UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

Performance and Emission Analysis on the Effect of Various Additives in Biodiesel/diesel blend as Engine Fuels

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PERFORMANCE AND EMISSION ANALYSIS ON THE EFFECT OF VARIOUS ADDITIVES IN BIODIESEL/DIESEL BLEND AS ENGINE FUELS

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**A report submitted
in fulfillment of the requirements for the Master of Mechanical Engineering (Energy)**

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DECLARATION

I Mohamad Riduan bin Ramli (M041820001) presented a report on the thesis entitled 'Performance and Emission Analysis on the Effect of Various Additives in Biodiesel/Diesel Blend as Engine Fuels' for my final project report in the Master by taught course to be submitted to the university. The results were completed by myself and this report was sent as part of the Master's requirements. This report has never been drawn up or submitted by any master and is not submitted simultaneously to any other master.

Signature : ....

Name : MOHAMAD RIDUAN BIN RAMLI

Date : 24/08/2020

APPROVAL

I, the supervisor of this student, confirm that I have read this thesis, that I am also here to declare the thesis in terms of scope and content as well as to meet the criteria for being recognized as a Master's degree in Mechanical Engineering.

Signature : ....

Supervisor Name : DR. MD. ISA BIN ALI

Date : 24/8/2020

DEDICATION

In the name of Allah S W.T., the most benevolent and good, I praise Allah the Lord of the Universe and thank His Prophet, Muhammad S.A.W, for Allah 's grace and peace. I thank Allah the Almighty, above all, for giving us the chance to carry out this project study. I was able to complete the final year project report with HIS blessing.

I would like to express my deepest appreciation to my lecturer, DR. MD ISA BIN ALI, for giving me a lot of brilliant advice and helping me manage my time to complete this final project. There is no word that can be said except gratitude for kindness and help. May God reward all the good works of DR. MD ISA BIN ALI. He has helped me a lot in a country that is struggling with the COVID-19 pandemic virus. Due to the very short timeframe and limitations of the situation that we were unable to meet, the time for laboratory use was very limited. But thanks to the guidance of DR. MD ISA BIN ALI, I was finally able to prepare and finalize this project report.

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ABSTRACT

Many countries have decided to realize that biodiesel is one of the most effective strategy for reducing fuel's environmental effects. Researchers in each country are looking for more effective techniques and better selection of materials to produce better biodiesel. Malaysia is also one of the leading countries in the production of biodiesel. A diversity of studies has been performed on the effectiveness of biodiesel in diesel engine. Malaysia is considered to be one of the largest palm oil producers in the Asian, and Malaysia produces a significant proportion of its biodiesel from palm oil. However, biodiesel cannot be directly used on diesel engines because biodiesel's viscosity and density are greater than pure diesel. The effects of various additives used in biodiesel are studied by most researchers in such a way that their biodiesel properties are similar to or near the properties of diesel fuels. The main aim of this study is to investigate the influence of propanol and dichloromethane as an additive in Biodiesel/diesel blend as engine fuels on engine efficiency and the effect of the combustion of biodiesel additive on environmental emissions from the blend. The additive and biodiesel physicochemical properties are carefully discussed, which are the key determinants of the consistency of the blended diesel. The determination of this research is to assess the additive capacity of mixed biodiesel and diesel fuel in accordance with additive form, mixing ratio and engine operation conditions. The research aims to determine the efficiency and emissions as a biodiesel fuel mixture of a limited proportion of propanol (5 percent by volume) and dichloromethane (5 percent by volume). The four samples were prepared and tested with a single cylinder engine. Sample A (D100) includes 100% diesel for comparison, sample B (D80POB20) diesel 80% and palm oil biodiesel 20%, sample C (D75POB20P5) diesel 75%, palm oil biodiesel 20% and propanol 5% and sample D (D75POB20DCM5) diesels 75% palm oil biodiesel 20% and dichloromethane 5%. Propanol and dichloromethane present in biodiesel blended fuel as an additives showed a lower percentage on exhaust emission of carbon monoxide, carbon dioxide, nitrogen oxide and hydrocarbon than biodiesel and pure diesel. While the engine power increase by using propanol and dichloromethane as an additive than biodiesel and decreases slightly than pure diesel and brake specific fuel consumption (BSFC) increases after use propanol and dichloromethane as an additive in Biodiesel/diesel blend as engine fuels.

