CHARACTERIZATION OF FUEL DELIVERY SYSTEM COMPONENTS IMMERSED IN DIFFERENT RATIO OF PALM OIL BLENDED WITH DIESEL

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Progress Report II

Projek Sarjana Muda

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2019

SUPERVISOR'S DECLARATION

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Date :.....

ABSTRACT

Due to high demands of diesel todays either for transportation or industry, a lot of study conducted as the pure diesel that extract from the fossil fuel is very harmful to environment and to us living things. Besides, the source of fossil nowadays is limited and one day the fossil fuel will not be found in the earth. Therefore, the alternative fuel is study and investigated to replace the pure diesel such biodiesel that extract from plant. One of the possible biodiesels and Malaysia have many sources of it is Palm Biodiesel. Compare to pure diesel, the exhaust gasses produce from combustion of biodiesel is low in harmful gases such Sulphur dioxide.

Malaysia Palm Oil Berhad (MPOB) give a grant to Universiti Teknikal Malaysia Melaka (UTeM) to perform a study of biodiesel effect on the existing car. One of the proposed study is the degradation of elastomer towards exposure to current implemented biodiesel (B10) and the new blend biodiesel (B30). Therefore, the degradation of elastomer in terms of mass change and mechanical properties such tensile test is perform. The testing is following ASTM D471 for soaking test and mass test. As for tensile test is following ASTM D412.

ABSTRAK

Oleh kerana permintaan diesel yang tinggi hari ini baik untuk pengangkutan atau industri, banyak kajian dilakukan kerana diesel tulen yang mengeluarkan dari bahan bakar fosil sangat berbahaya bagi alam sekitar dan bagi kita makhluk hidup. Selain itu, sumber fosil pada masa kini adalah terhad dan suatu hari bahan bakar fosil tidak akan dijumpai di bumi. Oleh itu, bahan bakar alternatif dikaji dan dikaji untuk menggantikan diesel tulen seperti biodiesel yang dihasilkan daripada tumbuhan. Salah satu kemungkinan biodiesel dan Malaysia mempunyai banyak sumbernya adalah Minyak Sawit. Jika dibandingkan dengan diesel tulen, gas ekzos yang dihasilkan dari pembakaran biodiesel rendah gas berbahaya seperti Sulfur dioksida.

Malaysia Palm Oil Berhad (MPOB) memberikan geran kepada Universiti Teknikal Malaysia Melaka (UTeM) untuk melakukan kajian mengenai kesan biodiesel pada kereta yang ada pada hari ini. Salah satu kajian yang dicadangkan adalah penurunan gred elastomer terhadap pendedahan kepada biodiesel yang dilaksanakan sekarang (B10) dan biodiesel campuran baru (B30). Oleh itu, penurunan elastomer dari segi perubahan jisim dan sifat mekanik seperti ujian tegangan dilakukan. Ujian ini mengikuti ASTM D471 untuk ujian rendaman dan ujian jisim. Adapun ujian tegangan mengikuti ASTM D412.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Dr. Mizah Binti Ramli, Senior Lecturer from Fakulti Kejuruteraan Mekanikal Universiti Teknikal Malaysia Melaka (UTeM) for her support, encouraging supervision and dedication towards the completion of this thesis. Besides, I would also want to express my gratitude to all students and supervisors under this project for helping me to perform the testing and give useful advices and suggestion on this project.

Special thanks to Fakulti Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka (UTeM) for the technical assistance provided, and the Malaysian Palm Oil Board under MPOB/2019/FKM-CARE/G00066 grant for the financial support in completing this project.

Last is a special thanks for both of my parents Hassan bin Sakka and Marhana binti Mayyade for giving me the chances to continuing my study to this level, support morally and financially throughout the completion of this project. Thanks to all my friends that helping me through the crucial part of completing this project.

