INVESTIGATION OF DIESEL AND BIO-DIESEL FUEL DEPOSITS ON A HOT WALL SURFACE BY USING SIMPLIFIED METHOD TEST

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SUPERVISOR'S DECLARATION

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor and to the second examiner.

Signature :.....

Name of Supervisor :.....

Date :.....

APPROVAL

I hereby declare that I have read this project report 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 Honours.

Signature :.....

Name of Supervisor :.....

Date :.....

DEDICATION

To my beloved mother and father

ABSTRACT

Deposit formation is a complex phenomenon which causes various problems in the combustion chamber of an engine such as reduce the engine performance, increase the engine emissions, and cause engine damage to the diesel engine. Therefore, the aim of this study is to investigate and analyze the deposit formation of diesel and bio-diesel fuels using a simplified method known as Hot Surface Deposition Test (HSDT). In this investigation, it was carried out by dripping different types of fuel droplets which are diesel and bio-diesel (B20) fuels continuously for 3000 repetitions onto an aluminum alloy sheets with a curved surface as the hot surface plate. The hot surface plate temperature will be set at various temperature which are 250 °C, 357 °C, 450 °C and 600 °C with an impingement interval of 1 and 5 seconds. These intervals are appropriate to simulate between wet and dry condition, respectively which the impingement interval of 1 second is used for wet condition and 5 seconds is used for dry conditions. The dry condition means all volatile components of the first fuel droplet are vaporized or all non-volatile components of the first fuel droplet formed into deposits before the next impingement of the second fuel droplet occur. As for the wet condition, the second impingement of the fuel droplet occurs when the volatile components of the first fuel droplet are not completely vaporized, creating an overlapped state. Based on the results, the amount of mass fuel deposit, M_D of diesel fuel deposit is higher compared to B20 fuel deposit and the highest M_D is produced at surface temperature of 250 °C, followed by 357 °C, 450 °C and 600 °C. This is because as the temperature increases to the point where the Leidenfrost effect is more prominent, the higher oxygen content in B20 fuel molecule aids in better fuel combustion thus, lesser deposit is formed compared to diesel fuel deposit. Therefore, bio-diesel has a potential to replace diesel in the consumer market.

ABSTRAK

Pembentukan deposit adalah fenomena kompleks yang menyebabkan pelbagai masalah di ruang pembakaran mesin seperti mengurangkan prestasi mesin, meningkatkan pelepasan mesin, dan menyebabkan kerosakan mesin pada mesin diesel. Oleh itu, tujuan kajian ini adalah untuk menyelidiki dan menganalisis pembentukan deposit bahan bakar diesel dan bio-diesel menggunakan kaedah yang dipermudah yang dikenali sebagai Uji Pemendapan Permukaan Panas (HSDT). Dalam penyelidikan ini, ia dilakukan dengan meneteskan berbagai jenis tetesan bahan bakar yang merupakan bahan bakar diesel dan bio-diesel (B20) secara berterusan selama 3000 pengulangan ke kepingan aloi aluminium dengan permukaan melengkung sebagai plat permukaan panas. Suhu plat permukaan panas akan ditetapkan pada pelbagai suhu iaitu 250 °C, 357 °C, 450 °C dan 600 °C dengan selang pengurangan 1 dan 5 saat. Selang ini sesuai untuk mensimulasikan antara keadaan basah dan kering, masing-masing yang selang pengurangan 1 saat digunakan untuk keadaan basah dan 5 saat digunakan untuk keadaan kering. Keadaan kering bermaksud semua komponen yang tidak stabil dari titisan bahan bakar pertama diuap atau semua komponen yang tidak mudah menguap dari titisan bahan bakar pertama dibentuk menjadi deposit sebelum terjadinya gangguan tetesan bahan bakar kedua. Bagi keadaan basah, hambatan kedua dari tetesan bahan bakar terjadi apabila komponen yang tidak stabil dari titisan bahan bakar pertama tidak sepenuhnya menguap, mewujudkan keadaan tumpang tindih. Berdasarkan hasilnya, jumlah deposit bahan bakar massa, M_D deposit bahan bakar diesel lebih tinggi dibandingkan dengan deposit bahan bakar B20 dan M_D tertinggi dihasilkan pada suhu permukaan 250 ℃, diikuti oleh 357 ℃, 450 ℃ dan 600 ℃. Ini kerana ketika suhu meningkat ke titik di mana kesan Leidenfrost lebih menonjol, kandungan oksigen yang lebih tinggi dalam molekul bahan bakar B20 membantu pembakaran bahan bakar yang lebih baik sehingga, deposit yang lebih rendah terbentuk dibandingkan dengan simpanan bahan bakar diesel. Oleh itu, bio-diesel berpotensi untuk menggantikan diesel di pasaran pengguna.

