CHARACTERISTICS OF DIESEL ENGINE USING WASTE COOKING OIL

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To my parents, my family, wife and children

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ABSTRACT

This experiment studies the characteristics of diesel engine using biodiesel (UCME) product from waste vegetable cooking oil which was collected from restaurants. WCO biodiesel is one of the promising alternative fuels for diesel engine due to its low cost and similarity of its properties to diesel fuel. This biofuel was prepared by Transesterification method which was used to obtain renewable fuel from WCO. The Transesterification used Potassium Hydroxide (KOH) as a catalyst and Methanol as solvent. The performance characteristics of UCME were obtained by combustion blends of biodiesel (B2%, B5%, B7% and B10%) in one cylinder direct injection C.I. engine operating at 3000 rpm. The biodiesel was blended with pure diesel to reduce UCME high viscosity which restricts their direct use in diesel engine. The fuel properties and the combustion characteristics of UCME are found to be close to that of diesel. A minor decrease in thermal efficiency (especially for blends B2 and B5) was observed. Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Unburnt Hydrocarbon (HC), Carbon Dioxide (CO_2) emissions of biodiesel blends was found to be higher than that of diesel whereas Oxygen (O_2) emission was found less. The use of Transesterified used cooking oil and its blends as fuel for diesel engines will reduce dependence on fossil fuels and also decrease considerably the environmental pollution.

ABSTRAK

Eksperimen ini mengkaji ciri-ciri enjin diesel menggunakan biodiesel (UCME). Produk daripada sisa minyak masak sayuran ini didapatkan dari restoran. Biodiesel WCO adalah salah satu bahan api alternatif yang menjanjikan untuk enjin diesel kerana kos yang rendah dan persamaan sifat-sifatnya kepada bahan api diesel. Bio bahan api ini telah disediakan dengan kaedah Transesterification menggunakan Hidroksida Kalium (KOH) sebagai pemangkin dan Metanol sebagai pelarut. Ciri-ciri prestasi UCME diperolehi dengan pembakaran biodiesel (B2, B5, B dan B10) dalam enjin CI satu silinder dan suntikan langsung yang beroperasi pada 3000, 2500 dan 2000 rpm. Biodiesel telah dicampur dengan diesel tulen untuk mengurangkan kelikatan UCME yang tinggi yang menghadkan kegunaan langsung mereka dalam enjin diesel. Sifat-sifat bahan api dan ciri-ciri pembakaran UCME didapati berada dekat dengan diesel. Penurunan kecil dalam kecekapan haba (terutama bagi campuran B2 dan B5) telah didapati. Pelepasan Karbon Monoksida (CO), Nitrogen Oksida (NO_x), Hidrokarbon tak terbakar (HC) dan Karbon Dioksida (CO_2) campuran biodiesel telah didapati lebih tinggi daripada diesel sedangkan pelepasan Oksigen (O_2) telah adalah lebih sedikit. Transesterified minyak masak yang digunakan sebagai campuran bahan api untuk enjin diesel akan mengurangkan pergantungan kepada bahan api fosil dan juga mengurangkan dengan ketara pencemaran alam sekitar.

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LIST OF ABBREVIATIONS/ SYMBOLS

ASTM	-	American Society for Testing and Materi
AFR	-	Air fuel ratio
B2	-	2% Biodiesel 98% diesel
B5	-	5% Biodiesel 95% diesel
B7	-	7% Biodiesel 93% diesel
B10	-	10% Biodiesel 90% diesel
B100	-	Pure Biodiesel
BSFC	-	Brake specific fuel consumption
BP	-	Brake power
BDC	-	Bottom dead center
BMEP	-	Brake mean effective pressure
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
CR	-	Compression ratio
D	-	100% Diesel
DI	-	Direct injection
FFAs	-	Free fatty acids
FAME	-	Fatty acid methyl ester
UCME	-	Used cooking oil methyl ester
UBHC	-	Unburned hydrocarbon
SFC	-	Specific fuel consumption
$\dot{m}_a$	-	Mass rate of flow of air
$\dot{m}_f$	-	Mass rate of flow of fuel
N	-	Engine speed in rpm