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LIST OF ABBREVIATIONS

MPOB	Malaysia Palm Oil Board
EPA	Environmental Protection Agency
ULSD	Ultra Low Sulphur Diesel
ASTM	American Society for Testing and Materials
EN	European Standards
ISO	The International Organization for Standardization
NBR	acrylonitrile butadiene rubber
FKM	fluoroelastomer
CR	polychloroprene rubber
SR	Silicone Rubber
HNBR	Hydrogenated acrylonitrile butadiene rubber
EPDM	Ethylene-Propylene-Diene rubber
ACM	Acrylic rubber
ECO	Epichlorohydrin
SBR	Styrene Butadiene Rubber
FDM	Fuel Delivery System
GHG	Greenhouse Gas

EMA	Exponential Moving Average
FAME	Fatty Acid Methyl Esters
NaOH	Sodium hydroxide
KOH	Potassium hydroxide
CN	Cetane Number
CI	Compression Ignition
CO_2	Carbon Dioxide
TPE	Thermoplastics
RTC	Real Time Clock
AMCHAL	Advanced Materials Characterization Laboratory

LIST OF SYMBOLS

ºC	Degree Celsius
ºF	Degree Fahrenheit
vol%	Volume percentage

CHAPTER 1

INTRODUCTION

1.1 Background

Diesel fuel commonly used for transportation such as trucks, buses, and trains. Besides, it is also used to move a diesel engine to produce electricity especially for their emergency power supply. Petroleum diesel which is also known as petro diesel or fossil diesel is a common type of diesel used. Crude oil is refined by undergoes fractional distillation between 200^{o}C (392^{o}F) and 350^{o}C (662^{o}F) at atmospheric pressure which will produce a mixture of carbon chains (Trakarnpruk and Porntangjitlikit, 2008) But there are some disadvantages from using diesel fuel and some of it is harmful to human health as the combustion of diesel contained high quantities of Sulphur (Singh *et al.*, 2019). In 2006, U.S. Environmental Protection Agency (EPA) issued requirement to reduce the Sulphur content and create a standard to be follow by the petroleum industry to produce Ultra Low Sulphur Diesel (ULSD) fuel.

Besides emitting harmful gas, fossil fuel is an unsustainable source of energy which means the source will be getting lesser every day and someday it will finish. This is due to continuous depletion and contamination of environment and to produce back the fossil fuel taking such a long time(Singh *et al.*, 2019). This will cause energy crisis for the next generation. Many studies were conducted to find a solution for this problem and one of it is by using biodiesel instead of using pure fossil diesel. According to American Society for Testing and Materials (ASTM), biodiesel is

monoalkyl esters of long-chain fatty acids which is extract from edible oils, non-edible oils, waste oils and assigned as B100, which produced through transesterification process of triglycerides using methanol and catalyst (Hoekman *et al.*, 2012). Triglycerides is produced from animal and vegetables. Whereas for the catalyst that commonly used to produce biodiesel are strong alkaline catalyst, strong acid and enzyme.(Singh *et al.*, 2019)

There are many components in the fuel delivery system that are directly contact with fuel such as the fuel pump, the fuel injector, the engine, and the exhaust system. **Figure 1** shows the position of some of the rubber and metal sections in the traditional automotive fuel system. Among the types of elastomers used in the automotive fuel system are acrylonitrile butadiene rubber (NBR), fluoroelastomer (FKM), poly chloroprene rubber (CR), silicone rubber (SR), hydrogenated NBR (HNBR), ethylene-propylene-diene rubber (EPDM), acrylic rubber (ACM), epichlorohydrin (ECO), styrene butadiene rubber (SBR) and polyurethane (Trakarnpruk and Porntangjitlikit, 2008b; Haseeb *et al.*, 2010; Chandran *et al.*, 2016)

Switching to biodiesel may lead to swelling and degradation of rubber (Chandran, 2019). In fact, the presence of various contaminants, unreacted materials and degradation by-products in biodiesels, when associated with high service temperature and mechanical processing, increases the corrosion of fuel delivery system components in the vehicle. As a result, in addition to the swelling and degradation of the elastomer structure, after exposure to biodiesel, elastomer additives incorporated (such as curing agents, processing aids, expansion oils, stabilizers and fillers) may migrate to the fuel and chemical reactions involving additives and the fuel itself may occur. For fact, this can also happen in the case of metallic parts, when the biodiesel itself can weaken the metal parts, and eventually the oxidation process can occur.

Furthermore, in order to operate in conventional engines, biodiesel blends usually require several additives to improve their lubricity, thermal stability, cold flow and combustion efficiency. Such additives also contain metal-organic or oxygenated compounds, which can also cause degradation of the rubber parts. Biodiesel blend composition and the bio-based element source (palm oil, soybean, etc.) have developed varying effects on the degradation quality of the elastomers (Alves, Mello, & Dutra-Pereira, 2017).

