EXPERIMENTAL STUDY OF THE BIO-ADDITIVES IN BIODIESEL FUEL ON PERFORMANCE AND EMISSIONS CHARACTERISTICS OF DIESEL ENGINE.

SYAHRUNNIZA BIN ABD HADI

A project report submitted in partial
fulfilment of the requirements for the award of
Master Degree of Mechanical Engineering with Honors

Faculty of Mechanical and Manufacturing Engineering
Universiti Tun Hussein Onn Malaysia

JULY 2015

DEDICATION

SPECIAL GRATITUDE TO:

MY TWO PRECIOUS AND BELOVED LADIES,

My Mother ***Pn. Zaleha Bt. Alang Rapor*** and *My wife* ***Pn Shariza Bt. Sharir***

For their love, moral support and encouragement throughout my life. Not forgotten to my beloved children ***Syaidatul Irdina, Sayyidul Iqbal and Sayyidul Iqram***

MY HONOURED SUPERVISOR,

Dr. Amir bin Khalid

For his guidance, support, encouragement and understanding from the initial until the completion of my project

Mr. Ridwan Shahputra and Mr. Mohd Shukri

Person that helps me during conducting the experiment

THE ENTIRE LECTURER,

For their endorsement, kind concern and consideration during my research work

ALL MY FRIENDS,

"Geng Persisir MDM Ipoh Year 2013-2015"

For their concern, encouragement, knowledge sharing and understanding all the support, enthusiasm and sacrifice in giving me assistance and strength to complete this thesis will never be forgotten.

"May Allah S.W.T repay your kindly and hopes Allah S.W.T will always blesses our life"

ACKNOWLEDGEMENT

In the Name of Allah, the Beneficent, the Merciful

First and foremost, I am highly grateful to God Al Mighty Allah s.w.t. Also the authorities of University Tun Hussien Onn Malaysia for providing this opportunity to carry out the present of my Master Project or dissertation work.

I would like to express a deep sense of gratitude and thanks profusely to my supervisor Dr. Amir Bin Khalid for his sincere and invaluable guidance, suggestion and commitment attitude which inspired me to submit this Master project report in the present form. Not forgotten, I would like to thanks Combustion Research Group (CRG) of Automotive Lab, Faculty of Mechanical and Manufacturing Engineering especially En. Dahrum Samsudin , En Latif Lambosi and Mr Ronny Yii and also staff from Marine Polytechnic Ungku Omar Lab, En. Ridwan Shahputra who willing to shared their precious time for invaluable assistance during my experiments work.

Other than that, I would also like to thanks my family; my mother, wife and all the student from Ipoh Offshore Post Graduate Student of Continuous Education Centre (CEC) University Tun Hussein Onn Malaysia who were always inspiring me from behind and give me a moral support during a hard time.

ABSTRACT

Among the alternative fuels the Bio diesel is one the most common and familiar to all. It's biodegradable, environment friendly as well as suitable source, to meet the future energy crises. The main concern of this experimental analysis is to reach a tentative goal, how this fuel can be utilised with maximum effective way. To find this ,an experiment data analysis of different parameter such as break power, break mean effective pressure consumption, emission characteristic (NOx, HC,CO. etc.), is done through bio diesel fuel and also compared with ordinary diesel which is also known as standard diesel. Despite years of improvement attempts, the key issue in using bio based fuels is oxidation stability, stoichiometric point, bio-fuel composition, antioxidants on the degradation and much oxygen with comparing to diesel gas oil. Thus, the improvement of emission exhausted from diesel engines fuelled by biodiesel is urgently required to meet the future stringent emission regulations. This investigation is carried out through 20 HP eddy current dynamometer and load cell arrangement which is controlled by a DYNOMAX^{tm} software computer in case of finding the break power and BMEP respectively. And the emission characteristics are observed using Airrex HG-540 exhaust analysers finally the result is compared with diesel engine which is run by standard diesel. Di Methyl Poly siloxane (DMPS) additive and D20 palm oil methyl formula was used in this studies. The final result implied that the bio diesel with some additives with (CP10+DMPS Power) and (JC15+ DMPS) shows best performance and reduce the exhaust emission including CO. Thus the decision may be taken, 10% - 15% blended bio diesel with DMPS additive as a best alternative fuel considering all the view aspects and alternatives.

