EFFECT OF BUTANOL OXYGENATES FOR B7 DIESEL ON ENGINE PERFORMANCE AND EXHAUST EMISSION

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This report has been submitted as part of the requirements for the degree of Bachelor of Mechanical Engineering

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DECLARATION

I declare that this project report entitled “Effect of Butanol Oxygenates for B7 Diesel on Engine Performance and Exhaust Emission” is the result of my own work except as cited in the references

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Date : 20 JUN 2021

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 (Maintenance)

Signature : .....

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DEDICATION

Dengan nama Allah yang Maha Pemurah lagi Maha Pengasih.

To my beloved mother, father, and me.

ABSTRACT

The depletion of fossil fuel resources, along with stringent pollution regulations, has fueled the hunt for more excellent diesel engine performance and cleaner combustion. Using biodiesel/diesel/butanol blend is one of the most significant ways to address these concerns. Throughout this research, the impacts of biodiesel/diesel/butanol additives on the performance and emissions of diesel engines were thoroughly examined. Under varied load circumstances and at an engine speed of 1800 rpm-2200 rpm, the combustion performance and emission parameters of a diesel engine fuelled by butanol/diesel/biodiesel mixes were experimentally examined. Blending with butanol enhanced the evaporation and atomization properties of biodiesel and changed the combustion characteristics of the mixed fuels. The ignition delay of tested fuels increased as the butanol ratio increased. However, when engine loads surpassed 0.38 MPa brake means adequate pressure, the combustion time would decrease as the butanol ratio increased (BMEP). Butanol/diesel/biodiesel blends increased HC emissions under all engine load settings while reducing CO emissions except at 0.13 MPa BMEP for controlled gaseous pollutants. By mixing butanol at moderate and high engine loads, NO_x emissions were considerably enhanced. In particulate matter (PM) emission, the peak number concentration of particles smaller than 10 nm rose, whereas bigger particles fell progressively as the butanol ratio increased.

ABSTRAK

Kekurangan sumber bahan bakar fosil, bersama dengan peningkatan pencemaran yang teruk, telah mendorong pencarian prestasi enjin diesel yang lebih tinggi dan pembakaran yang lebih bersih. Menggunakan campuran biodiesel/diesel/butanol adalah salah satu kaedah terbaik untuk mengatasi masalah ini. Sepanjang penyelidikan ini, kesan campuran biodiesel/diesel/butanol terhadap prestasi dan pelepasan enjin diesel diperiksa secara menyeluruh. Dengan menggunakan beban yang berlainan dan pada kecepatan mesin 1800 rpm, prestasi pembakaran dan parameter pelepasan mesin diesel yang didorong oleh campuran butanol / diesel / biodiesel diperiksa secara mendalam. Campuran dengan butanol meningkatkan sifat penyejatan dan atomisasi biodiesel dan mengubah ciri pembakaran bahan bakar campuran. Kelewatan pencucuhan bahan api yang diuji meningkat apabila nisbah butanol meningkat. Namun, ketika beban mesin melepasi 0.38 MPa brek berarti tekanan efektif (BMEP), waktu pembakaran akan berkurang ketika nisbah butanol meningkat. Campuran butanol/diesel/biodiesel meningkatkan pelepasan HC di bawah semua tetapan beban enjin sambil menurunkan pelepasan CO kecuali pada 0.13 MPa BMEP untuk pencemaran gas terkawal. Dengan mencampurkan butanol pada beban enjin sederhana dan tinggi, pelepasan NO_x ditingkatkan. Dari segi pelepasan partikulat (PM), kepekatan bilangan puncak zarah yang lebih kecil daripada 10 nm meningkat, sedangkan zarah yang lebih besar jatuh secara progresif ketika nisbah butanol meningkat.

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LIST OF ABBREVIATIONS

PM	Particulate matter
NO_x	Nitrogen Oxide
CO	Carbon monoxide
HC	Hydrocarbon
SO_x	Sulphur oxide
BSFC	Brake specific fuel consumption
BTE	Brake thermal efficiency
CN	Cetane number
CV	Calorific value
OC	Oxygen content
CI	Compression ignition
BioD	Biodiesel

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Biodiesel is considered an alternative fuel equivalent to being traditional or 'fossil' diesel fuel and may be made from animal oil/fat, vegetable oil, waste cooking oil, and grease. Biodiesels are now a reality, drawing enormous recognition from the academy, community, and the industry. Several reasons contribute to this, but the most important ones are the market fluctuations of fossil fuels, the quest for lower emissions, and even the different alternatives for producing electricity.

Various biodiesel has been researched for the transport sector, including the automotive industry. This biodiesel can be extracted from renewable feedstock and not from fossil feedstock, as in petrol or diesel fuels. Ethanol and methanol are examples of alcohols that are most commonly used as biodiesel and widely known oxygenates. The soaring use of heavy and long-distance transportations on the road has caused alarming emissions onto the surrounding environment, especially the air quality. Since transportation such as a lorry or any other heavy and long-distance transportations are important to carry the byproduct of industry, they use a considerable amount of fossil fuel that produced the black smokes contain particulate matter (PM) which will cause a lot of airborne diseases.

