# EFFECT OF B20 AND B30 PALM OIL BIODIESEL ON PERFORMANCE AND EXHAUST EMISSION OF A DIESEL ENGINE

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

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# Faculty of Mechanical and Manufacturing Engineering Technology

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**A thesis submitted**
**in fulfillment of the requirements for the degree of**
**Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours**



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**2023**

**DECLARATION**

I declare that this thesis research project entitled " Effect of B20 and B30 palm-oil biodiesel on performance and exhaust emissions of a diesel engine" is the result of my own research except as cited in the references. The research project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : syariz

Name : Muhamad Syariz Syazwan Bin Amran.

Date : 11/1/2023

**APPROVAL**

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

Signature : Taufik

Supervisor Name : Dr. Mohd Taufik Bin Taib

Date :

## DEDICATION

This report is dedicated to my beloved family in particular, for their endless love, support and encouragement. To my supervisor DR. MOHD TAUFIK BIN TAIB who has guided me along the way to finish this project. Thank you for all your support, and give me strength untill this project is finished.

## ABSTRACT

Most palm oil manufacturers, such as Indonesia and Malaysia (which contribute 80–85% of global capacity), have substantially invested in developing multiple techniques to convert palm oil,  into biodiesel. Palm biodiesel output has also grown in comparison to petro-diesel. More appealing since, based on present practices in the Malaysian palm oil business, it has the potential to reduce GHG emissions by 50–70%. Differences of various biodiesel feedstock such as palm oil will generate differences in engine performance and exhaust emissions. The purpose of this study is to clarify the exhaust gas emission and engine performance produced from B20 and B30 palm oil biodiesel-diesel blends fuel in a fuel injection single-cylinder diesel engine by 3 different loads. The transesterificationprocess has been used to produce palm oil biodiesel-diesel blend fuel. The engine being coupled to an engine dynamometer to measure the engine performance parameters and a gas analyzer to measure the exhaust emissions from the engine. An engine run has been done by using D100, B20 and B30 to inspect the condition of the engine and to evaluate the data of engine performances and exhaust emissions. The result indicates that B20 and B30 biodiesel fuel was the optimum blend that had improved the engine performances and reduced the exhaust emissions without making any modifications to the direct-injection diesel engine. B20 biodiesel produced highest horsepower and torque even it consumed highest volume of fuel to travel. Other than that, B30 biodiesel emitted the lowest exhaust emissions except for Nitogen Oxide and Carbon Dioxide. Biodiesel fuel can be clarified as an effective solution to reduce greenhouse effect that produced from burning of fossil fuel.

# ***ABSTRAK***

Kebanyakan pengeluar minyak sawit, seperti Indonesia dan Malaysia (yang menyumbang 80–85% daripada kapasiti global), telah banyak melabur dalam membangunkan pelbagai teknik untuk menukar minyak sawit, kepada biodiesel. Pengeluaran biodiesel sawit juga telah berkembang berbanding petro-diesel. Lebih menarik kerana, berdasarkan amalan semasa dalam perniagaan minyak sawit Malaysia, ia berpotensi untuk mengurangkan pelepasan GHG sebanyak 50–70%. Perbezaan pelbagai bahan mentah biodiesel seperti minyak sawit akan menghasilkan perbezaan dalam prestasi enjin dan pelepasan ekzos. Tujuan kajian ini adalah untuk menjelaskan pelepasan gas ekzos dan prestasi enjin yang dihasilkan daripada biodiesel-diesel minyak sawit B20 dan B30 campuran bahan api dalam enjin diesel satu silinder suntikan bahan api dengan 3 beban berbeza. Proses transesterifikasi telah digunakan untuk menghasilkan bahan api campuran biodiesel-diesel minyak sawit. Enjin digandingkan dengan dinamometer enjin untuk mengukur parameter prestasi enjin dan penganalisis gas untuk mengukur pelepasan ekzos daripada enjin. Pengoperasian enjin telah dilakukan dengan menggunakan D100, B20 dan B30 untuk memeriksa keadaan enjin dan menilai data prestasi enjin dan pelepasan ekzos. Hasilnya menunjukkan bahawa bahan api biodiesel B20 dan B30 adalah campuran optimum yang telah meningkatkan prestasi enjin dan mengurangkan pelepasan ekzos tanpa membuat sebarang pengubahsuaian pada enjin diesel suntikan terus. Biodiesel B20 menghasilkan kuasa kuda dan daya kilas tertinggi walaupun ia menggunakan isipadu bahan api tertinggi untuk bergerak. Selain itu, biodiesel B30 mengeluarkan pelepasan ekzos terendah kecuali Nitogen Oxide dan Karbon Dioksida. Bahan api biodiesel boleh dijelaskan sebagai penyelesaian yang berkesan untuk mengurangkan kesan rumah hijau yang dihasilkan daripada pembakaran bahan api fosil.