ANALISIS PRESTASI DAN PELEPASAN TERHADAP KESAN PELBAGAI BAHAN TAMBAHAN DALAM BIODIESEL/DIESEL CAMPURAN SEBAGAI BAHAN API ENJIN

ABSTRAK

Banyak negara telah memutuskan untuk menyedari bahawa biodiesel adalah salah satu strategi yang paling berkesan untuk mengurangkan kesan persekitaran bahan bakar. Penyelidik di setiap negara mencari teknik yang lebih berkesan dan pemilihan bahan yang lebih baik untuk menghasilkan biodiesel yang lebih baik. Malaysia juga merupakan salah satu negara terkemuka dalam pengeluaran biodiesel. Kepelbagaian kajian telah dilakukan mengenai keberkesanan biodiesel dalam enjin diesel. Malaysia dianggap sebagai salah satu pengeluar minyak sawit terbesar di Asia, dan Malaysia menghasilkan sebahagian besar biodieselnya dari minyak sawit. Namun, biodiesel tidak dapat langsung digunakan pada mesin diesel kerana kelikatan dan ketumpatan biodiesel lebih besar daripada diesel tulen. Kesan pelbagai bahan tambahan yang digunakan dalam biodiesel dikaji oleh kebanyakan penyelidik sedemikian rupa sehingga sifat biodieselnya serupa atau hampir dengan sifat bahan bakar diesel. Matlamat utama ujikaji ini adalah untuk mengkaji kesan propanol dan diklorometana sebagai bahan tambahan dalam campuran Biodiesel / diesel sebagai bahan bakar enjin pada kecekapan enjin dan kesan pembakaran aditif biodiesel terhadap pelepasan persekitaran dari campuran tersebut. Sifat fizikokimia aditif dan biodiesel dibincangkan dengan teliti, yang merupakan penentu utama konsistensi diesel campuran. Penentuan kajian ini adalah untuk menilai kapasiti tambahan biodiesel campuran dan bahan bakar diesel sesuai dengan bentuk aditif, nisbah pencampuran dan keadaan operasi mesin. Penyelidikan ini bertujuan untuk menentukan kecekapan dan pelepasan sebagai campuran bahan bakar biodiesel dengan sebilangan propanol yang terhad (5 peratus mengikut isipadu) dan diklorometana (5 peratus mengikut isipadu). Keempat sampel itu disiapkan dan diuji dengan mesin silinder tunggal. Sampel A (D100) merangkumi diesel 100% untuk perbandingan, sampel B (D80POB20) diesel 80% dan biodiesel kelapa sawit 20%, sampel C (D75POB20P5) diesel 75%, biodiesel minyak sawit 20% dan propanol 5% dan sampel D (D75POB20DCM5) diesel 75% biodiesel minyak sawit 20% dan diklorometana 5%. Propanol dan diklorometana yang terdapat dalam bahan bakar campuran biodiesel sebagai bahan tambahan menunjukkan peratusan yang lebih rendah pada pelepasan ekzos karbon dioksida, karbon monoksida, hidrokarbon dan NOx daripada biodiesel dan diesel murni. Sementara tenaga enjin meningkat dengan menggunakan propanol dan diklorometana sebagai bahan tambahan daripada biodiesel dan menurun sedikit daripada penggunaan bahan bakar diesel tulen dan brek khusus (BSFC) meningkat apabila menggunakan propanol dan diklorometana sebagai bahan tambahan dalam campuran Biodiesel / diesel sebagai bahan bakar enjin.

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CHAPTER 1

INTRODUCTION

1.1 Background

Biodiesel was one of the source materials used to decrease the environmental impact of nitrogen oxide, carbon oxide, hydrocarbon and carbon monoxide. The term “biodiesel” and “biodiesel/diesel blend” have frequently use correspondently in renewable energy analysis, both of it have contra definition between each other. Biodiesel consists of long-chain fatty acid esters. It's a type of diesel fuel derived from plants or animals. It's normally formed by chemical reactions such as animal fat, soya oils or other vegetable oil that contains alcohol and produces a methyl, ethyl or propyl ester. Biodiesel blends can be mixed and used at different rates. B5 (up to 5% biodiesel) and B20 (6% to 20% biodiesel) are the most common used. B100 (pure biodiesel) is typically used as a blend stock for the production of lower mixtures and is seldom used as a transport fuel.

Fuel additives are compounds designed to improve the quality and efficiency of carburant that are used in motor vehicles. They increase the octane rating of a fuel and/or act as corrosion inhibitors or lubricants, allowing higher compression ratios to be used to improve power and efficiency. Fuel additives can help avoid problems like rugged idle, weak acceleration, stumbling and stagnation. For this project, a mixture of propanol and dichloromethane is used as an additive in biodiesel/blend fuel. The term “performance” and “emission analysis” have frequently use correspondently in internal combustion engine analysis, both of it have contra definition between each other. Engine performance explain clearly about characterized by the engine operating behavior in the speed–load domain, for example, the behavior of emissions, noise, fuel consumption, thermal loading and mechanical. The engine performance test was performed at various speed with load using single cylinder engine. The MRU Air Emission Monitoring system Delta 1600-V (MRU 1600-V), exhaust gas analyzer was used to test emissions analysis from the engine drainage pipe.

