Faculty of Mechanical and Manufacturing Engineering Technology

ENGINE PERFORMANCE OF BIODIESEL FROM NON-EDIBLE OILS BIODIESEL

Muamar Zil Haniff bin Mohd Nazeri

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ENGINE PERFORMANCE OF BIODIESEL FROM NON-EDIBLE OILS BIODIESEL

MUAMAR ZIL HANIFF BIN MOHD NAZERI

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DEDICATION

Dedicated to

my beloved father, Mohd Nazeri bin Salleh

my lovely mother, Wan Fatimah binti Wan Daud

my brothers, Muamar Adib Hakimi, Muamar Zul Ikhman and Muamar Aliff Imran

my sweet sisters, Anis Natasha binti Abi Nizam and Nor Saffa binti Darman

my nephews and nieces, Muamar Ariq Abbasy, Adeera Humaira,

Muamar Khayr Ahnaf, Khayrah Ameena and Muamar Aniq Yusoff

my companion, Mila

for giving me moral support, cooperation, encouragement and understandings.

Thank You So Much & Love You All Forever

You'll Never Walk Alone

ABSTRACT

The performance and emission of a single-cylinder, four-stroke, naturally aspirated, direct injection engine when fueled with 10% and 20% Jatropha curcas oil (JCO) and rubber seed oil (RSO) blended with diesel are examined and compared with standard diesel. The purity of the produce biodiesel was performed by Gas chromatography–mass spectrometry (GCMS). The effect of compression ratio has been investigated and presented on fuel consumption, brake thermal efficiency and exhaust gas emissions. Microwave-assisted are used in transesterification process with help of the mussel as catalyst. At the end, this study shows higher efficiency and lower biodiesel exhaust emissions compared to regular diesel properties. At the end of study, B20 for each of JCO and RSO have better engine performance than conventional diesel, B20JCO result in the best result of engine emission than conventional diesel.

ABSTRAK

Prestasi dan pelepasan enjin suntikan langsung empat-lejang, secara semulajadi, disuntik langsung apabila didorong dengan 10% dan 20% minyak biji pokok jarak pagar (JCO) dan biji minyak getah (RSO) yang dicampur dengan diesel diuji dan dibandingkan dengan diesel biasa. Ketulenan minyak biodiesel akan diperiksa menggunakan Kromatografi Gass-Spektrometri Massa. Kesan nisbah mampatan telah diselidiki dan dibentangkan pada penggunaan bahan bakar, kecekapan terma brek dan pelepasan gas ekzos. Pembantu gelombang mikro digunakan dalam proses transesterifikasi dengan bantuan kupang sebagai pemangkin. Pada akhirnya, kajian ini menunjukkan kadar kecekapan yang tinggi dan kadar pengurangan kadar perlepasan ekzos biodiesel berbanding sifat diesel biasa. Pada akhir kajian, B20 bagi setiap biji pokok jarak pagar dan biji minyak getah mempunyai prestasi enjin yang lebih baik daripada diesel konvensional, keputusan B20 biji pokok jarak pagar menghasilkan hasil pelepasan enjin terbaik daripada diesel konvensional

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You'll never walk alone.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

JCO	-	Jatropha Curcas Oil
RSO	-	Rubber Seed Oil
GCMS	-	Gas chromatography–mass spectrometry
ASTM	-	American Society for Testing and Material
AV	-	Acid Value
B10	-	10 percent of bio, 90 percent of diesel
B20	-	20 percent of bio, 80 percent of diesel

LIST OF APPENDICES

LIST OF SYMBOLS

ppm	-	parts per million
°C	-	Degree celcius
mm	-	milimetre
g/cm^3	-	Gram per centimetre cubed
mg KOH/g	-	milligrams of potassium hydroxide per gram
mm2/ s	-	Square millimeter/second
kg/ L	-	Kilogram Per Litre
kg/ m3	-	kilogram per cubic metre
rpm	-	Revolutions per minute
kW	-	Kilowatt
g/kW	-	gram/kilowatt

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, there are a lot of technology used biodiesel as a source for the combustion such as transportation, heavy-duty machine, industrial used and others (Efe et al., 2015). Biodiesel has received much attention from developer and has high potential to be used for market demand due to their great advantages such as environmentally friendly, renewable, non-toxicity, and not produce hydrocarbon (Mishra et al., 2018). The main sources for producing biodiesel is triacylglycerols which is the mixture of vegetable oil or animal fat, identified by Knothe et al. (2015). These often-called triglycerides (TAG) which is the combination of fatty acids (FA) with glycerol esters.