Many studies have come out with identical chemical and physical properties of diesel fuel and biodiesel. Biodiesel has certain benefits compared to diesel fuel. Examples of the benefit include a high cetane number (CN), nearly no aromatics nor sulphur, and 10–11% oxygen by weight. These diesel fuel properties tend to minimize concentrations of PM, nitrogen oxides (NO_x), hydrocarbon (HC), and carbon monoxide (CO), similar to jet fuel.

However, biodiesel's effect impedes its usage as a total substitute for diesel fuel, such as kinematic viscosity and density at a high rate, including low calorific value. From that information, scientists and investigators have researched biodiesel mixing with diesel by adjusting the amount of biodiesel and diesel to examine their compatibility as fuel in current diesel engines (Hasan, M. M., 2017). Research claims that issues associated with biodiesel could be solved with the use of biodiesel-diesel mixtures. They found improved thermal performance and decreased PM, HC, CO, and NO_x emissions.

Ethanol has already been developed in some countries as an alternative fuel with several fuel benefits, especially engine performance and efficiency. And also, although not recognized by many, butanol could serve efficiently as green fuel for internal combustion engines due to its several benefits. Biomass-based green fuel also could be achieved and generated using fermentation of biomass feedstock. 1-butanol (or n-butanol), isobutanol and tert-butanol used to be fuel additives.

Among the list, n-butanol is the best option due to its effectiveness which is easily blended with diesel/biodiesel. It may also become a further alternative for diesel blending due to a higher oxygen content (OC) difference to biodiesel, possibly lead to a decrease in emissions, primarily soot. Butanol serves more evaporation heat than ethanol, thus reducing combustion temperature and may lead to a reduction in NO_x formation. As a result, despite

ethanol advantages to the engine performance and efficiency, n-butanol may have some additional benefits as biodiesel compared to other bio-alcohols such as ethanol.

Compared to ethanol, butanol has a higher heating value. A higher heating value means more power can be generated because butanol can withstand higher temperatures than ethanol. Butanol also has lower viscosity properties than ethanol. Lower viscosity is better because the engine will not easily clog, especially for a country with seasonal weather

1.2 Problem Statement

In its tidy or mixed type with petrodiesel, Biodiesel is generally known as a substitute fuel for diesel engines. Due to the possibility of biodiesel being correlated with lower PM, CO_2, and HC emissions, disadvantages occurred, including higher NO_x emission, lower heating value, lower volatility, and higher viscosity. Thus, to overcome these deficiencies and conform to rigorous environmental requirements, diesel/biodiesel additives have increasingly gained further interest due to their potential to boost engine efficiency and reduce dangerous pollution. Although careful pollution analysis can provide valuable knowledge on the environmental causes output of various fuel additives, decisions on this outcome may become quite complicated and challenging, as different fuel additives will have distinct pros and cons outcomes on contaminants produced along with the combustion phase.

Besides, several previous reports also concluded that while the biodiesel fuel engines that emit particulate are far lower than in oil, the NO_x emissions are rising dramatically. Adjusting the ignition delay in the pre-mixed combustion process, higher fuel burn rate, advanced combustion start, heat transfer radiation depletes, and the various adiabatic flame temperature is primarily in charge for the development of NO_x and from some more pollutants.

Consequently, additives of fuels can have a significant key to play in counteracting specific problems and achieving various defined standards

1.3 Objectives

The objectives to achieve for this project are:

a) To study the properties of butanol as oxygenated fuel additives for diesel/biodiesel blends.
b) To investigate the effect of diesel/biodiesel/butanol on engine performance and exhaust emissions.
c) To propose the near-optimal blend ratio of diesel/biodiesel/butanol for cleaner diesel blends design.

1.4 Scope of Project

This research covers the use of butanol as oxygenated fuel additives for diesel/biodiesel blends in proposing a near-optimal blend ratio of diesel/biodiesel/butanol.

Table 1.1: Summary of research objectives and their scopes

Obj. No.	Research Objectives	Research Scopes
1	To study the properties of butanol as oxygenated fuel additives for diesel/biodiesel blends.	Butanol as an oxygenated fuel additive with its advantages and how its physiochemical properties influence the effectiveness of the B7 diesel/biodiesel blend that will contribute to the improvement of engine performance and exhaust emissions

2	To investigate the effect of diesel/biodiesel/butanol on engine performance and exhaust emissions	Butanol is considered the best prospect for fuel additives because of its physicochemical properties: the high degree of latent heat of evaporation, high burning rate, and especially oxygenated additives. The performance of the engine can improve significantly with the help of oxygenated additives. It also provides the solution for reducing the exhaust emission from industries because butanol is produced from various sources of biomass
3	To propose the near-optimal blend ratio of diesel/biodiesel/butanol for cleaner diesel blends design.	By experimenting with different ratio of diesel/biodiesel/butanol, we can obtain an optimal ratio of fuel blend for cleaner exhaust emission