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LIST OF ABBREVIATIONS

HSDT	-	Hot Surface Deposition Test
EDT	-	Engine Deposition Test
NOx	-	Oxides of nitrogen
POME	-	Palm oil methyl ester
TGA	-	Thermogravimetric analysis
CCD	-	Combustion chamber deposit
HCCI	-	Homogeneous charge compression ignition
HC	-	Hydrocarbon
A/F	-	Air/Fuel
DI	-	Direct injection
DF	-	Diesel fuel
JO	-	Jatropha oil
MEP	-	Maximum Evaporation Rate Point

LIST OF SYMBOLS

$T_{Deposit}$	-	Surface temperature of deposit
T_{Wall}	-	Surface temperature of clean wall
T_i	-	Indicated temperature
T_S	-	Surface temperature
T_d	-	Surface temperature of deposits
°C	-	Degree Celsius
mm	-	Millimeter
mg	-	Milligram
h	-	Hour
m_T	-	Total mass of petri dish with fuel droplet
m_p	-	Mass of the empty petri dish
m_d	-	Mass of a fuel droplet
V_d	-	Volume of a fuel droplet

d	-	Diameter of a fuel droplet
ρ	-	Density of a fuel droplet
$\frac{M_D}{m_D}$	-	Diameter of A Fuel Droplet, d (mm)
N_D	-	Number of droplets

CHAPTER 1

INTRODUCTION

1.1 Background

For couple of years, diesel engines have advantages over petrol engines such as high thermal efficiency, high power/weight ratio, rigid structure, simple mechanisms, high fuel economy and low breakdown rate. Due to these reasons, diesel engine has been widely used in transport. The diesel's higher efficiency makes it possible to use less fuel at the same distance compared to petrol. The big explanation for the success of diesel engines is the usage of low fuel consumption. Unfortunately, emissions released from diesel engines during combustion have been known as the world's main source of air pollution. The rising price of oil is another issue concerning diesel fuels instead of environmental pollution. Moreover, the global economic growth has been affected by this phenomenon.

One of the factors behind the production of new technology is that the oil prices and air pollution. Numerous analysts have looked for to form unused sorts of fuel in arrange to overcome issues related with diesel fuel. A few of them stretch the capacity of palm oil ester, which is alluded to as bio-diesel fuel as a substitution for customary diesel fuel. Palm-oil methyl ester was used by Kalam and Masjuki (2004). From the studies, it found that the engine production was comparable to diesel fuel by the mixing of Palm-oil methyl ester with standard diesel fuel in the automotive diesel engine. The blends from the bio-diesel fuel

are moreover able of bringing down emanations. In expansion, the grade of cetane, which is an indicator of ignition efficiency, is higher than that of commercial diesel fuel when it is mixing with the oil methyl ester.