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# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

## LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| $CO_2$ | - | Carbon dioxide |
| $C_O$ | - | Carbon monoxide |
| HC | - | Hydrocarbon |
| NOx | - | Nitrogen oxides |
| $D_2$ | - | Pure diesel |
| B20 | - | 20 percent palm oil biodiesel, 80 percent pure diesel |
| B30 | - | 30 percent palm oil biodiesel, 70 percent pure diesel |
| WCO | - | Waste cooking-oil |
| PO | -- | Palm oil |

## LIST OF APPENDICES

## CHAPTER 1

## INTRODUCTION

### 1.1 Background

Due to the expensive cost of raw vegetable oils, biodiesel was created from non-edible vegetable oils, quickly becoming an environmentally benign alternative to diesel. The research goal was to identify suitable alternatives to petroleum oil, and biodiesel is today one of the finest options (Abed et al., 2018).

Biodiesel usage and studies on biodiesel-diesel fuel blends have been conducted to solve the problem of fossil fuel depletion and its environmental effect. Biodiesel is a fuel made by transesterifying animal fats or vegetable oil. (Gad et al., 2018). Due to the geographic issue, each area now prefers to use various sources, such as soybean oil in the US, Brazil, and Argentina, rapeseed oil in the European Union, and palm oil in most Asian countries. Several studies have shown that palm oil as a main raw material is economically viable. In the EU, for example, Malaysian palm biodiesel is still quite inexpensive. Meanwhile, other research has found that Malaysian palm oil can compete with the price of Middle Eastern oil crops cultivated domestically (Zahan & Kano, 2018).



Although palm oil is native to West Africa, it has been cultivated during the late twentieth century in Southeast Asia. During the middle of the 15th century, European explorers to West Africa relied on palm oil as a food supply. Palm oil was in massive demand for candle making and machine lubrication during the 18th century's British Industrial Revolution. (Zahan & Kano, 2018).

Most palm oil manufacturers, such as Indonesia and Malaysia (which contribute 80–85% of global capacity), have substantially invested in developing multiple techniques to convert palm oil, by-products, and mill effluent into biodiesel. Since the 1980s, Malaysia's Malaysian Palm Oil Board (MPOB) has been at the forefront of palm-biodiesel research and development. The MPOB has accomplished its goal. Many techniques for producing methyl esters for biodiesel from crude palm oil (CPO) and its by-products have been developed. Palm-biodiesel output has also grown in comparison to petro-diesel. More appealing since, based on present practices in the Malaysian palm oil business, it has the potential to reduce GHG emissions by 50–70%.(Zahan & Kano, 2018).

Due to an increase in oil palm farms in Indonesia, the production of palm oil biodiesel is in doubt, prompting concerns about the environmental effect.. Land conversion to oil palm plantations has additional environmental effects, such as greenhouse gas (GHG) emissions from changes in soil carbon stocks and biomass, forest fires, air pollution emissions, biodiversity losses and animal, plant, and species losses in forest ecosystems. As a consequence, a life cycle assessment (LCA) is needed to assess the environmental impact of palm oil biodiesel production. Most palm oil biodiesel LCA studies concentrate on just one factor: greenhouse gas emissions. When it comes to palm oil production, one company conducted life cycle assessments (LCAs) that included global warming, ozone depletion, acidification, eutrophication and photochemical smog, as well as land use, biodiversity and land change. However, study participants were restricted to the mid-level, and results were evaluated at the endpoint level alone (Wahyono et al., 2020).

## 1.2 Problem Statement

As the price of crude oil grows day by day, more people are converting to biodiesel to save money and lessen their dependency on fossil fuels. (Nayak et al., 2022).The combustion process happened in the chamber for biodiesel-diesel blends has produced torque to the engine and smoke through the exhaust system. The combustion process causes a number of issues.:

- Differences of various biodiesel feedstock used affect the characterization of biodiesel.

- Palm oil as biodiesel feedstock will generate differences in engine performance

- Palm oil as biodiesel feedstock will generate different exhaust emissions by the gas analyser

As a result, the goal of this research is to demonstrate and clarify that biodiesel is a compatible alternatives of diesel derived from fossil fuel.

## 1.3 Objective

The purpose of this study is to:

1. Produced biodiesel using the transesterification process

2. Analyse the diesel engine performance of B20 and B30 biodiesel

3. To investigate the exhaust emissions of B20 and B30 biodiesel

## 1.4 Scope of Research

1. Biodiesel manufacturing using palm oil as a feedstock
2. Engine performance test, horse power, torque and brake specific fuel consumption.
3. Exhaust emission, $CO_2$, CO, HC, and $NO_x$ by gas analyzer

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter presents how palm oil (PO) was used as a biodiesel feedstock. Fuel properties of biodiesel, various feedstocks, and the applications of their compression ignition (CI) engines are summarised to choose the best various type of biodiesels blending feedstock. In this study, two biodiesel blends (B20 and B30) were utilised to measure engine performance such as brake power (BP), torque (BT), brake specific fuel consumption (BSFC), and brake thermal efficiency (BTE). In addition, emission tests on diesel-biodiesel blends (B20 and B30) were performed to evaluate the result of each blends on the engine exhaust emissions when using biodiesel.

