PHYSICAL AND COMBUSTION CHARACTERISTICS OF RICE BRAN OIL BIODIESEL IN AN OIL BURNER

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requirements for the award of the degree of
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Specially dedicated to
my loving and caring father
"Dr. Karam Hussain Shaikh",
mother, siblings, friends
And my supervisor
Prof. Dr. Mohammad Nazri Mohd. Ja'afar.

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ABSTRACT

The concept of biodiesel as an alternative fuel is not an overnight thought, but high prices, pungent gas emissions and non-ecological behaviour of fossil fuels has constrained the researchers to take the step. Biodiesels which are renewable in nature and having environmental friendly attitude have shown the potential to be the perfect replacement for the diesel fuels. Similarly, this study demonstrates the characteristics of Rice Bran Oil (RBO) which can be used as a latent substitute for diesel products. RBO is the vegetable oil, which is extracted from the rice bran (by-product of rice grain). As the rice is the steeple diet for more than half of the population of the world, the quantity of RBO that can be extracted is enormous. In this study, RBO is converted to the biodiesel first and then it is blended with diesel to produce B5, B15 and B25 to study the physio-chemical properties and exhaust emissions. Conversion of RBO into biodiesel is compared by altering the amount of different catalysts i.e. KOH and NaOH. At catalyst amount of 1% (w/w to crude RBO), KOH converts 5.55% more RBOBD than NaOH thus keeping other parameters i.e. methanol amount, reaction time and reaction temperature constant. Owing to highly packed molecules of RBOBD, the properties such as density, specific gravity, viscosity and surface tension are higher in RBOBD blends than diesel. In contrast, calorific value is lower. In combustion test, the highest wall temperature is achieved at stoichiometric fuel mixture, while among the fuels, the wall temperature gets lower as biodiesel proportion increases in diesel. Moreover, in B25, emissions such as CO and SO_2 are 68% and 50% lower than diesel respectively. However, due to the additional oxygen present in the biodiesel structure, NO_x emission of B25 is 15.668% higher than CDF.

ABSTRAK

Konsep biodiesel sebagai bahan api alternatif bukan sesuatu yang difikirkan semalaman, namun disebabkan harga bahan api yang tinggi, pembebasan gas pencemaran dan sifat bahan api yang tidak mesra alam telah memaksa para penyelidik mengambil langkah menggunakan biodiesel. Biodiesel merupakan bahan api semulajadi yang boleh diperbaharui dan mesra alam telah menunjukkan potensi yang sesuai sebagai pengganti kepada minyak diesel. Minyak dari Dedak Padi (MDP) adalah minyak sayuran, yang di ekstrak dari dedak padi iaitu produk daripada butiran beras. Memandangkan beras merupakan sumber diet kepada separuh daripada populasi penduduk dunia, MDP dapat diekstrak dalam sumber yang banyak. Dalam kajian ini, MDP ditukar kepada biodiesel dan dicampur dengan minyak diesel untuk menghasilkan campuran biodiesel B5, B15 dan B25 bagi mengkaji sifat fizikal, kimia dan gas emisi pembakaran. Pertukaran MDP kepada biodiesel dibandingkan dengan cara mengubah jumlah pemangkin yang digunakan, iaitu Kalium Peroksida (KOH) dan Natrium Peroksida (NaOH). Pada jumlah pemangkin sebanyak 1% (nisbah berat pemangkin kepada berat MDP), KOH berjaya menukarkan 5.55% lebih banyak biodiesel berbanding NaOH, dengan mengekalkan jumlah metanol, masa tindak balas dan suhu tindak balas. Disebabkan kandungan MDP terdiri daripada struktur molekul yang padat, sifat-sifat yang terdapat pada MDP biodiesel iaitu ketumpatan, graviti tentu, kelikatan dan tekanan permukaan minyak adalah lebih tinggi berbanding minyak diesel. Namun, nilai kalori MDP biodiesel adalah lebih rendah. Dari segi ujian pembakaran, suhu dinding kebuk pembakaran yang paling tinggi diperolehi semasa campuran minyak dan udara adalah stoikiometri, manakala peningkatan campuran MDP dalam minyak diesel menyebabkan penurunan kepada suhu dinding kebuk pembakaran. Selain itu, pada MDP biodiesel B25, penghasilan gas emisi pembakaran seperti CO dan SO_2 adalah 68% dan 50% lebih rendah berbanding minyak diesel. Disebabkan faktor kandungan oksigen lebih tinggi dalam struktur biodiesel, gas emisi NO_x dalam biodiesel B25 adalah 15.668% lebih tinggi daripada minyak diesel.