1.2 Problem statement

The transport network plays a main role in improving the economy of every country in the world. The energy supplies that fossil fuels, such as diesel and petrol, facing today is a key issue for the global transport sector. In overall, the average energy consumption of the transport sector greater than before by 1.0% annually due to the development of the automotive sector. It has been estimated that only the transport sector has a 64% share of the increase in global consumption of liquid fuel between 2010 and 2040 (Neveux, De Bandt, Chaumeil, & Cynober, 2002). The internal combustion engine for hydrocarbons remains the primary form of transport for decades 31% of the world's carbon emissions are actually from the transport sector (Awad et al., 2018). Different types of toxic compounds such as inorganic ions, elemental carbon, organic carbon and trace elements are found in the suspended particle emissions. These chemicals can threaten the environment and health (Erdiwansyah et al., 2019). Biodiesel is known as the most effective renewable fuel in the world. For all sectors, including light-duty vehicles, pure diesel may be replaced by biodiesel. Wide industries of vehicles, machinery, marine and remote manufacturing. But biodiesel is not suitable for low temperature applications. In the cold weather, biodiesel become gels but the temperature of the gel depends on the oil or fat it was used for production. Biodiesel can best be used in the colder months by blending it with winter diesel fuel. This article aims primarily to explore the potential of biodiesel as an another fuel with additives in the transport field. Both liquid natural mobile portage, ready availability, renewability, improved combustion capacity, aromatic content and lower sulfur, higher cetane number and biodegradability are the advantages of biodiesel as a diesel fuel. Biodiesel's primary advantages are domestic roots, minimizing reliance on imported fuels, biodegradability, high flash points and neat inherent lubricity (Demirbas, 2007). Additionally, biodiesel must be produced with a suitable additive, as biodiesel thickens at low temperatures, so it requires cold flow enhancer additives with an appropriate cold filter plug point (CFPP). Weak biodiesel oxidation stability can require increased stabilizer levels. In the presence of water, some biocide may be required to prevent the growth of algae. However, biodiesel cannot be used directly on diesel engines because some researchers have found that the viscosity and density of biodiesel is higher than pure diesel. Previous researchers have observed that by using the transesterification process the viscosity and density levels can be reduced, but they are not yet able to approach the viscosity and density of pure diesel. However, in terms of gas emission biodiesel there is a reduction in environmental impact. To overcome the problems faced, additional materials are needed to change the biodiesel structure to match the pure diesel. The propanol and dichloromethane additives are used for the purpose of this study as low viscosity and density can affect biodiesel and help in engine performance and reduce environmental pollution (Abed, Gad, El Morsi, Sayed, & Elyazeed, 2019).

1.3 Objective

The core objective of this study is to incorporate dichloromethane (DCM) and propanol as additives in biodiesel-diesel fuel mixtures. In order to achieve this objective, the following objectives were being set:

a) To improve biodiesel/diesel blend fuel properties in terms of viscosity and density by using additional 5% dichloromethane and 5% propanol as an additive.
b) To evaluate the diesel engine performance by using biodiesel/diesel blend fuel with an additive of 5% dichloromethane and 5% propanol
c) To determine the effect of biodiesel/diesel blend fuel with an additive of 5% dichloromethane and 5% propanol towards exhaust emission of the diesel engine.

1.4 Scope of project

The present study is based on the effects of different additives namely propanol and dichloromethane on combustion behavior, efficiency and exhaust emission characteristics of diesel engine output in biodiesel fuel blends. In the previous experiment, specific additives are used. In my analysis, therefore, as follows:

a) Preparing biodiesel via transesterification process
b) Preparation of blends of biodiesel, diesel and additive
c) Tested fuel sample properties
d) Conduct engine performance and emission test at various speeds start from 2200rpm, 2400rpm, 2600rpm, 2800rpm and 3000rpm
e) Performed the analysis by comparing all the result from each sample
f) The four-stroke single-cylinder engine is used for this experiment

1.5 Organization of report

This present study considers of five sections which will explain about the fields studied in this project. In the first chapter, the introduction describes the background of the research to be undertaken, the problems encountered, the objectives of the project and the scope to be demonstrated. In the second chapter, there is a need for literature to find references and to find out the reasons for the problem, as well as references to the improvements that need to be made in order for this study to produce better results than the previous one. Next chapter is the methodology used to demonstrate the method used to gather all the data needed for this project. In the fourth chapter, the data collected is included for analysis and discusses whether it meets what is planned. Finally proceed with chapter five with the conclusion as the outcomes for this analysis project.