ABSTRAK

Dikalangan bahan api alternative, Bio Diesel adalah merupakan paling banyak yang digunakan . Ianya adalah bahan mudah diproses-balikkan dan mesra alam serta sumber asli yang terbaik bagi menangani krisis tenaga pada masa kini. Punca permasalahan utama di dalam analisa eksperimen ini adalah untuk menemui matlamat tentative utama iaitu mencapai keberkesanan penggunaan maksimum yang tebaik. Oleh yang demikian, data eksperimen menganalisa parameter seperti Kuasa brek, Penggunaan tekanan effektif secara min, karakter pencemaran (NOx, HC,CO. dan lain-lain.) dilakukan dengan Bio Diesel dan juga dibeza-tarakan dengan bahan Diesel yang asal, yang dikenali sebagai Standar Diesel. Walaupun pelbagai percubaan penambahbaikan, kunci utama isu di dalam penggunaan Bio Diesel adalah keseimbangan penyahoksida, titik stoichiometric, kandungan bahanapi Bio, anti-penyahoksida gred bahanapi dan keperluan oksigen yang berbeza dengan bahanapi gas diesel. Dengan demikian pengujian pencemaran ekzos engine diesel yang menggunakan bahanapi Bio diesel perlu ditambah baik menepati keperluan Peraturan Pencemaran yang ketat di masa hadapan. Penyiasatan didalam eksperimen ini dikawalkan menggunakan 20 HP "*eddy current dynamometer*" dan pengatur sel beban dengan perisian computer DYNOMAX^{tm} untuk mencapai data tekanan brek dan BMEP secara teratur dan berpatutan. Pencemaran pula dibuat pemerhatian menggunakan 'Airrex HG-540 exhaust analysers. Keputusan data-data tersebut digunakan selanjutnya untuk perbandingan dengan perlaksanaan Standard Diesel dimasukkan kedalam enjin Diesel Bahan api campuran atau aditip Di Methyl Poly siloxane (DMPS) dan 'D20 palm oil methyl formula' telah digunakan di dalam eksperimen ini Keputusannya menunjukan Bahan aditip atau campuran kedalam Bio Diesel jenis (B10+DMPS Power) dan (JC15+ DMPS) memberikan prestasi yang agak baik dan pencemaran yang lebih baik terutama CO. Dengan demikian pencampuran melebihi 10% - 15% Bio Diesel dijangka memberikan alternatif terbaik didalam pertimbangan semua aspek dan alternatif

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-	American society of Testing and Material
B10	-	10% biodiesel blend with 90% diesel content
B15	-	15% biodiesel blend with 85% diesel content
B20	-	20% biodiesel blend with 80% diesel content
B30	-	30% biodiesel blend with 70% diesel content
B5	-	5% biodiesel blend with 95% diesel content
BDF	-	Bio Diesel Fuel
BMEP	-	Brake mean effective pressure
BSFC	-	Brake specific fuel consumption
BTE	-	Brake thermal efficiency
CEN	-	European Committee for Standardizations
CI	-	Compression Ignition
CO	-	Carbon monoxide
CO2	-	Carbon dioxide
CPO	-	Crude palm oil
FAME	-	Fatty acid methyl ester
HC	-	Hydro carbon
J10	-	10% Jatropha biodiesel oil blends with 90% diesel
J15	-	15% Jatropha biodiesel oil blends with 85% diesel
J5	-	5% Jatropha biodiesel oil blends with 95% diesel

NOx	-	Nitrogen oxide
POME	-	Palm Oil Methyl Ester
RPM	-	Different engine speed
RPM	-	Revolution per minute
STD	-	Standard diesel fuel
WC10	-	10% waste cooking biodiesel oil blends with 90% diesel
WC15	-	15% waste cooking biodiesel oil blends with 85% diesel
WC5	-	5% waste cooking biodiesel oil blends with 95% diesel
WCO	-	Waste cooking Oil

CHAPTER 1

INTRODUCTION

1.1 Background of study

This study is about the effect of bio additives; Di Methyl Poly Siloxane Power (DMPS Power) and Palm Oil Methyl Ester (D20 Booster) performances and emissions in diesel engine fueled with Bio Diesel Fuel (BDF) i.e., Crude Palm oil, Jatropha Curcas oil and Waste Cooking oil. Furthermore, due to alternative fuels for diesel engine are becoming increasingly important because of diminishing petroleum reserves and the environmental consequences of exhaust gases from petroleum-fueled engines. Several developed countries have introduced policies encouraging the use of BDF made from grains, vegetable oil or biomass to replace part of their fossil fuel use in industries in order to prevent environmental degradation by using cleaner fuel and to reduce dependence on imported, finite fossil supplies by partially replacing them with renewable, domestic sources. The DMPS and D20 Bio-additives can remarkably improve the fuel economy of Compression Ignition (CI) engine while operating on all kinds of BDF. The power output of BDF depends on its, blend, quality, and load conditions under which the fuel consumed. Hence, the performance, combustion characteristics and emissions of diesel engine learnt under different speed and load conditions.