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AFR	-	Air Fuel Ratio
ASTM	-	American Society for Testing & Materials
B5	-	5% Rice Bran Oil Biodiesel and 95% Diesel
B15	-	15% Rice Bran Oil Biodiesel and 85% Diesel
B25	-	25% Rice Bran Oil Biodiesel and 75% Diesel
BSFC	-	Brake Specific Fuel Consumption
CDF	-	Conventional Diesel Fuel
CH_3OH	-	Methanol
C_3H_8	-	Propane
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
EMF	-	Electromagnetic Force
EGT	-	Exhaust Gas Temperature
FAME	-	Fatty Acid Methyl Ester
FFA	-	Free Fatty Acids
H_2O	-	Water
H_2SO_4	-	Sulphuric Acid
HC	-	Hydrocarbon
HCl	-	Hydrochloride
HHVs	-	Higher Heating Values
KOH	-	Potassium Hydroxide
N_2	-	Nitrogen
N_2O	-	Nitrous Oxide
NaOH	-	Sodium Hydroxide
$NaOCH_3$	-	Sodium Methoxide
$NaOCH_2CH_3$	-	Sodium Ethoxide
NO	-	Nitrous Oxide

NO_2	-	Nitrogen Dioxide
NO_x	-	Nitrogen Oxides
O_2	-	Oxygen
ppm	-	parts per million
RBO	-	Rice Bran Oil
BRODB	-	Rice Bran Oil Biodiesel
RBOME	-	Rice bran Oil Methyl Ester
SG	-	Specific Gravity
SO_2	-	Sulphur Dioxide
SO_x	-	Sulphur Oxides
UHC	-	Unburnt Hydrocarbons
ULSD	-	Ultra Low Sulphur Diesel
v/v	-	Volume to Volume
w/w	-	Weight to Weight

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CHAPTER 1

INTRODUCTION

1.1 Overview

Today's global crisis of reduction in fossil fuels resources has become the main root problem for many countries. The problem which is being faced today due to the overwhelming demand of the fossil fuels, is never felt in the past. This modern era is totally dependent on the fossil fuels, due to which our industrial sectors operate, our automobiles run on the road and our stoves ignite in our homes. With such demand and corresponding reduction in fossil fuels resources, many countries' economy structures have destroyed. The countries which produces electricity mostly from fossil fuels, face half day electrical load-shedding due to the dearth of fossil fuels. As per the statistics, the fossil fuels will be completely vanished in near future. The reserves for coal will last for 215 years, for oil they will last for 38 years where in 60 years the natural gas will become only history [1]. Moreover, fossil fuels are also the main reason for the atmospheric devastation. Emission of poisonous gases using fossil fuels i.e. Nitrogen Oxides (NO_x), Sulphur dioxide (SO_2), Carbon Monoxide (CO), Unburnt hydrocarbon (UHC) and Carbon dioxide (CO_2) are found to form greenhouse effect, smog and acid rain.

As the demand rises abruptly, the fossil fuels are vanishing at the similar rate. Furthermore, the fossil fuels usage has gifted us remarkable health devastations. With exposure of CO (which is the main emission of the fossil fuels) can cause headache, dizziness, vomiting or it can cause even death with continuous exposure of CO. The

other main emissions are NO_x and SO_2, which can cause asthma and heart-attack respectively.