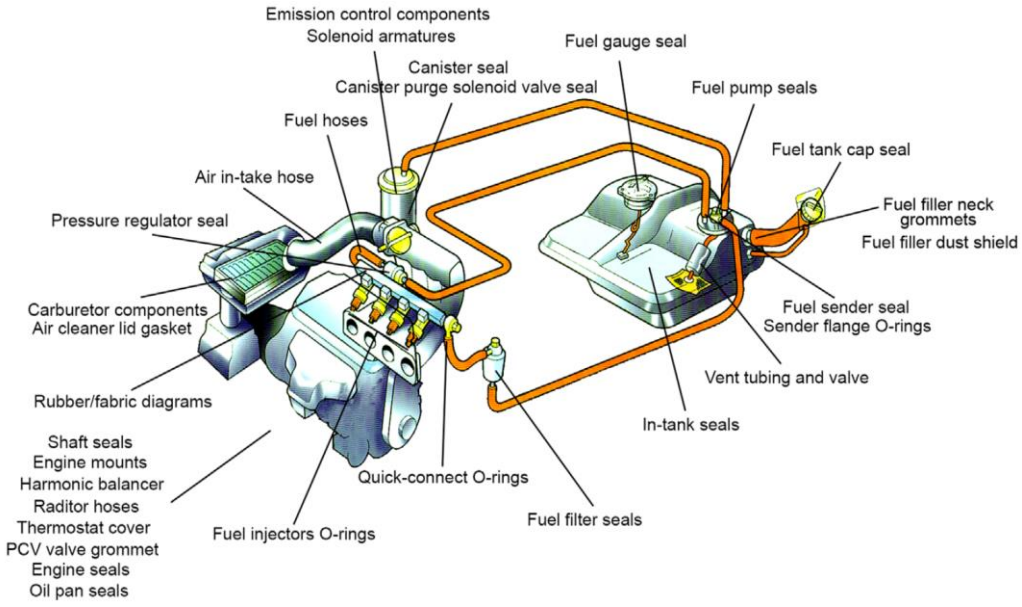

Figure 1.1 The location of some of the rubber parts in a conventional fuel system

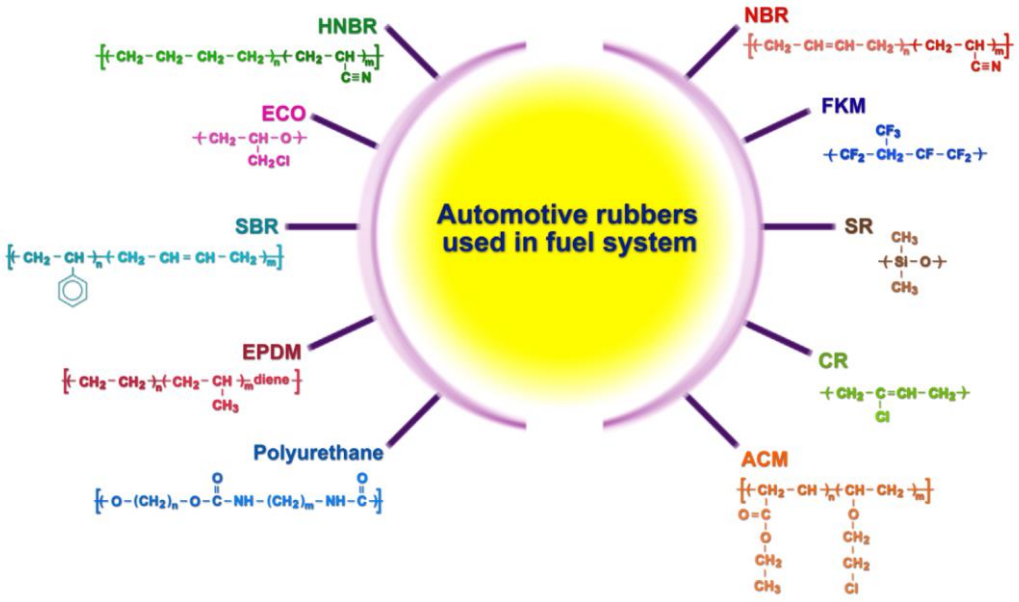

Figure 1.2 Chemical structures of the rubbers most frequently used in automobile fuel systems