There are still debates in what the advantages and disadvantages of Bio-additives with BDF has to offer. (Fuel, Retrofits, & Neighborhood, 2005) (Wirawan, 2007) (Suffian, 2014)

1.1.1 The advantages of BDF with Bio-additives

i) Cost: The potential to cost less than fossil fuels (Will increase in importance, as price for fossil fuels will rise when the amount available lowers).
ii) Lower carbon emissions: When BDF burned, they produce less carbon output and fewer toxins.
iii) Renewability and availability: Unlike fossil fuels, BDF will not take long to be able 'harvest'. Moreover, are renewable due to their short time needed to grow.
iv) Economic stimulation and security: Where fossil fuels often travel thousands of miles, BDF gathered locally offering jobs for hundreds and thousands of people.

1.1.2 The disadvantages of BDF with Bio-additives

i) Lower output: BDF offer a lower energy output than fossil fuels, therefore need a larger amount for the same energy.
ii) Production Carbon Emissions: Where the burning of BDF create less carbon output and toxins, the production is a different thing. Due to nitrate, fertilizers and machinery necessary to cultivate the plants several studies have shown that they sometimes create equally or even more greenhouse gasses than the fossil fuels.
iii) Food prices and shortages (Mostly for bio-ethanol): Food prices may rise and shortages occur due to the growing demand for BDF.
iv) Water use: Massive quantities of water used for the cultivation of these plants.

The optimal ratio of DMPS power to BDF depends on the fuel used and on the different engine operating conditions. As we know Crude Palm Oil (CPO), Waste Cooking Oil (WCO) and Jatropha Curcas Oil (JCO) have potential to use as an alternative fuel that can reduce the total emission CO_2 emissions from the internal

combustion engine. While for the DMPS power and D20 Booster used in this project claimed as environment friendly, and could increase 20% - 35% power of engine. These three different types of BDF will be mixed with DMPS power with a volume that recommended by the manufacture. The performance and emission test carried out through eddy current dynamometer and emission analyzer. It expected to investigate and analyze the combustion characteristic outcome. A Small Diesel Engine used in the experiment is YANMAR TF120ML.

Many researchers and scientists have been studying the effects of Bio-additives with BDF blends on engine performance and emissions characteristics. Most of the study reported that Bio-additives could produce lower emissions than unleaded diesel on CI engines (Khalid & Osman, 2013). Although many studies only evaluated the effect of blending ratio, researches on influences of DMPS power and BDF with combustion analysis by integrated sensors like pressure transducer in the engine performance is rarely. Hence, further report on the combustion analysis generated.

In investigation of the influences of combustion characteristic P-V diagram, cumulative pressure, heat release rate and ignition delays in CI engine, three different types of BDF (CPO, WCO and Jatropha) mixed with Standard Diesel No. 2 (STD) into different blending ratios and each mixture together with Bio-additives.

1.2 Problem Statement

The use of Bio-additives has received actively attention due to increase demand for energy and strict air pollution regulation. Researchers are actively studying and developing alternative clean fuels. Among alternative fuels, BDF with Bio-additives added is very attractive and employed most generally for CI engines to lessen carbon monoxide (CO), NOx level and total hydrocarbon emissions (HC) and to reduce the depletion of petroleum fuels simultaneously.

Nowadays the cost of domestic fuel rising become more problematic directly to consumer therefore solution in better performance of engine pressure, power and fuel consumption must be studied. According to MPOB (2012), Malaysia currently accounts for 39 % of world palm oil production and 44% of world exports. However, engine fuelled by biodiesel fuels faced the problem where the fuels are not operating

efficiently due to the variant in fuel properties. In diesel engine, the relation between mixture formation during the ignition delay period and burning process in diesel combustion that strongly affects the exhaust emissions. Thus, the improvement of emissions exhausted from engines fuelled by biodiesel is urgently required to meet the future stringent emission regulations. *(Khalid, A. et, al., 2011)*

BDF blends will require more heat to vaporize than STD. Some concerns was raised about difficulty in starting vehicles using blends at extremely low temperatures. Other concerns about low temperature fuel characteristics of blends include increased viscosity of BDF blends which may impede fuel flow and also phase separation in the vehicle fuel system due to reduced solubility (Dinesh, *et. al.*, 2000).

