho, 2011).

Malaysia was formulated a Five Fuel Policy for Power Generation in 2000 as a step to overcome the problems that will occur if government continue to depend on fossil fuels as a main source of primary energy. This five fuel policy is actually continuity from Four Fuel Policy that begins in 1981 which renewable energy was added as a fifth fuel source to become Fifth Fuel Policy (Eighth Malaysia Plan 2001-2005). When natural gas discovered, Malaysia had a Four Fuel Policy which is hydro, natural gas, coal and oil. The policy has changed to a Fifth Fuel Policy, include hydro, natural gas, coal, oil and energy efficiency (Lalchand, 2004).

Renewable energy can reduce the reliance on sources of fossil fuels such as biomass resources from oil palm, wood and rice husks. Mckendry (2002) has defined that biomass is the most common form of renewable energy and it is gaining popular among country that has a lot of waste material or feedstock. Biomass can be categorized into two groups of compounds. The first group is the cell walls which serve as physical supporting structures and the content of the cells in form of proteins, lipids, starches and sugars. The second group is lignocellulosics are mainly composed of cellulose and hemicelluloses held together by lignin (Preston, 2009).

In addition, many biomass feedstocks are easily to found such as woody plants, herbaceous plants or grasses, aquatic plants and manures that are potential to produce a renewable energy resources (Mckendry, 2002). Cow manure is one of an example of the biomass available in Malaysia. The dependence on fossil fuel are able to diminish by modification on biomass resources to become alternative fuel like bioethanol and briquette.

For this study, the densification process was used to producing a cow manure briquette as a solid biofuel. Densification of this materials would contribute to improving their behaviour as a fuel by increasing their homogeneity and allowing a wider range of lignocellulosic materials to be used as fuel (Tabares et al., 2000). This densification process can be completed by mixture between binder and cow manure that will increases the structure strength of the product. Other than that it easier to transport and manage allowing a greater diversity of lignocellulosic materials to be used as fuel (Tabares et al., 2000).

1.2 Problem statement

Lately, the natural resources in Malaysia become decrease due to the increasing number of population. Based on Department of Statistics Malaysia, the number of population in Malaysia 2010 are 27,565,821 peoples and until May 2015, the number of population in Malaysia increase to 30,458,199 peoples. Therefore, it requires a lot of energy quantities to fulfill the requirements in present generation to carry out daily activities without prejudice to their needs in the future. Nowadays, Malaysia only depends on one source which is fossil fuel as an energy source.

From that problem, government of Malaysia and all people must think and shift toward green renewable energy. Biomass is one of the sources of renewable energy and cow manure was selected because it's easier to find. Cow manure usually use as fertilizer. Using cow manure as fertilizer can cause water pollution because it can seep into groundwater and flow to the river. Based on article from drinking water impact at United State Environmental Protection Agencies (EPA), in 2011, contamination of cow manure in water can brings negative effect for human health due to the microorganism content such as cryptosporidium. Moreover, if cow manure not managed properly, it can cause disease in human because it contains ammonia, antibiotics, hormones, heavy metal, sediments, pathogens, nutrients and organic matter that can produce danger gas such as methane gas.

Beside that, excess use of farms livestock wastes can overload soil with macronutrients like nitrogen and phosphorous and micronutrients that have been added to animal feed like heavy metals (Burkholder et al., 2007). Aside from that, operations of farms livestock are possibility of lowering air quality in the areas around them and also emit greenhouse gases, and therefore contribute to climate change. Globally, farms livestock operations are responsible for approximately 18% of greenhouse gas production and over 7% of U.S. greenhouse gas emissions (Massey and Ulmer, 2008).

Other than that, the problem that occurred in previous studies is on the structure and quality of cow manure briquette was brittle. This research also shows the result of calorific value is conversely. This is because the carbonization sample has produced a lowest calorific value while it should be highest (Badarulzaman, 2014). One of the solutions for that problem is cow manure briquette are mixed with starch and calcium hydroxide as binder materials before going to the densification process to increase the impact of cohesive quality and structure strength of the product.

1.3 Objectives

The objective of the project is:

1. To obtain briquette from cow manure in presence of binder materials namely starch and calcium hydroxide.
2. To analyse the cow manure briquette product in term of calorific value, proximate analysis compressive test and FTIR.
3. To compare the result of calorific value, proximate analysis and compressive test of cow manure briquette with binder and without binders.