Due to the excess fuel demand, reduction and unfriendly environmental behaviour of fossil fuels, the ecologists are insisted to focus on the implication of renewable energy. Renewable fuels are not only replacement for fossil fuels but they are also eco-friendly. The successful applications of renewable energy are found in Wind mills, Solar Power plants and Hydro Power Plants. The mentioned applications use the direct form of natural resources i.e. wind, sunlight and water to generate electricity. But sometimes such (renewable) resources need to be converted into the suitable form to get the desired task. For instance, the vegetable oils which are renewable, cannot be used directly into the engine, but need to be converted into the biodiesel first. Similarly, Rice Bran Oil (RBO) is a vegetable oil, which is extracted from Rice Bran, the by-product of rice. Owing to favourable fatty acids, RBO is one of the most nutritious oils with unique combination of naturally occurring biological active and antioxidant compounds.

Biodiesel works similar to CDF. It can be used directly in diesel applications or it can be blended with diesel. Biodiesel blends are categorized in the form of "BXX" where "B" stands for biodiesel and "XX" shows its blend percentage e.g. "B50" shows 50% of biodiesel is blended with 50% of diesel. This thesis elaborates the conversion of RBO into RBOBD, compares several properties i.e. density, kinematic viscosity, surface tension, specific gravity and calorific value of RBOBD blends with diesel and correlates exhaust emissions of RBOBD blends with diesel.

1.2 Problem Statement

World's dependency on fossil fuels increases day by day as these resources are used to operate industrial and automobile applications over decades. Fossil fuels such as diesel and coal may seem quite cost-effective but they are environmental unfriendly. The emissions exhausted by fossil fuels are the reason behind global warming and ozone destruction. Thus, governments around the world are imposing the use of

biodiesel. Biodiesels which are converted from the vegetable oils are main substitutes of the CDF. To minimize the emissions from biodiesels, the combustion processes and fuel injection processes should be thoroughly understood. As the diesel's and biodiesel's constituents are different, the physical and chemical properties vary, so, the properties need to be investigated. The performance of RBOBD and CDF should also be analysed in the liquid burner in terms of temperature and CO, NO_x and SO_2 emissions for B5, B15 and B25..

1.3 Objectives

The objectives of the study are mentioned as:

(i) To develop Rice Bran Oil Biodiesel (RBOBD) using different amount of different catalysts and compare corresponding conversion efficiencies.
(ii) To determine several physical properties of RBOBD and corresponding blends.
(iii) To compare combustion characteristics of different blends of RBOBD with diesel in an oil burner

1.4 Research Scope

The scopes of the research are listed below:

(i) Carry out literature study on extraction and usage of RBOBD.
(ii) Setup rig for production of biodiesel from Rice Bran Oil (RBO) through transesterification process
(iii) Carry out measurement of several physical properties from RBO.
(iv) Setup rig for combustion test.

(v) Carry out measurement of temperature and emissions performance of RBOBD.

1.5 Significance of the Project

Previously, many researchers have converted RBO into biodiesel and replaced CDF by RBODB in the diesel engines to study the emission characteristics. This study examines the emissions in an oil burner system which is used in many industrial applications.

Furthermore, this study purposes the analysis of combustion performance of blends of RBOBD with CDF under different combustion processes. To compare and replace CDF with RBOBD, it is very important to know the emission characteristics of RBOBD.

1.6 Report Organization

This report is consisted of five (5) chapters.

Chapter 1 illustrates the overview of the study, objectives of the research, plus scopes of the project and significance of the research.

Chapter 2 is devoted to literature studies, where the biodiesels are studied in detailed way and the description of RBO is also described. Moreover, Chapter 2 also covers the previous researches on the RBODB.

Chapter 3 is based on the methods that how we can achieve our objectives of this research.

Chapter 4 depicts the results obtained from the experiments and discusses the reasons behind the achieved results

Chapter 5 draws the conclusion about the results and suggests the future recommendation regarding the study.

1.7 Gantt Chart

The project schedules for Master project 1 and Master project 2 are shown in Appendix A as Gantt chart. Gantt chart shows the done activities of master project 1 and scheduled activities for master project 2.

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