Furthermore, a very rare studies about the effect of BDF with Bio-additives fuel with combustion analysis in an engine. In response to this problem, this study proposes to investigate the effect of combustion analysis and BDF-DMPS power and BDF-D20 Booster blends on compressed ignition engine.

1.3 Objective

The objective for this experiment are as follows:

i) Investigate the effect of Bio-additives, DMPS power and D20 Booster on performance and emissions of Diesel Engine fueled by Bio Diesel Fuel (BDF).

ii) Investigate the effect of Bio-additives, DMPS power and D20 Booster on combustion characteristic of Diesel Engine fueled by Bio Diesel Fuel (BDF).

iii) Comparative studies between Bio-additives; DMPS power and D20 Booster.

iv) Future recommendations

1.4 Scope of Study

The test is carried out through 20 hp eddy current dynamometer with a 0.638 liter engine and with the differences engine speed (800 rpm, 1200 rpm, and 1600 rpm to

2000 rpm). This research introduces three types of BDF with Bio-additives from three types of BDF such as crude palm oil based (CP5, CP10 and CP15), wastes cooking oil (WC5, WC10 and WC15) and Jatropha Curcas (JC5, JC10 and JC15) and analyzes the effects of BDF on performance and emissions of diesel engine. The fuels will be tested were commercial standard diesel no. 2 (STD) and blends of DMPS power with the BDF. The ordinary gas oil with commercial standard diesel designated as a reference standard fuel (STD). Engine used in these experiments was Yanmar Motor Diesel Engine Model TF120-ML complete with attached sensor as below:

i) Tachometer
ii) Exhaust Temperature Sensor
iii) Dynamometer
iv) Fuel Consumption Glass Gauge
v) Combustion Transducer Sensor
vi) Eddy Current Dynamometer
vii) Emission Analyzer

Each BDF type will use at the difference blending ratio. The blended rates are 5%, 10% and 15% by volume and compared with the commercial standard diesel fuel (STD). A 20 HP eddy current dynamometer with 0.638-liter CI engine and with the differences engine speed (rpm) and load. Initial load in this experiment is to be applying load from 0%, 50% and 90% with maximum rated engine speed at 2400 rpm. Effect of DMPS power on performance, emissions and combustion characteristic of Diesel Engine fueled by BDF then was tested.

1.5 Rationale and Significance

Based on the research scopes mentioned above, the following rationale and significance that to be expected to get have been outlined.

i) It shall increase performance and reduce emission level of blending BDF with Bio-additives.

ii) It shall increase the production of BDFs from vegetable oils

iii) Alternative way to produce valuable product from three type of BDF (Crude palm oil, Waste Cooking Oil and Jatropha with bio-additive)

iv) New substitute of raw material for DMPS power and D20 booster production

v) It shall reduce environmental problem as Bio-additives added BDF is environmentally friendly alternative to conventional STD fuel.

Also Important of this study is to compare the performance and emission of BDF in normal condition and BDF with Bio-additives power compare to STD. Therefore, a silicone oxygenated fuel additive DMPS Power was studied in variant conditions. Another fuel additive D20 Booster also was used in comparison using CP20 blending ratio. This is important because the comparison of both Bio-additives in the BDF could provide vital information to increases its qualities and performance when used in diesel engine fleets in the future. The data that recorded during the test may be very useful for the other studies especially in Bio-additives development.

According to (Baumgarten, 2005), a stoichiometric mixture has just enough air to completely burn the available fuel. In practice this event gradually, due primarily to the very short time available in an internal combustion engine for each combustion cycle. Most of the combustion process completes in approximately 4–5 milliseconds at an engine speed of 6000 rpm. Physical intake, engine thermodynamic, and combustion models predict ignition delay, period of pre mixture at the beginning of compression in the cylinder. The air and fuel mixture ratio has to be balance to start the combustion. Therefore, combustible ignition delay and pre-mixture period outcome from this project will provided a limitation and even benchmark for improvement. Previous experiments has indicated that extremely low emissions and high efficiencies are possible if ignition of homogeneous fuel-air mixtures is accomplished. The limitations of this approach suspected to be misfiring and knock (Pradesh, 2014).

