EFFECT OF USING THE SECOND GENERATION BIODIESEL AND ITS BLEND IN THE COMPRESSION IGNITION ENGINES

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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 with Honors (Thermal-Fluid)

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DECLARATION

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

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This report is dedicated to my family. Thank you for your continuous support during my vital educational years. Without their patience, understanding and most of all love, the completion of this work would not have been possible.

To my mother,

Zaiton Binti Ismail

My siblings

Bibi Suriati Binti Omar

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Mohd Rashidi Bin Omar

Mohd Firdaus Bin Omar

Mohd Fuad Bin Omar

Muhammad Aliff Bin Omar

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“In The Name Of Allah, The Merciful, The Beneficent”

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ABSTRACT

Shortage of fuel and increasing environmental pollution is one of the concerns for publics to alert about this problem. Therefore, study after study undertaken by researchers to find alternative sources to replace fuel sources. The study was done by researcher trace a variety of fuel sources that can replace the existing fuel. For example, biodiesel from plant sources is one of the new sources explored. Many viewers say the source of biodiesel from plants can reduce the rate of emissions and improve engine performance. This project investigated the performance and emission of engine without any substantial hardware modification. The fuel from jatropha biodiesel blend with diesel will be used in the engine. In this project, performance of engine such as torque, power and brake specific fuel consumption were evaluated. Other than that, gas emission from engine such as hydrocarbon (HC) and carbon dioxide (CO_2) also were measured. It was found that the JB5 gave the best performance and similar with D2. The lower blends of biodiesel increase the power of engine and reduce the brake specific fuel consumption. The gas emissions from combustion chamber are reduced with increase in biodiesel concentration. The experiment results proved that the use of biodiesel in compression ignition engines is viable alternative to diesel.

ABSTRAK

Kekurangan bahan api serta peningkatan pencemaran alam sekitar merupakan salah satu kebimbangan kepada manusia yang prihatin kepada masalah ini. Oleh yang demikian, kajian demi kajian diusahakan oleh pengkaji untuk mencari sumber alternatif untuk mengantikan sumber bahan api. Hasil kajian yang dilakukan oleh pengkaji menemukan pelbagai sumber bahan yang boleh mengantikan bahan api yang sedia ada. Sebagai contoh biodiesel dari sumber tumbuh-tumbuhan merupakan salah satu sumber baru diterokai. Ramai pengkaji mengatakan sumber biodiesel daripada tumbuhan dapat menggurangkan kadar pelepasan gas dan meningkatkan prestasi enjin. Projek ini bertujuan menyiasat prestasi dan pelepasan gas dari enjin tanpa sebarang pengubahsuain perkakasan yang ketara. Bahan api daripada jatropha campuran biodiesel dengan diesel akan digunakan di dalam engine sebagai bahan api. Dalam projek ini, prestasi enjin seperti tork, kuasa dan penggunaan bahan api telah dinilai. Selain daripada itu, pelepasan gas daripada enjin seperti hidrokarbon (HC) dan karbon dioksida (CO_2) juga diukur. Didapati bahawa JB5 memberikan prestasi yang terbaik yang hampir serupa dengan D2. Campuran biodiesel yang lebih rendah meningkatkan kuasa enjin dan mengurangkan penggunaan bahan api tentu brek. Pelepasan gas dari kebuk pembakaran dikurangkan dengan peningkatan kepekatan biodiesel. Keputusan eksperimen membuktikan bahawa peggunaan biodiesel dalam enjin pencucuhan mampatan adalah alternatif yang berdaya maju untuk diesel.

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f	=	Fuel consumption, g/h
N	=	Speed of engine (rpm)
P	=	Brake power output (kW)
T	=	Torque (Nm)
CO	=	Carbon Monoxide
CO_2	=	Carbon Dioxide
HC	=	Hydracarbon

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, we must begin to think more seriously the problem of limited availability against the need for fuel to high demand. Biodiesel as a renewable fuel sourced from plant materials now gets special attention from scientists and industries. During this first generation biodiesel has been produced and widely used, either in pure form or as a blend with diesel fuel petroleum derivatives. The first generation biodiesel is known as fatty acid methyl esters (FAME), which is obtained from the transesrification vegetable oil (triglycerides) with methanol using a catalyst. Any conversion of one molecule of triglyceride would produce three molecules of FAME and one molecule by a product which is glycerol. The first generation biodiesel although declared ready to apply, still has some compatibility issues for current diesel engines. Among them is the corrosion caused by the high content of oxygen atoms from the FAME and the maximum concentration allowed in combination with petroleum derived diesel. In terms of carbon dioxide (CO_2), the contribution of CO_2 emissions from the combustion of FAME also tend still relatively high due to the high oxygen content in the FAME. To overcome these problems, we have developed a second-generation biodiesel with the petro diesel specification approach. In principle, the second-generation biodiesel is a hydrocarbon derived from vegetable oils undergoes a process of hydrogenation. Through this pathway, vegetable oils, animal fats, or mixtures biodiesel and petroleum, even used vegetable oil (e.g., waste cooking oil) can be processed at the same time produce a prepared various hydrocarbon fractions separated purified. Hydro process crude vegetable oil offers a more efficient process without producing byproducts except water with CO_2.