According to Mishra et al. (2018), animal fat, vegetable oil, and waste cooking oil able to form biodiesel where the vegetable oil or animal fat is expose to a chemical reaction called transesterification. Knothe et al. (2015) founded that the mixture of vegetable oil or animal fat that responded to the existence of catalyst plus an alcohol to give the equivalent alkyl ester of the fatty acids mixture that founded in the parent of vegetable oil or animal fat. Besides that, algae, microalgae and fungi can also be used to producing biodiesel.

In 2005, Ramadhas et al. reported that vegetable oil are an alternative to diesel fuel because they are renewable in environment and can be produced locally and biodegradable friendly. They have no sulfur content, no storage problems and excellent lubrication properties. It also found that various vegetable oils as fuel in compression ignition engines where the value of caloric of vegetable oil is comparable to diesel. The viscosity of vegetable oil is ten times greater than diesel and it causes the poor fuel atomization, incomplete combustion and carbon deposition on the injector and valve seats resulting in serious engine fouling.

Moreover, the vegetable oil is one of the sources that helps to produce biodiesel these day for example, edible or nonedible plant oil. Edible oil can be used to produce the biodiesel are barley, used cooking oil, corn, coconut and others. In another hand, Ahuja (2015) has studied that nonedible plant oil can be used to produce the biodiesel are jatropha, neem, kusum, kapok, soapnut and others. However, Ahuja mentioned that developing edible plant oil to be source for producing biodiesel received many attentions from researcher that the edible plant oil not suitable to be source to produce biodiesel due to probably will affected lack of food, mainly for certain country. Therefore, the use of the nonedible plant oil is most suitable to develop as the source for producing biodiesel.

Jatropha curcas, a species of flowering plant that belongs to Euphorbiaceae family where it is native to the American tropics, mostly found in Mexico and Central America. Jatropha curcas grow under a variety of tropical climate conditions and harvesting processes in 9 to 12 months, but to obtain the best yield after 2 to 3 years. However, the plant best grown on wastelands and almost any terrain, including gravelly, sandy, and saline soils. It can thrive in poor and stony soils. (Ahuja 2015)

Jatropha curcas is one of common non-edible plant oil that used in biodiesel production. Jain (2019) stated Jatropha curcas seeds cannot be ingested by human due to their toxicity. The overall weight of the oil contains by Jatropha seed is 30 % to 35 %. However, Patel *et al.* (2015) found different suggesting that Jatropha seed contain 50 % to 60 % of oil. It can be concluded that Jatropha have the potential that will be great source to for the biodiesel production.

Indonesia has a largest rubber plantation area of the world in total 3.4 million hectares and rubber production reached 2.6 million tons. The development of rubber plant seed is less popular and not utilized, whereas oil content is high enough for about 40 to 50 %. The potential of utilization of rubber seed as raw material of biodiesel production is high in Indonesia. There are most biodiesel is produced from Crude Palm Oil (CPO) using methanol and base catalyst. (Wibowo 2013)

Other than Jatropha, rubber seed also one of the plant oil that gain the attention of the researcher to provide the rubber seed to became one of the source for biodiesel production. Rubber seed oil is one of considered potential feed stock in this research. There are many countries that have rubber plantation all around the world such as Bangladesh (Morshed et al*.*, 2011), Indonesia (Wibowo, 2013) and others. Furthermore, the consumption of rubber seed is not considerable.

According to Mishra et al. (2018), diesel engine usually used for combustion that related to internal combustion engine for the transportation, power generation, industrial used and other. For example, diesel engine use in on-road, off-road and stationary. On-road is a simple vehicle that always been use for human nowadays, heavy duty truck and other. Then Off-road that used diesel engine is construction equipment, trains and other. Electricity generator and furnaces are stationary that use diesel engine. Atadashi *et al.* (2010) analyzed that existence of biodiesel help to decrease the greenhouse gas emission and growth more engine performance.

Wibowo (2013), demonstrated the biodiesel production from rubber seed by in situ method with maximum yield of FAME 53.61 % at H_2SO_4 0.25 % (v/v) and maximum yield of FAME 91.05 % with ratio of raw material to methanol (1:3). It can be concluded that the ratio of raw material to methanol is important to increase yield of FAME.

1.2 Problem Statement

An experimental investigation was conducted to explore more about performance of biodiesel. There are countless study about biodiesel feedstock that can be produce by vegetable plant, whether edible plant or non-edible plant and the investigation about performance of biodiesel. Therefore, the research is to discover out to analyze the performance of the feedstock characteristics and to study the biodiesel engine performance. Wibowo (2013) describes that the alternative energy to develop the of eco-friendly alternative fuels is biodiesel which is to reduce dependence on petroleum and meet the requirements of the market environment. According to Zamberi M.M *et al.* (2016), one of the main concerns of biodiesel producers in the marketing of biodiesel is the feedstock costs and the production process. One of the possible alternatives is the use of heterogeneous waste catalysts to perform a transesterification method that allows simple product separation and purification and does not require neutralization.

