Faculty of Mechanical Engineering

THE EFFECT OF STORAGE DURATION AND VARIANCE TEMPERATURE ON HIGH BLEND LEVEL BIODIESEL FUEL PROPERTIES

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DECLARATION

I declare that this thesis entitled “The Effect of Storage Duration and Variance Temperature on High Blend Level Biodiesel Fuel Properties” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

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 Master of Science in Mechanical Engineering.

Signature :……..……..

Supervisor Name :……....…….……

Date :…….……..……..

DEDICATION

To my beloved mother and father

ABSTRACT

Biodiesel is one of the alternative fuels that have been studied to overcome the problem of depleting fossil fuel and its impact on the environment. Biodiesel also has high potential as engine cleaning agent as well as reducing harmful exhaust emissions from combustion process. The objectives of this study are to investigate the effect of High Blend Level (HBL) biodiesel properties and the degradation of HBL biodiesel in certain storage duration and temperature. This study also analysed the potential of running the HBL biodiesel on a diesel engine. Four blend levels of biodiesel are selected from B70, B80, B90 and B5. The properties of biodiesel were investigated according to American Society for Testing and Materials (ASTM) D6751 focused on acid value, flash point, water content and density. Fourier Transform Infrared Spectroscopy (FTIR) was used to examine chemical content and finding degradation. The samples were stored in three different storage temperatures and durations. Three phases have been designed in this study involving sample preparations, fuel properties experiment and engine performance test. The important finding obtained from this study is the HBL biodiesel fuel properties such as acid values, flash points, water content and density proportionally increase with the storage temperatures and durations. The blend samples of B70, B80 and B90 degrade over time as the storage duration increases. The temperature also plays significant roles to accelerate the degradation process. FTIR spectrum results show, small changes in seven weeks of storage had significant effect to the fuel properties especially for flash point and acid value. Due to technical limitation and difficulty, only B70 biodiesel have been experimented and showing similar engine performance curve as compared to the standard B5. After three weeks of storage duration, the B70 fuel degraded and the results from the engine torque and power curves show reduction. Further investigation is needed to analyse others biodiesel properties impact on storage durations and temperature to the engine performance.

ABSTRAK

Biodiesel merupakan salah satu daripada bahan bakar alternatif yang telah dikaji untuk mengatasi masalah pengurangan bahan bakar fosil dan kesannya terhadap alam sekitar. Biodiesel juga mempunyai potensi yang besar sebagai ejen pembersihan enjin serta mengurangkan asap yang berbahaya daripada proses pembakaran. Objektif kajian adalah untuk mengkaji kesan Campuran Nisbah Biodiesel yang Tinggi (CNBT) terhadap ciri-ciri biodiesel dan degradasinya dalam tempoh simpanan dan suhu yang tertentu. Campuran nisbah biodiesel yang tinggi turut dikaji untuk melihat potensinya di dalam enjin diesel. Empat jenis sampel telah dipilih, iaitu B70, B80, B90 dan standard *B5 dijadikan sebagai rujukan. Ciri-ciri biodiesel yang dikaji mengikut standard* American Society for Testing and Materials (ASTM) D6751 *difokuskan kepada nilai asid*, flash point, *kuantiti air dan ketumpatan. Untuk kajian terhadap kandungan kimia dan penurunan kualiti minyak,* Fourier Transform Infrared Spectroscopy (FTIR) *telah digunakan. Semua sampel telah disimpan di dalam tiga tempat penyimpanan yang mempunyai suhu yang berbeza. Tiga fasa telah dirangka dalam kajian ini melibatkan penyediaan sampel, eksperimen ciri-ciri bahan bakar dan ujian prestasi enjin. Penemuan yang penting dalam kajian ini ialah peningkatan campuran nisbah biodiesel yang tinggi berkadar terus dengan ciri-ciri biodiesel iaitu nilai asid*, flash point, *kuantiti air dan ketumpatan. Kualiti sampel campuran B70, B80 dan B90 menurun apabila tempoh penyimpanan meningkat. Suhu juga memberi kesan kepada peningkatan proses degradasi. Keputusan dari* FTIR spectrum *menunjukkan perubahan yang sedikit pada sampel-sampel yang telah disimpan selama tujuh minggu memberi kesan yang besar kepada ciri-ciri biodiesel terutama* flash point *dan nilai asid. Kerana keterbatasan teknik dan kesulitan, hanya B70 yang telah dikaji dan graf lengkungannya prestasi enjin menunjukkan persamaan bila dibandingkan dengan standard B5. Selepas menyimpan selama tiga minggu, minyak B70 terdegradasi dan keputusan tork dan kuasa enjin menunjukkan penurunan. Kajian yang lebih mendalam diperlukan untuk menerokai ciri-ciri biodiesel yang lain yang berkaitan serta memberi impak kepada tempoh penyimpanan dan suhu kepada prestasi enjin.*