CHAPTER 2

LITERATURE REVIEW

2.1 Biodiesel

Due to its benefits, such as regenerability, biodegradability, less environmental pollution and superior combustion performance, plant oils and animal fats biodiesel is a promising alternative to diesel fuel. Food supplies that are used for the making of biodiesel include mainly edible oils, non-edible oils, waste oils and animal fats. Consistent research is being conducted to recognize new oil resources and to reduce the use of expensive food grade oils for the production of biodiesel (Avhad & Marchetti, 2015). However, the extent to which biodiesel can help to reduce air pollution without affecting the performance of the diesel engine. Many investigators have previously agreed that biodiesel could reduce air pollution from fuel, but it still needs to be modified the biodiesel by add some additive so that its use meets the required criteria.

2.1.1 Production of biodiesel

The biggest drawback of straight vegetable oils is the viscosity that must be decreased to make them safe for engine use. It is mainly accomplished by transesterification reactions. The main features and comparisons of different vegetable oils with diesel oils are listed in Table 2.1. The fuel properties of various oils are described in Table 2.1. The table shows that the kinematic viscosity of the oil is very high and transformed into vegetable oil biodiesel for comparison to diesel. Foods including jatropha, waste cooking oil, polanges, chicken fat and rice bran oil also contain a considerably greater amount of acidity and free fatty acid (FFA) and require a two-stage acid-based biodiesel transesterification process. Vegetable oil feed stocks have a lower calorific value than petroleum diesel. Besides that, the biodiesel flash point is greater than diesel and safer than pure diesel for storage. Many properties similar to diesel are also related (Verma & Sharma, 2016).

Table 2.1 Lists the main properties of different vegetable oils (Verma & Sharma, 2016).

Oil feedstock	Density (kg/m^3) at 40°C	Viscosity cSt at 40°C	Flash point (°C)	Cloud point (°C)	Pour point (°C)	Calorific value (MJ/kg)
Petroleum diesel	820-860	3.5-5	60-80	-16 to -5	-33 to -16	42-45
Jatropha	919.5-932	35.62-51	242-274	-	2	37.01-38.73
Palm oil	880-991	39.4	252-256	-	-	-
Corn	910	34.9	277	-	-	39.5
Rice brain	913-920	35.29-43.52	280-316	4-13	-6.5 to 1	-
Soybean	891	28.07	-	-	-	-
Sun flower	922.3	33.5	-	-	-	-

Literature states that oil from vegetables cannot be used immediately in diesel engines because it has a higher viscosity which cause problems like low fuel spray atomization and less effective operation of the engine injectors. (Bhuiya, Rasul, Khan, Ashwath, & Azad, 2016). Nevertheless, certain methods could be used to manufacture biodiesel and to reduce vegetable oils viscosity. Dilution, pyrolysis, micro-emulsification, and transesterification are the available techniques. Pyrolysis is the phase in which a substance is converted by heat in the present of catalyst into another material. This is easier than other methods. Dilution is the procedure used in conjunction with diesel fuel for vegetable oils both for reduction of viscosity and for engine use. The production of micro emulsions, possible solution to the problem of higher viscosity in vegetable oils, constitutes micro emulsification. Transesterification is some successive reversible reaction between vegetable oil and alcohol with a catalyst, which is also known as alkyl esters. Triglycerides are converted into monoglycerides during the transesterification process. The transesterification cycle can be defined as the transesterification of acid catalyst, alkaline catalyst and lipase catalyst. Fig. 2.1 demonstrates the conventional process of producing biodiesel from vegetable oils. Amongst all conversion techniques is the inexpensive and effective method that is commonly used for the making of biodiesel.

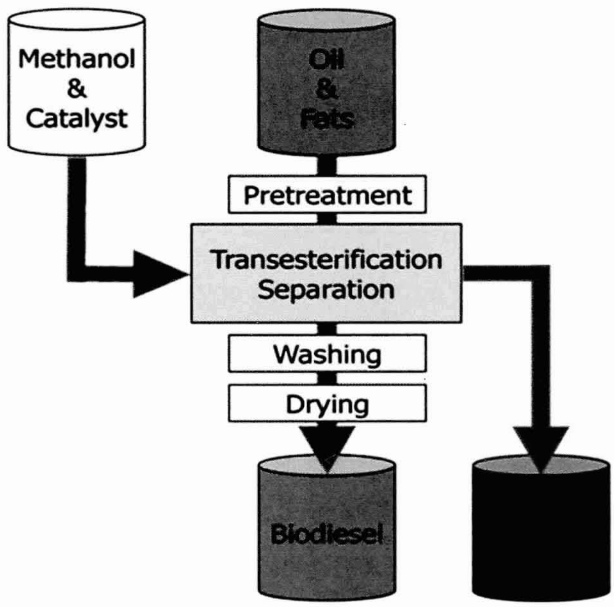

Fig. 2.1 Conventional biodiesel production cycle from raw vegetable oils (Mofijur et al., 2016).