Bio-diesel fills have preferences in lessening outflows and their mixing with diesel fuel has appeared comparable engine effectiveness. The properties of bio-diesel fuel cause the diverse behaviors and impacts of bio-diesel and bio-blended diesel fuel within the engine compared to diesel fuel. Among the properties are such as viscosity, density, chemical properties, and distillation properties. By alluding to the properties, these forms of fuel would have a higher propensity towards the creation of deposits. The aspects of the creation of deposits when utilizing bio-diesel fuel are not well archived or caught on. The usage of bio-diesel fuel in engines often causes numerous problems, as stated by (Senda et al., 1988).

Investigations on gasoline and diesel engine deposits were carried out probably about more than 50 years ago. Several studies have been performed to understand the effects of engine deposits including about how these deposits are carried out in engines. Deposits were found to form in combustion chambers by three different forms of forming process which are: (1) condensation from unburned gases on cooler walls in combustion chambers; (2) impingement droplets on walls of unburned fuel; and (3) fuel flow on walls such as intake valves and injector tips.

Usually, three main repository inquiries still exist due to the numerous engine types and the latest innovations in engine technology. The surveys cover: (1) the influence of engine deposits; (2) the factors leading to deposit formation; and (3) inquiries into deposit properties. (Güralp et al., 2006). Emissions, loss of heat, engine outputs and engine damage include deposit effects on engines. However, for different engine types, factors which influence deposits

formation, such as wall temperatures, operating conditions, fuel and oil, and ratios of air/fuel are still being considered. To learn more about the thermal properties and their structures, deposit properties were also studied.

The purpose of this project is to analyze the deposition of diesel and bio-diesel fuels formation on the piston wall which, a simpler method known as the Hot Surface Deposition Test (HSDT), is used instead of using the Engine Deposition Test (EDT). This method is more important when used with biodiesel fuel, where these forms of fuel are more likely than traditional diesel to produce more fuel deposits in engines. In addition, engine damage due to uncertainty in the accumulation of deposits where various forms of bio-diesel fuel are used can also be avoided and the costs of engine service due to long operation can be avoided (Agarwal and Agarwal, 2021).

1.2 Problem Statement

Detailed research on deposit formation is still lacking in information. Deposits formation in the combustion chamber were not well understood and further study is needed. This is a major prerequisite, as stated above, for dealing with deposit-related issues. The formation of deposit in the internal combustion of an engine have cause the deterioration of engine performance and diminished the drivability of the car. Example of the effect that cause by the deposits are engine stalling, increased fuel consumption, engine power restriction and reduce the engine power. Clarifying understanding of deposit formation can help to minimize the formation of engine deposits. It is also possible to solve any problems relating to the formation of deposits.

1.3 Objective

The objectives of this project are as follows:

1. To investigate deposit formation for diesel and bio-diesel fuels.
2. To analyze deposit formation between diesel and bio-diesel fuels.

1.4 Scope of Project

The scopes of this project are:

1. Record total mass deposit of diesel and bio-diesel fuels at different surface temperature with different time interval.
2. Analyze the growth percentage of diesel and bio-diesel fuels at different surface temperature.
3. Diesel and bio-diesel blends fuel namely B20 is used in this investigation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, it describes further understanding about the phenomena of deposit that will be studied. The literature review is mainly about the understanding of deposit formation that formed due to the fuel droplets in the combustion engine, bio-diesel properties, deposit mechanism, factors of deposit formation, engine problem that cause by the deposits and the preventive measure of deposit formation.

2.2 Bio-diesel Fuel

A study of characterization of the properties of palm oil bio-diesel blended fuel compared to the ASTM D7467 blended fuel standard, was made by (Ali et al., 2015). Bio-diesel fuel is a blend of mono alkyl esters of long-chain fatty acids that are saturated and unsaturated and with high density and low cold flow characteristics, compared to diesel minerals. The combination of bio-diesel fuel and mineral diesel is the most common approach to overcome low temperature flow problems in bio-diesel fuel and improve its properties because of similar features. Fuel energy levels are one of the most significant technical issues indicating the use of mixing bio-diesel fuel at a high mixing ratio since the engine power output is directly affected by the energy content of the fuel (Karmakar et al., 2010).