In addition to combustion and emission performance, the effect of the biodiesel blend on the elastomer and metallic-based components is also a crucial factor in the performance of the biodiesel blend. It is concluded that there are many factors involved which relate to fuel and elastomeric as well as metal components within the fuel system and need to be fully understood and carefully investigated in order to introduce a successful blend of biodiesel as a substitute for pure diesel for automotive applications. This research is therefore proposed to examine the effect of the B30 palm biodiesel blend on the physical and mechanical properties of the automotive elastomer using mass test and tensile test. The objective is to characterize the effect of the properties of elastomer subjected to a blend of B10 and B30 palm biodiesel and to identify the mechanism of failure associated with it. By acquiring valuable information, any limitation of the performance of the product relating to the blending of biodiesel with elastomer components can be identified and improved in order to achieve the successful B30 blending of biodiesel as a renewable and more sustainable alternative vehicle fuel in the future.

1.2 Problem Statement

Research for an alternative fuel are conducted due to the depletion and environmental degradation. Previous research finds out that a biodiesel could replace the pure diesel that we use today that were produced from fossil fuel. Biodiesel is a product of transesterification process of either vegetable oils or animal fats. But for this project, we are focusing on palm-based biodiesel which are B10 and B30.

The compatibility of biodiesel against petro diesel is different according to the mixture in the fuels where petro diesel contain hydrocarbons whereas for biodiesel is a mixture of fatty acid esters. In diesel engine, fuels in contact with a wide variety of materials especially for the fuel delivery system (FDM). Research for compatibility of hose materials that commonly used for FDM has been established long ago but not yet tested for the new blended palm-based biodiesel B30. Regarding from the research that have been reported using B7, B10 and B20 biodiesel, degradation of certain elastomers is one of the main issues regarding material incompatibility with biodiesel. According to (Haseeb *et al.*, 2011) increased in vol% of biodiesel in a diesel as to minimize the usage of fossil fuel, the more the elastomer swelling and decrease in mechanical properties.

1.3 Objective

The proposed objectives of the project are: -

i. To analyze the degradation of elastomers by measuring sample weight and volume.

ii. To determine the mechanical properties (strength, stiffness, and hardness) properties after expose to B10 and B30 palm biodiesel.

iii. To compare the degradation of elastomer after exposed to B10 and B30.

1.4 Scope of Project

The proposed scopes of project are: -

i. To prepare experimental test procedure and develop testing capability.

ii. To perform physical and mechanical properties characterization tests.

iii. To perform failure analysis study using advanced characterization methods.

iv. To generate test report and failure analysis report.

1.5 General Methodology

The overall methodology of the proposed projects is divided into four phases, and described in detail as follows: -

Phase 1: Designing apparatus to be use

In this step, the apparatus and method that will be use in this project will be defined according to customer requirements. For the specialized test equipment and jigs for tensile test are design and fabricate same with the water bath temperature control equipment.

Phase 2: Sample Preparation

All samples received will be prepared according to the test standard requirements. Elastomer samples shall be group into 2 types, which are samples that is not immersed and immersed samples. For the immersion test, pure diesel shall also be used (in addition to the B10, B20 and B30 biodiesels) to obtain the baseline data for comparison purpose. To get the average result, 5 samples prepared so that the result more valid and the error manage to be reduced.

Phase 3: Materials Characterization

In this phase, characterization activities shall involve physical and mechanical analysis. Details of the proposed activities are described as below: -

3.1 Physical property

Physical analysis can be conducted using static immersion of the samples inside the fuels (pure biodiesel, B10 and B30 palm biodiesel blend). All tests shall be performed at fix room temperature with varying immersion time of 3-7 days. Prior to immersion, all samples shall be dried by blotting with lint-free cloth followed by air drying at room temperature for 30 - 40 minutes (Haseeb *et al.*, 2011). Measurement on the changes in weight (using 4 decimal units accuracy balance) and volume (using Vernier caliper and micrometer) of the elastomer before and after immersion shall be conducted. Changes in term of sample mass and volume shall be calculated using **Eqs. (1)** and **(2)**.

$$\%\, Mass\ change = \frac{M_2 - M_1 \times 100}{M_1} \qquad \textbf{(1)}$$

where $\boldsymbol{M_1}$ and $\boldsymbol{M_2}$ are the initial sample weight and the sample weight after immersion, respectively.

$$\%\, Volume\ change = \frac{V_2 - V_1 \times 100}{V_1} \qquad \textbf{(2)}$$

where $\boldsymbol{V_1}$ and $\boldsymbol{V_2}$ are the initial sample volume and the sample volume after immersion, respectively.