The molar ratio is a parameter which affects the biodiesel yield. The lower alcohol / oil molar ratio will influence the conversion of triglycerides into methyl esters, whereas the higher molar ratio can be less. Polar hydroxyl methanol contributes to emulsification of glycerol and to biodiesel during the reaction. The reaction is usually reversed. i.e. recombination with glycerol and esters, reducing biodiesel yield (Verma & Sharma, 2016). It needs to be remembered that the transesterification reaction is reversible in nature and that a significant amount of alcohol is required for its operation. When methanol was rising from 11% to 31%, the maximum yield was attained at 91.6%. As the molar ratio increases, the biodiesel yield also increases, but begins to decrease after peak reaching. The literature has also found that fatty acid ethyl esters (FAEEs) have improved fuel consistency than methyl esters, but it is hard to isolate and purify them from the former (Reyero, Arzamendi, Zabala, & Gandía, 2015).

Several experiment have been carried out by previous researchers in order to produce the perfect biodiesel. Growing biodiesel generated from different feeds has different parameters for the production of biodiesel. Studies on palm oil have also been extensively conducted to determine the most suitable criteria for the production of biodiesel. Previous researcher (Issariyakul & Dalai, 2012) used homogeneous as a type of transesterification and used 1% potassium hydroxide as a type / concentration catalyst. The best temperature and stirring speed for this process was found to be at 40°C - 60°C and 600 rpm for stirring speed. The time required for this process is 30 minutes. Other researchers (Shahbazi, Khoshandam, Nasiri, & Ghazvini, 2012) who use sodium hydroxide as a catalyst type / concentration agree that the correct temperature for this method is 60°C and that the stirring process speed is 600 rpm and takes 60 minutes. Nan, Y. *et al.* (2015) using a molar ratio of 10:1 and using 0.4% potassium hydroxide as a type/concentration catalyst found that 70-110°C was the ideal temperature for this process (Nan, Liu, Lin, & Tavlarides, 2015). The biodiesel commodity should be washed another way to eliminate all sources of glycerin and impurities after transesterification process is completed. The washing method includes the boiling water on the biodiesel, which can be put in a separating beaker for 8 hours. Until a clear sample was obtained, the lower layer was continuously extracted. Biodiesel discharged into a beaker is heated to 70°C to remove the water content (Ishola et al., 2020).

2.1.2 Effect of biodiesel blends for engine performance and gas emission

Biodiesel blends as a fuel have a significant impact on the performance of diesel engines, including ignition delay, fuel spray pattern, air-fuel mixture quality, air turbulence, fuel properties and fuel injection pressure. Engine performance may also vary depending on the blend of bio-diesel used and the ratio of biodiesel blends used to test engine performance. Most researchers test the efficiency of biodiesel in terms of engine parameters, engine power, engine torque, brake specific fuel consumption, brake thermal efficiency and exhaust emissions (Wan Ghazali, Mamat, Masjuki, & Najafi, 2015).

Most researchers believe and assume that there is a decreasing in exhaust gas emission from carbon dioxide, carbon monoxide and hydrocarbons due to the inclusion of biodiesel in fossil fuels. However, there is an increase in NOx emissions (Gad et al., 2018). There is also a decrease in engine output and mechanical efficiency in the use of biodiesel in fuel. Other researcher (Hasan & Rahman, 2017) it also stated that the presence of biodiesel in the fuel blend caused the brake specific fuel consumption (BSFC) increase and most researchers agreed that, as the speed and load increase, the BSFC decreases and these residues have a negative impact on BSFC. Wan Ghazali, W. N. M. *et al.* (2015) it says that the engine power will increase with the presence of biodiesel in pure diesel, while lower heating value (LHV) will cause the engine power to decrease with diesel-biodiesel. For BSFC higher than pure diesel, this is due to lower LHV and higher biodiesel viscosity than pure diesel. BSFC biodiesel is higher than pure diesel because of its lower calorific value in biodiesel compared to pure diesel (Wan Ghazali et al., 2015).