## 2.2 Feedstock for biodiesel production.

Biodiesel is considered as one of the possible alternate sources of renewable energy that can be found in a variety of forms in nearly every country (Verma et al., 2021). Biodiesel is easy to use, biodegradable, nontoxic, and virtually sulphur and aromatic-free (Nayak et al., 2022). Vegetable oil, waste animal fats, waste cooking oil, and palm oil are the most commonly used feedstock sources found in the literature. Biodiesel is classified into three generations depends on the kind of feedstock. An evaluation of the potential for use as a fossil fuel alternative for several generations of biodiesel and their feedstocks will be presented in this section. Biodiesel's first generation was produced from sugarcane, food crops, and vegetable oil among other sources. Many researchers have used edible oilseeds as a raw material for biodiesel manufacturing, while wheat and sugar go together frequently used as a feedstock for ethanol production. Even though biodiesel of the first generation is primarily made from food crops, rising demand for biofuels as a result of which, the number of crops diverted from the food market, resulting in a rise in global food prices in recent years. On the other hand, organic waste, non-edible seeds, timber, waste food crops, and other non-edible materials are being used to make second-generation biofuel. They are not in competition with food crops and do not require clearing land; these are being considered as a possible substitute for conventional edible food crops. Finally, algae is the principal source of third-generation biofuel. Alternative generating feedstock must be selected, which in most cases is based on the region's domestic birthplace. Feedstocks for biodiesel and the parameters of their blends will affect the overall performance, combustion, and emission characteristics of CI engines in some way. CI engine performance was unaffected by the first, second, or third generation biodiesel-diesel mixes, and the exhaust gas emissions from these engines were less dangerous than those from diesel fuel, according to the research findings. (Verma et al., 2021).

### 2.2.1 Waste cooking oils

Waste cooking oil has a lower utilisation rate than first-generation feedstocks, making it a better biodiesel production feedstock. WCO is also a more cost-effective feedstock than jatropha, karanja, mahua, algae, and other second- and third-generation feedstocks. Because of the frying process, WCO has distinct physicochemical properties than parent vegetable oils. In the process of oxidation and hydrolysis, the cooking process alters physicochemical qualities.. These reactions raise the moisture and free fatty acids of the WCO in comparison to raw oil, resulting in soap creation in the biodiesel synthesis process. Engine wear is also caused by WCO with a high FFA level (Singh et al., 2021a). So the Mineral acids were used to treat raw WCO (Sulfuric Acid ($HSO_4$), Hydrochloric Acid (HCl), and Phosphoric Acid ( $H_3PO_4$)) in an esterification process to reduce its free fatty acid (FFA) concentration, which determines the acid value (AV). The oil was treated in two phases with $H_2SO_4$ to minimise the FFA in the WCO. AV was lowered from 3.9 to 1.45 mg KOH/g in the first step and then to 0.34 mg KOH/g in the second. WCO was then transformed into biodiesel via a transesterification method (Razzaq et al., 2020). The future will require the use of waste oil created by various food processing businesses. The majority of waste oils come from edible oils that have been fried or cooked. Figure 2.1 depicts the percentage contribution of various oils used in the manufacturing of biodiesel. It is possible that the cost of making biodiesel might be reduced, since feedstock expenses account for around 70–80 percent of the total production costs. If waste cooking oil (WCO) is utilised as a feedstock, 60–70% can be saved (Singh et al., 2021a).



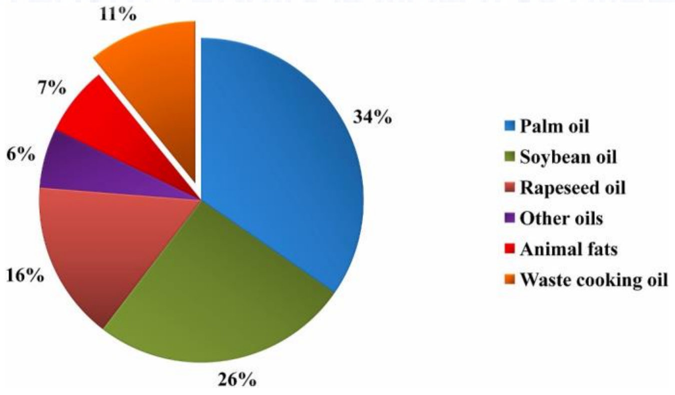


Figure 2.1 Different oils' percentage participation in biodiesel production

(Singh et al., 2021a).