1.4 Scope

This project is about the preparation of cow manure as raw material to produces briquette as a solid biofuel. The main purpose is to study the binder effect on densification of cow manure as a solid biofuel. It includes the process of drying, pulverization, carbonization and densification which is mixture between binder and cow manure. Two types of binders that mix with sample briquette is starch and calcium hydroxide. Furthermore, observation on calorific value, proximate analysis (moisture content, ash content, volatile matter and fixed carbon) and compressive test will perform on cow manure briquette. Load capacity for compressive test is range 60–120 kN with cross head speed at 2 mm/min.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

Nowadays, natural resources in our earth become decrease due to increasing the number of population in world. To reduce dependency toward natural resources, there are many alternative way is introduced to generated energy such as biofuel. Biofuels come in many forms which is biogases, liquid fuels and solid biomass. Cow manure is one of an example of the biomass available in Malaysia.

Recently, increasing annually the volume of cow manure generated from feedlot farming, most cow manures are disposed into landfills or applied to the land without treatment (Baba and Nasir, 2012). Usually, the cow manure was used as fertilizer and biogas production. Therefore, the industry of biofuel was introduced as a new solution for overcome the shortage of natural resources and prevent from adverse environmental and health problems. Based on that, research about producing solid biofuel will conduct as well as binder effect on densification of cow manure briquette is observed.

2.1 Biomass

Biomass can be defined as a term for all organic material that stems from plants that include algae, trees and crops. Mckendry (2002), stated the organic material of plant is happened between the reaction of CO_2, water and sunlight at a natural process. Photosynthesis is a process by which they convert solar energy into chemical energy to produce carbohydrates that form the basis formation of biomass and the carbon fixation by reduction of carbon dioxide (Demirbas, 2009). Equation (2.1) presents the reaction of photosynthesis process.

$$6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2 \tag{2.1}$$

Furthermore, Demirbas (2009) stated that the term biomass refers to non-fossilized and biodegradable organic material originating from plants, animals, and microorganisms derived from biological sources. Example of biomass are waste, wood, alcohol fuel and gas (hydrogen). In addition, the production of fibers and chemicals from plants and animals also belong to the biomass (Piech, 2012). Based on Preston (2009), biomass can be defined as cellulose materials which can be broadly classified as woody and non-woody biomass. Woody biomass is from trees while non-woody biomass is from agricultural residues. Recent studies stated lignocellulosic biomass such as wood contains about 50 % of cellulose, 25 % of hemicellulose and 25 % of lignin from total content of hydrolyzable biopolymers (Feng et al., 2012).

Biomass also has great potential to provide heat and power to industry and to provide feedstocks to make a wide range of chemicals and materials or bioproducts. Ciubota-Rosie (2008) stated that biomass feedstock can be divided into four general categories which are waste, forest product, energy crop and aquatic plant. Manure, crop residues and agriculture product waste are an examples of waste stock. Forest product stock is like wood, trees and sawdust while energy crop is a material such as short rotation woody crop, sugarcane and rice husk. Aquatic plant has an examples of algae, water hyacinth and water weeds.

To reduce the emission of carbon dioxide, there a lot of biomass source in this world due to it sustainable and renewable source compared to the fossil fuel (Supatata, 2013). Moreover, Parveen et al., (2009) stated that biomass are cleaner burning than fossil fuel, and the short cycle of growing plants and burning fuel made from them does not add CO_2 to the atmosphere. As a result, its maybe can be a good alluring of clean mechanism option for reduce the global warming factor and lowering the green gas house effect.

According to Jamradloedluck (2007), the uses of biomass will discharged less environmental pollution and health risk than the fossil fuel combustion and biomass was considered as neutral because during the combustion it releases the same amount of carbon dioxide . This is because the contains of biomass are less sulphur and nitrogen where it will generate lower emission compared to the fossil fuel (Fernandez et al., 2011). Furhermore, it make the utilization of the biomass is more ecofriendly.

2.1.1 Biomass Components

Biomass contains lignocelluloses and its call lignocellulosic biomass. Lignocellulosic biomass contains cellulose, hemicelluloses and lignin. Hydrogen bonding is use to tightly bound between the carbohydrate polymers and lignin, but also through some covalent bonding (Ahindra, 2008). Recent study from Carriquiry et al., (2010), stated that cellulose and hemicellulose are the main components of lignocellulosic feedstock.

Based on the Parveen et al., (2009), almost 90% of the dry weight of plant materials is stored in the form of cellulose, hemicellulose, and lignin. Table 2.1 shows the content of cellulose, hemicellulose and lignin in common lignocellulosic composition. The presence of lignin in lignocelluloses leads to a protective barrier that prevents plant cell destruction by bacteria and fungi for conversion to fuel. For the conversion of biomass to fuel, the cellulose and hemicellulose must be broken down into their corresponding monomers which are in sugars, so that microorganisms can utilize them.