1.5 Research Framework

This thesis is separated into five chapters: an introduction, literature review, methodology, result, and conclusion. Chapter 1 depicts the introduction, problem statement, objective, scope of the study, and report structure. Chapter 2 provides a literature review of the study which highlight theories, process, and some earlier research related to this study. Chapter 3 will discuss the method used in this research. The research on butanol as an oxygenated fuel additive for B7 diesel is explained in this chapter. Chapter 4 is about the result of butanol as an oxygenated fuel additive agent and resulted in NO_x and CO_2 exhaust emissions. Chapter 5 discusses the conclusion of the research and provides some potential future work to be going.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Cleaner fuel output has been commonly used in the world. The increased popularity of the usage of cleaner diesel is attributed to the fact that experts are conscious of the dangers of particulate matter (PM), carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x) and even sulphur oxides (SO_x) from cars to the atmosphere and human health (Mofijur et al., 2016). Numerous researchers have concentrated on seeking more effective ways to eliminate harmful pollution. The government has also begun to increase support for researchers to discover more alternate fuels than the common usage of fossil fuels because it is a non-renewable resource. The use of biodiesel/diesel blends would increase engine efficiency and pollution from heavy and long-distance transport. Also, engine efficiency and pollution from these blends rely on fuel composition, engine construction, and operating conditions.

Authors	Key Objectives	Methodology	Key Research Findings
(Giakoumis E. G., 2013)	To study the exhaust emission of diesel engines produced under transient conditions such as against acceleration, loads, and others	The exhaust emission data produced by diesel engines were collected and identified regarding significant aspects of the transient operation and differentiating the properties of alcohol concerning diesel oil used.	The particulate matter (PM) is decreasing by using different alcohols such as ethanol and butanol. As for NO_x emissions, the decreasing and increasing of NO_x is affected by specific alcohol percentage and temperature.
(Bannikov, M. & Gillani, 2015)	To compare and analyze the performance and emissions of diesel engine affected by alcohols blending and fumigation	Acting as a supplementary fuel, ethanol and butanol are added into diesel engines with different techniques such as dual injection, blending, and fumigation	Based on the research, the blending process of ethanol and butanol were significantly decreased PM, NO_x, and CO emission while a slight increase in HC produced. As for fumigation, reduction in NO_x emission depends on the engine loads and PM emission, decreasing at all engine loads.
(Khalife E. & Tabatabaei M., 2017)	To review the effects of biodiesel/diesel additives on the performance and emission of diesel engines	Additives are added into diesel engines such as oxygenates additives, metallic and non-metallic based additives, water, antioxidants, and	The impacts of oxygenated fuel additives such as alcohols help reduce PM emissions and negatively increase the NO_x and CO emissions

		polymeric based additives	produced. Besides, using water in the form of emulsion significantly improves engine performance compared with other additives. The use of antioxidants will only increase CO emission produce and does not significantly affect engine performance and emission.
(Xue, J., Grift, T. E., & Hansen, A. C., 2011)	To analyze the effect of biodiesel on engine power, economy, durability, and emissions	Biodiesel is used in conventional diesel engines without modification	The lower heating value of biodiesel compared to diesel will reduce the engine power although biodiesel has no significant impact on engine power. As biodiesel has lower soot formation and inherent lubricity compared to diesel, thus it will help to improve the durability of the engine. Lastly, the PM emission produced by biodiesel significantly reduced compared to diesel because of the higher cetane number and oxygen contents

(Hasan, M. M., & Rahman, M. M., 2017)	To study the emission characteristic, engine performance, and properties of diesel/biodiesel blends employed in CI engines	CI engines employed with biodiesel/diesel blends	The diesel/biodiesel blends in CI engines lead to the vast elimination of HC, CO, and PM emissions despite producing a higher NOx emission than diesel fuel. As for engine performance, the engine performance made almost the same as using diesel.
(Verma, P., Stevanovic, S., & Ristovski, Z. D., 2019).	To study alternative fuels such as biodiesel, alcohols, and oxygenated additives on PM emissions from diesel engines.		Oxygenated additives such as n-butanol have the best characteristic in reducing PM emission because of theirs highest oxygen contents.
(Singh, R., Singh, S., & Kumar, M., 2020).	To determine the properties of eucalyptus biodiesel and compared with standard diesel whereby n-butanol as an additive	The preparation of n-butanol as an additive and eucalyptus biodiesel-diesel blends in diesel engine	Based on the research, diesel has a lower viscosity and density than biodiesel obtained from eucalyptus oil and blends. The decrease of HC and CO does not affect the decreasing NOx, as the NOx emission increases. So, the addition of n-butanol in eucalyptus biodiesel-

			diesel blends will lower the NO_x emission produced
(Chang, Y. C., Lee, W. J., & Chen, S. J., 2014)	To investigate the use of water-containing ABE (acetone-butanol-ethanol) solution as a biodiesel-diesel blend additive to lower NO_x emissions from diesel engines	ABE as a biodiesel/diesel blend additive is added into the diesel engine to collect data.	Despite both biodiesel-diesel blends and ABE-biodiesel-diesel solution, improve the reduction of PM emission but still for NO_x, resulting in higher emissions.