Moreover, hydro process to produce biodiesel directly utilizing established petroleum purification. Hydro process can produce second generation biodiesel with lower oxygen levels, even close to zero, so that the engine corrosion problems can be avoided. Similarly, emissions from the combustion of second generation biodiesel contain less carbon. Biodiesel from hydro process also very in keeping with the conditions of diesel engines in use today because it can reach 55-90 numbers cetane number (cetane number compared with the number of outstanding diesel currently at 40-45). In such conditions, the concentration of biodiesel allowed in the biodiesel - petro diesel blend will be higher without the need to modify the engine. One of the disadvantages of the second-generation biodiesel is probably it is easily frozen at a temperature below 20°C. Of course the problem is only relevant in the four season’s countries, while in countries in Southeast Asia that is not the issue at all. This can be overcome by adding a catalyst or do mixing. Until now the second-generation biodiesel has not been used commercially, but several major industries are ready to produce it in bulk sizes. UOP (A Honeywell Company), a company the United States, as well as Petro bras, Brazil, the copyright holder hydro process vegetable oil, are pioneering second generation biodiesel production capacity of 400 kilotons per year (Honeywell's UOP et al., 2009).

1.2 Problem Statement

Biodiesel is one of the promising renewable energy, alternative and environmentally friendly that can be used in diesel engine with little or no modification in the engine. Biodiesel is one of the alternative fuels to reduce environmental pollution and gas emissions produced by fossil fuel diesel. However, there is a downside of using biodiesel. Due to its high value of viscosity, coupled with low amount of volatility, long term exposure or usage of biofuel can cause problem when applied in compression ignition engine. For countermeasure, a various blends of jatropha oil and diesel will be prepared. Comparison between both types of fuels will also be done. The comparison will consist of the properties of the fuel which is viscosity, calorific value, flash point and density. As mentioned, different blends of biodiesel will be used and every type of blend will be tested on the performance of the engine and the emission test as well. For this experiment will use compression ignition engine as a medium to make comparison between diesel and jatropha biodiesel blend. The main focus will be on performance and emission characteristic of the engine. The data obtained will be analyzed.

1.3 Project objective

This project aimed at exploring technical feasibility of the second generation biodiesel and its blend in the compression ignition engines without any substantial hardware modification.

1.4 Project scope

a) Comparing engine performance between biodiesel and its blend with Malaysia petroleum diesel by using single cylinder 4 stroke compression ignition engine.

b) To measure and compare emission characteristic of engine between biodiesel and its blends with Malaysia petroleum diesel.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Academic research is one of the very important steps to gather information on selected topics. The way to get this information is available via the internet, journals, books and other resources such as attending any of the seminars or offer courses outside the university and in the university. It is very important to study or do research on a system before starting any study. This is also to get a certain knowledge of the system is to ensure that the project is still in the selected scope. This chapter will explain more about the background of biodiesel and previous research.

2.2 Background of biodiesel

Biodiesel is a renewable alternative fuel for use in compression ignition diesel engines, which are made from agricultural products such as vegetable oils or animal based and not on the allocation for the spark ignition (SI) engines. Although diesel is part of its name, biodiesel contains no petroleum or other fossil fuels. Biofuel is a non-petroleum or non-fossil fuel. Although it does not contain petroleum, biodiesel can mix with conventional diesel fuel in the same fuel tank creating a biodiesel blend. Conventional diesel fuel is diesel fuel derived from petroleum and is often called petro diesel. Biodiesel is chemically similar to petro diesel. Caused by having chemical properties and performance characteristics very similar to petro diesel, biodiesel in its pure form can be directly used in modern diesel engines with little or no engine modification. In a small percentage of biodiesel can be used as a fuel lubricity additive, mixed with petro diesel that its low sulfur content such as ultra-low sulfur diesel (ULSD), to improve lubricity or lubricating ability is lost when the sulfur is reduced. Biodiesel is great for use in modern diesel engines because a diesel fuel type has a lubricity that excellence, better than petro diesel. The superior lubricity of biodiesel is to reduce wear on diesel engines and can increase the lifespan of the components.

Similarly, the use of biodiesel can actually extend engine life. In addition, biodiesel flammability is high and can have natural solvent properties that will help clean up deposits in the fuel lines, storage tanks and fuel delivery system. Biodiesel is a fuel oxygenated which contains approximately 11% oxygen in the molecular structure. The presence of these oxygen atoms allows fuel combustion processes that occur in the engine combustion chamber to be more perfect than when using petro diesel. Petro diesel is a non-oxygenated fuel and by because it is the vehicle that is not equipped with emission control system produces significantly fewer emissions of carbon monoxide (CO), unburned hydrocarbon (HC) and particulate matter (PM) or soot from the tailpipe. However, the use of oxygenated fuels tends to result in increased emissions of nitrogen oxides (NOx). This environmentally friendly fuel also reduces smoke and noxious odors. Table 2.1 show general properties of biodiesel. This standard must have at each biodiesel before use. This is to make sure that biodiesel in accordance with standard designated. Technically, biodiesel is as a fuel for diesel engine. This fuel comprised monoalkyl ester of long chain fatty acid. Biodiesel design B100 and meeting the requirement of the ASTM D6751 standard.