3.2 Mechanical properties

Mechanical analysis of the performance of the samples shall be conducted using static immersion condition (immersed in pure biodiesel, B10 and B30 palm biodiesel blend). All samples shall be immersed at fix room temperature and varying immersion time of 3-7 days. The samples shall be dried using clean cloth after immersed. Later, the samples shall be subjected to tensile test and hardness test. For the tensile test, the sample will be cut into a dog bone shape. The tensile strength and tensile modulus measurement shall be conducted to American Society of Testing and Materials **(ASTM) D412-16** standard (at strain rate of 500 mm/min) using Instron Universal Testing Machine (5 kN) (Haseeb *et al.*, 2011).

Phase 4: Documentation

At the end of this project, all experimental data and findings obtained from the experiment are reported and submit the customer.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Some of the natural resources that we have now are unsustainable resources, this means that one day the resources cannot be use anymore. It is very important to take a precaution step so that the resources can be maintain and it can be used for future generation. The usage of natural resources such fossil fuel can led to pollution which it will emit harmful gas as product when burnt other than useful energy that we need and it is very dangerous for human health which can led to severe diseases (Haines *et al.*, 2006).

The fossil fuels are mainly use in transportation and industry sector where the fuel is used to move the engine. Fossil fuels accounted for 88% of the primary energy consumption with oil (35% share), coal (29%) and natural gas (24%) as major fuels, while nuclear energy and hydroelectricity account for 5% and 6% of the total primary energy consumption respectively (Brennan and Owende, 2010). Therefore, the transportation and industry such as truck and other vehicles create and important field. In order to achieve reinvestment from petroleum products, this is where the use of alternative fuels arises as a very effective, long-term alternative solution.

Besides, the effect of the emitted greenhouse gaseous will affect the ozone layer and this will cause the global warming. This is cause by the present of nitrous oxide and nitrogen dioxide that was release from burning of fossil fuel. As the main function of ozone layer is to prevent direct exposure of UV light from sun towards human, the depletion of ozone layer will cause skin cancer

premature aging, eye cataract and damage or weak the immune system (Coldiron *et al.*, 1992). The effect of global warming is it will cause our global hot and rises of sea level which is cause by the melting of ice at the north pole.

Due to the demand of the fossil fuel, continuous depletion and contamination of the fossil fuel, it is now considered as an unsustainable source of energy. Many study and research were made to generate a new source that can be sustainable and can function same or nearly the same with fossil fuel such biodiesel. This study is to run the test on elastomer behavior immersed in various type of biodiesel in order to investigate the mechanical-physical properties of the elastomer as biodiesel is one of sustainable resources that tends to replace the diesel.

2.2 Biofuel

Advanced liquid biofuels are being marketed in the United States (U.S.) to achieve national energy independence and safety and reduce greenhouse gas (GHG) emissions. U.S. first generation biofuels are produced primarily from major commercial crops such as corn (Zea mays, L.)-grain ethanol and soy (Glycine mix, L.) biodiesel. (Wu, 2008). A study made for the next generation feedstocks and categorized as cellulosic components of municipal solid waste, forest residues and thinning, annual crop residues, dedicated herbaceous perennial energy crops, short-rotation woody crops and microalgae. These feedstocks may produce a various type of biofuels such ethanol, biodiesel, jet fuel, green gasoline, green diesel. There also other feedstock such Jatropha (Jatropha curcus L.), grease and cooking waste oil and animal fats (Pamela R. *et al.*, 2009).

Since a fossil fuel have a lot of negative impact towards environment and human, a biofuel was produced which will reduce those negative impact. In this project we will focus on biodiesel