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction of Bio-additives or Fuel Additives

McGraw-Hill Dictionary of Scientific & Technical Terms, Diesel Bio-additives is a compounds added to diesel fuels to improve performance, such as cetane number improvers, metal deactivators, corrosion inhibitors, antioxidants, rust inhibitors, and dispersants.

While fuel additives are largely associated with additives to gasoline, diesel and oil based fuels in the interest of environmental protection, curbing emissions and increasing mileage, the innovation around additives has a broader impact of being able to change, alter or enhance specific attributes of a fuel whether liquid, solid or gas. Additives have been developed to increase combustion rates, as anti-oxidants, to effect burn rates, to enable fuels to work under extreme temperatures, reduce harmful emissions and more. Over the years various hybrid compounds and blends have been engineered to create better fuels for industries, commercial use and end consumers alike.

2.2. Categories and Types of Bio-additives

According to a source wiki on autoropolis.com on the topic of fuel additives. The types of Bio-additives include oxygenates, ethers, antioxidants (stabilizers), antiknock agents, fuel dyes, metal deactivators, corrosion inhibitors and etc.

2.2.1. Oxygenates compound in Bio-additives

Oxygenates are fuels infused with oxygen. They are used to reduce the carbon monoxide emissions creating when burning fuel. Oxygenates can be based on either alcohol or ethers**.**

i). Alcohol – methanol, ethanol, isopropyl alcohol, n-butanol, and gasoline grade t-butanol

ii). Ethers – methyl tert-butyl ether, ethyl tertiary butyl ether, di isopropyl ether, tertiary amyl methyl ether, tertiary hexyl methyl ether.

2.2.2. Influences of Antioxidants in Bio-additives

Antioxidants are used as a stabilizer in fuel to prevent oxidation. Examples of some antioxidants used are:

i). Butylated hydroxytoluene

ii). 2,4-Dimethyl-6-tert-butylphenol

iii). 2,6-Di-tert-butylphenol

iv). Phenylene diamine

v). Ethylene diamine

Injector fouling tests show that multifunctional Bio-additives can reduce the injector deposit levels generated when biofuel blends are used. Specialized flow improvers are also available to address the challenging low-temperature operability profile of many biodiesel fuels, while specific antioxidants can help to stabilize the fuel against the degradation that may lead to fuel system deposits and corrosion (Trapel et al., 2005).

2.2.3. Antiknock Agents in Bio-additives

Antiknock Agents is a gasoline additive that works to reduce engine knocking while trying to increase the octane rating of the fuel. The mixture of air and gas in a traditional car engine has a problem with igniting too early and when it does, it causes a knocking noise. Some of the antiknock agents are**:**

i). Tetra-ethyl lead
ii). Methyl cyclopentadienyl manganese tricarbonyl
iii). Ferrocene
iv). Iron pentacarbonyl
v). Toluene
vi). Isooctane

2.2.4. Fuel Dyes for colouring in Bio-additives

Fuel Dyes are dyes that are added to fuels. Some countries dye a fuel that is taxed at a lower rate to identify it when used incorrectly. Untaxed are the dyed fuels and taxed fuels are clear. For example, in the United Kingdom, the fuel they use for agriculture and construction vehicles are taxed at a different rate than for fuel used for commuter vehicles. They dye this fuel red. If a vehicle is found to have this fuel in it and not being used for the express purposes that it was intended for then there is a heavy penalty involved. The most often used colours are:

i). Solvent Red 24 and 26
ii). Solvent Yellow 124
iii). Solvent Blue 35

2.2.5. Metal deactivators effects in Bio-additives

Fuel Bio-additives and lubricant Bio-additives that are used to stabilize the fuel. It works by deactivating metal ions. Metal deactivators inhibit the formation of gummy residues. An example of a metal deactivator that is often used for gasoline is N, N'-disalicylidene-1, 2-propanediamine. This compound has been approved for both military and commercial use.

2.2.6. Corrosion inhibitors effects in Bio-additives.

Corrosion chemical compounds slow down metal corrosion. A good corrosion inhibitor will give 95% inhibition in certain circumstances. Examples of some corrosion inhibitors are sodium nitrite, hexamine, and phenylenediamine.

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