Table 2.1: General properties of biodiesel
(Sources: Ram B.G (2010) "Gasoline, Diesel and Ethanol Biofuels from Grasses and Plants 1st Edition Cambridge University press)

Chemical name	Fatty acid (m)ethyl ester
Chemical formula range	C_{14}-C_{24} methyl esters or C_{15-25} $H_{28-48}O_2$
Kinematic viscosity range	3.3-5.2 mm^2/s, at 40°C
Density range	860-894 kg/m^3, at 15°C
Boiling point range	200°C
Flash point range	155-180°C
Distillation range	195-325°C
Vapor pressure	<5 mm Hg, at 22°C
Solubility in water	Insoluble in water, however, biodiesel can absorb up to 1500 ppm water.
Physical appearance	Light to dark yellow, clear liquid
Odor	Light musty/soapy odor
Biodegradability	More biodegradable than petro diesel
Reactivity	Stable, but reacts with strong oxidizers

2.3 Biodiesel production

There are various biodiesel produced through several processes. A process that is often done is comprised of biodiesel a crop is used directly and crude oil blending, micro-emulsion, thermal cracking and transesterification. A process that is often used for biodiesel production is transesterification process. Currently, much researcher study about non-edible oil to substitute edible oil. But the problem faced by researchers when producing biodiesel from non-edible oil has higher total content of Free Fatty Acids (FFA). (Lapuerta et al. ,2008) there has two steps to convert high content of Free Fatty Acids, first step acid-catalyzed pretreatment and the second step is alkaline-catalyzed transesterification. The first step is a reduce 2% of FFA. The effect of reduce less than 2% of FFA, the biodiesel suitable use in the compression ignition engine. Using alkaline-catalyzed step can affect the conversion efficiency of the process such as molar ratio, catalyst amount and reaction temperature and reaction duration. After complete the process, comparison between biodiesel and diesel will be conducted. The comparison can be evaluated in terms of properties such as specific gravity, flash point, cloud point and density. The important of this study is to ensure that there are source of renewable energy that can be substitute fossil fuel.

2.3.1 Transesterification

The main process to convert raw material feedstock to biodiesel is known as transesterification process. This process happens as a result of the reaction of ethanol to triglyceride oil content in vegetable oils, animal fats or recycled greases. This process will form the alkyl esters of fatty acids and glycerin. A strong base catalyst such as sodium hydroxide or potassium hydroxide is required to perform the reaction process. There have several process transesterification to produce biodiesel:

2.3.1.1 Catalytic Method

Transesterification process can be catalyzed by alkalis, acid, or enzymes (Zhang et al., 2003). A typical procedure for the alkali-catalyzed method as follows. The catalyst such as potassium hydroxide or sodium hydroxide is dissolved into methanol by vigorous stirring in a small vessel. Then, this mixture is pumped into a reactor containing oil. The reactor is heated and vigorously stirred for about 2 hours to complete the trasesterification process. Upon successful completion of the reaction, settling of the phases is allowed in which crude glycerin (heaver liquid) remains at the bottom and biodiesel remain at the top. For phase separation, it starts in 10 minutes. But to complete the phase separation process takes about 2 up to 20 hours. After settling is complete, ester is carefully washed. Water is added and stirred for 5 minutes and the water used by 5.5% by total ester and glycerin allowed to settle again. A water wash solution at 28%

by volume of ester and 1 g of tannic acid per liter of water is added to the ester and gently agitated. Oil was stir gently and at the same time carefully introduced into the aqueous layer. According to Ma and Hanna (1999), and Demirdas (2002) paper, this process continues until the ester layer became clear and after that the aqueous is drained. Water was added by volume of ester to final washing. Now, the aqueous phase is again drained, resulting in the final biodiesel product. For sodium methoxide-catalyzed transesterification, vegetable oil is transesterification in a solvent with methanol containing fresh sodium. The reaction process typically carried out at 25°C for 10 minutes.

In the case using sulfuric acid, hydrochloric acid and sulfonic acid as an acid catalyst, there were dissolved into methanol by vigorous stirring in small vessels. Then, the mixture is pumped into a biodiesel reactor containing vegetable oil. The reaction is typically carried out at 30 to 35°C for 1 to 6 hours. Various transesterification methods are compared in Table 2.2 (Ram B. Gupta et al. 2010).

Table 2.2: Comparison of various methanolic transesterification methods (Sources: Ram B.G (2010) “Gasoline, Diesel and Ethanol Biofuels from Grasses and Plants 1st Edition Cambridge University press)

Method	**Reaction temperature (°C)**	**Reaction time (min)**
Acid or alkali catalytic process	30-70	60-360
Boron trifluoride-methanol	87-117	20-50
Sodium methoxide-catalyzed	20-25	4-6
Noncatalytic supercritical methanol	250-300	6-12
Catalytic supercritical methanol	250-300	0.5-1.5