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LIST OF ABBREVATIONS

ASTM	-	American Society for Testing and Materials
FTIR	-	Fourier Transform Infrared Spectroscopy
HBR	-	High Blending Ratio
STD	-	Standard diesel
KBr	-	Potassium Bromide
KOH	-	Potassium Hydroxide
NaOH	-	Sodium Hydroxide

LIST OF SYMBOLS

V	-	final volume – initial volume of KOH
g	-	gram
M	-	Molarity

LIST OF PUBLICATIONS

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Biodiesel is produced from living organisms such as plant oils or animal fats. The living organisms have large size of chemical compound, where the compound will gel in cold weather. As consequent, the viscosity of the fuel increases and makes it difficult to be use in engine for combustion. The oils have gone through a refinery process to break the size of the chemical compound to form biodiesel. Through the refinery process called transesterification, the alcohol was mixed with oils and catalysed by potassium hydroxide (KOH) or sodium hydroxide (NaOH) to form biodiesel also known as fatty acid methyl ester (FAME) and glycerin as a co-product (Satriadi et al., 2016).

The biodiesel can be used alone and stable but could easily oxidize when being stored in long storage period and exposed to high temperature (Pattamaproma et al., 2012). To reduce the oxidation effect, the biodiesel was blended with petroleum diesel. The blend level is denoted as B, followed by the percentages of the biodiesel blend. As example, B5 contain 5% of biodiesel and 95% of petroleum diesel.

Biodiesel has tendency to reduce the harmful gaseous such as carbon monoxide (CO), hydrocarbon (HC) and nitrogen oxide (NOx) because biodiesel has higher oxygen contents compared to petroleum diesel. As the blend level increased, the oxygen content also increased. As per theory, the enrichment of oxygen would help increasing the percentage of complete combustion process (Demirbas, 2008).

1.1 Background of research

In Malaysia, the most preferable feedstock of biodiesel is crude palm oil (CPO) due to low cost and its abundant availability. Through a refinery process called transesterification, the CPO is processed to form biodiesel (Khalid et al, 2013b). The properties of biodiesel could be changed due to storage duration and temperature. The critical properties that give significant effect as the storage time increase under various temperatures are acid value, flash point, water and sediment, cloud point and oxidative stability.

Most recent studies have confirmed that when the storage time increases, the acid value of the biodiesel samples will increased (Wu et al., 2011; Khalid et al., 2013b; Ashraful et al., 2014). Increasing the acid value occur due to hydroperoxide produced from oxidative degradation which undergoes hydrolysis reaction of ester further oxidize into acid (Zakaria et al, 2014). The increment of the acid value could damage the engine component such as a piston, cylinder wall and shaft due to corrosion and oxidation process.

Flash point is an important parameter for biodiesel while handling, storage and safety when it used in transportation (Khalid et al, 2014). The purpose to find the flash point is to measure the tendency of fuel sample to combust when mixes with air in controlled laboratory conditions. According to Zakaria et al. (2013), a good fuel for diesel engine should have a low auto-ignition temperature because the engine uses air compression to ignite the fuel in combustion chamber. Studies have found that, flash point of fuel with a present of antioxidant is higher than fuel without antioxidant under storage (Obadiah et al., 2012). A study by M. Shahabudin et al., (2012) found that the flash point temperature reduces when the fuel was stored in long duration.

The kinematic viscosity of the biodiesel will increase depending on temperature and storage condition. At an ambient temperature in the dark area, C. Pattamaprom et al. (2012) found that there is no significant effect on kinematic viscosity and the value remains unchanged. The changes of kinematic viscosity also can be effected by density because the kinematic viscosity is measured from the resistance of substance flow. Previous research found that water content will increased if the sample being stored at high temperature where the water content rises up to 30% in storage and remain unchanged at low temperature (Leung et al., 2006)

In addition, a degradation of biodiesel could occur because of the increasing of storage time. It would change the chemical compound and deteriorate the quality of the fuel. Some problem may occur in the engine such as poor cold flow properties, deposits on injector, accelerated oxidation and filter plugging (Wilks, 2008). The problem occurs can also lead to the engine performance issue such as incomplete combustion process because of the impurities developed in the fuel after long storage duration such as acid, alcohol, aldehyde and hydrocarbon (Azhari et al. 2014).