Then, author added that because of the food crisis, one of the efforts to reduce dependence on edible sources is becoming widely recognized as a 2^{nd} generation of biodiesel or also familiar as non-edible sources. Examples of recently extensively reviewed non-edible oils include *Jatropha curcas, Calophyllum inophyllum, Madhuca indica* and others.

1.3 Objective

The objective of the study is:

(a) To examine purity of biodiesel (B100) using Gas Chromatography-Mass Spectrometry and the properties of the feedstock by performing the ASTM D6751 and EN 14214 test.

(b) To study the common biodiesel engine performance and emission characteristics, dynamometer models, measurement type and common critical parameters during engine diagnose.

(c) To examine the performance and emission of diesel engine using several proportions of biodiesel fuel (FAME) with diesel fuel.

1.4 Scope

In this study will focus on performance and emission of diesel engine using several proportions of biodiesel fuel (FAME) with diesel fuel. This research will include:

(a) Analyze the purity of the biodiesel(B100) using Gas Chromatography-Mass Spectrometry perform the fuel characteristic test according to ASTM D6751 and EN 14214

(b) Blend ratio B10, B20 with D2 from Petronas

(c) Perform the fuel characteristic test according to ASTM D6751 and EN 14214

(d) Analyze and examine the performance and emission of diesel engine with different proportions.

(e) Review on the important of parameter on engine performance of biodiesel fuel using Jatropha Curcas oil and rubber seed oil.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Biodiesel

Nowadays, the use of biodiesel is quite popular in South-east Asian countries by way of the conversion of petro-diesel as power generation and transportation to biodiesel (Abedin *et al*., 2016). According to Abedin *et al* (2016), Malaysia and Indonesia were the two biggest country in Asia that producing biodiesel and in Malaysia, the government has start to put B5 (5% palm oil and 95% diesel) blend into action aimed at industrial sector and vehicles. The Palm Oil Biodiesel Program has been started in 1982.

Knothe et al. (2015) found that before the crisis of energy in 1970s and the early 1980s, the studied of the vegetable oil and animal fat as diesel fuel were triggering to learn more about alternative fuels. The creator of the engine, well known Rudolf Diesel had some attention to the fuels. According to Radich (2018), Rudolf Diesel is graduated from the predecessor school to the Technical University of Munich, German in 1878 and has been presented to work of Sadi Carnot. On that day, steam engine efficiency is lower than engine efficiency theoretical and engine can reach more efficiency had been proven by Sari Carnot. Rudolf Diesel wanted to use Sari Carnot's theory to the internal combustion engine.

As highlighted by Radich (2018), engine with the maximum potential compression ratio is one of the Rudolf Diesel desired to build. The fuel that only when combustion was wanted and enable the fuel to combust on its own in the hot compressed air also produced by Rudolf Diesel is stated by Radich (2018). Efficiency of Diesel's engine is higher than efficiency by steam engine. The trouble-prone electric spark eruption system also had been removed. There are many books had been produced by Rudolf Diesel, the book contains the studied and examine of every details of the biodiesel. Knothe *et al*. (2015) stated that Rudolf Diesel wanted to build efficient engine, that the objective. Every of his statement obviously shows that he come near to the improvement of the diesel engine from a thermodynamic point of view.

2.1.1 Generation of Biodiesel

There have been several studies in the literature reporting that biodiesel is methyl esters of fatty acids (Ambat *et al.,* 2018). Author stated that methyl esters of fatty acids is gained from transesterification of triglycerides alongside methanol using a catalyst and biodiesel can be categorized into three generation. Author described that the first generation is the biodiesel that formed from edible feedstock. For example, of edible feedstock is peanut, sunflower, palm, coconut oil and others. The edible feedstock is deliberate to be first generation of biodiesel. However, used of edible feedstock as sources for biodiesel produce leads to major environmental problem (Mishra et al., 2018).

Then, second generation of the biodiesel is produced by non-edible feedstock (Ambat *et al.,* 2018). Jatropha curcas, karanja or honge (Pongamia pinnata), Aleurites moluccana, Pachira glabra nagchampa (Calophyllum inophyllum) and others are the example of the non-edible oil’s feedstock. Non-edible oils feedstock is the solution for avoid from using edible oils feedstock as the source for biodiesel production. After that, the third generation of biodiesel is obtained from microalgae. There are factors that algal biodiesel is beneficial. First, the algal biodiesel contains greater ratios of oil content and had more growth rates and productivity. Used algal biodiesel also minimize greenhouse effect and degrade competition