1.2 Problem statement

Most recent studies of biodiesel were focused on different type of vegetable oils and various biodiesel blends however it is limited to pure and low blend level biodiesel (Baig, 2011; Rahim, 2012 ; Kah et al., 2013; Satriadi et al., 2016) Moreover, the difference type of vegetable oil has a different effect on properties of biodiesel (Hamidreza et al., 2012). As consequence, the properties condition of high blend level (HBL) biodiesel from CPO attracted more research interest in the area.

The storage duration and temperature could affect the fuel properties. The biodiesel has tendency to accelerate oxidation after long storage duration and at high temperature (Khalid et al, 2014). The oxidation would change the properties of biodiesel because of the peroxide produced during the storage duration. Moreover, the properties changes were affected by the changes of chemical compound in the fuel. Because of the oxidation process, the impurities were produced in the fuel such as acid value, alcohol, water, aldehyde, alkanes and other product (Zuleta et al., 2012). The properties changes would lead to the engine problem and performance (Wilks, 2008).

Therefore, palm oil biodiesel is used for this study due to its promising potential as Malaysia is the second biggest exporter of palm oil (Chin, 2011). Hence, it is good opportunity to study further about palm oil biodiesel. Meanwhile, the blending is focused on HBL biodiesel. The samples are stored in three different storage temperature and will be investigated their properties and chemical changes. This study also will investigate the potential of the HBL biodiesel on diesel engine and its performance.

1.3 Aim

This study investigates the properties of HBL biodiesel in variant storage temperature. The chemical changes were investigated by comparing the FTIR spectrum of the samples blending within storage period. The chemical changes were investigated shows the degradation of the fuel. One of the samples is selected and will be tested to investigate whether HBL of biodiesel can be used in the diesel engine without modification and to study the effect of storage to the engine performance.

1.3.1 Objectives

a. To study the effect of HBL biodiesel properties in storage duration and temperature.
b. To investigate the degradation of HBL biodiesel in storage duration and temperature.
c. To explore the effect of running HBL biodiesel against the engine performance.

1.3.2 Scopes

The scopes for this study are focused on HBL biodiesel (B70, B80, and B90) without additive. The samples were stored at different storage temperatures (cold: 9-11 °C; room temperature: 24-26 °C and hot: 38-40 °C) for a duration up to seven weeks.

a. The properties for this study are acid value, flash point, density and water content. The properties selected are critical parameter where the changes have significant impact to the engine component, safety storage the fuel and the engine performance.

b. The samples were tested using FTIR to investigate the changes of chemical compound in the samples and were focused on alkanes (CH_2 and CH_3), alcohol (C-O) and ester (C=O). It was assumed that the fuel was stored in diesel fuel tank. For this study, the samples were stored in a laboratory glass bottle for weekly test.

c. The single cylinder compression ignition diesel engine was used to study the engine performance (power and torque against speed) for HBL biodiesel (B70 only because of the limitation for engine testing and it was selected based on the closest properties to the baseline fuel).

1.4 Thesis organization

The organization of the thesis corresponds to the three objectives in this study.

Chapter 2 discuss on the literature review of the past work and relevant information with regards to the biodiesel and biodiesel blend and focus on the properties, storage temperature and chemical compound of the fuel.

Chapter 3 describes the methodology of this study. Besides, the process of blending the fuel, experimental preparation and the procedure for running the fuel properties will be explained. This chapter would also explain the experimental flow involved in this study in order to gather the results.

Chapter 4 covers the results and discussions of the analysis. The results and data obtained are evaluated including the analysis of the initial biodiesel properties blend in different temperatures, degradation and engine performance.

Chapter 5 concludes the finding of this investigation and suggested some recommendation for the future study.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

Many researches investigating renewable and sustainable energy were conducted across the globe as a result of depleting petroleum diesel as well as the problem of environmental degradation. One of the renewable and sustainable energy that triggered research attention is biodiesel at various blending level. Biodiesel also have the advantages of engine cleaning agent and reduce harmful emission from the combustion process (Gulzar et al., 2016). In the following section, a bit of biodiesel as alternative fuel, history, comparison against petroleum diesel and various biodiesel blend ratio would be discussed. Then, section 2.2 would discuss on the basic fuel properties required for biodiesel study and results obtained. In section 2.3, the literature on degradation from various studies has been adopted for this investigation. This would provide some basic knowledge on degradation investigation and overview of some insight of biodiesel degradation impact over time and temperatures. Later, engine performance and emission studies were reviewed to reveal what have been done by other researchers and their respective findings.

The objectives of this research have been formulated as previously described in section 1.3. The methodology utilized in this research are as reviewed in section 2.2 onward and later discussed in details in chapter 3.