NO_x	-	Nitrogen oxides
O_2	-	Oxygen
ppm	-	Parts per million
Q_{HV}	-	Heat supplied from combustion of fuel
rpm	-	Revolutions per minute
SFC	-	Specific fuel consumption
TDC	-	Top dead center
WCO	-	Waste cooking oil
WVO	-	Waste Vegetable oil.
VCO	-	Virgin cooking oil
V_d	-	Engine displacement volume
i.p	-	Indicated power
f.p	-	Friction power
η_m	-	Mechanical efficiency
η_{th}	-	Brake thermal efficiency
η_{IT}	-	Indicated Thermal Efficiency

CHAPTER 1

INTRODUCTION

1.1 Introduction

It has been generally acknowledged by various publications that over 70 million vehicles are profusely into the global market by various automotive car manufacturers. Particular category of vehicles produced has been highlighted to be about 10.5 million light category vehicle, 2.5 Heavy category vehicle and 0.5 Heavy Bus and 56 million cars. This figure is expected to be on the increase in the next five years up to a billion cars on the roads (Jon Van Gerpen, 2008).

Continuous increase in production of automobiles by new and existing auto firms in the recent years have been believed to lead to a high demand for petroleum products, Authors have opined that the world supply of natural gas and oil from traditional sources is not likely meeting the required increasing energy for the next 20 years (Zhang, *et al.*, 2003)

However, the consistent increase in world prices of crude oil sources recently and threat to the society as a result of exhaust emissions and the uncertainty about energy production and supply, coupled with other reasons was found significant to create new alternative fuel source with features that are similar to petroleum based fuels. This thinking leads to efforts globally to explore fuel of lesser cost with minimum environmental impact for many internal combustion engines as an option or additives such as waste cooking oil, rice bran oil, and palm oil to petroleum energy particularly in years to come. Due to this additives are cheap with less environmental effect. The new choice of fuel should be cost efficient and attractive so as to compete with recent adopted fossil fuels, in the low fuel consumption utilization for diesel engine efficiency.

One such alternative fuel source is the vegetable oils, which is an alternative fuel using for diesel engine gives a benefit due to its comparable properties with diesel. But it was reported that the main limitation of making use of vegetable oil is because of its viscosity. This covers the examination of energy resources and created inexpensive diesel fuel powering a customized "Diesel Engine". Most of these additives are utilized as diesel fuel, though a large volume of waste cooking oils and animal fats are obtainable globally, usually in the developed nations, in this regards the waste cooking oil is the most appropriate fuel. Though its high viscosity due to the huge molecular mass and chemical structure of vegetable oils, limits their direct use in diesel engines, which in turn result to the pumping problems and excessive load on the pumps, combustion and atomization in the injector systems of a diesel engine that result to the lacquering issues. Production of biodiesel from WCO for diesel substitute is mostly useful due to the reducing trend of low cost oil reserves, environmental problems generated from fossil fuel use and the high cost of crude oil products in the global market. Considering this perspective, substantial efforts has been given to the production of biodiesel as a substitutional energy source for automotive engines.

This research derives its motivation from the combustion, emission and performance properties of waste cooking oil methyl ester (UCME) and its blends with diesel are analyzed in a direct injection engine. The major benefits of the used cooking oil to attract popular authors are the renewable and greener qualities it possess to the environment due to related properties with the diesel fuel used cooking oil can be accepted as a proper substitute to the diesel fuel because of plants, vegetable oils and animal fats are renewable biomass sources

1.2 Background

The discovery of Biodiesel as a cleaner burning diesel alternative fuel processed from natural, renewable oil source derived from biological materials like used cooking oil and refined bleached deodorized palm oil (Mahfuzah, 2009). The biodiesel has lower sulphur and aromatics contents and reduced CO_2 emissions compared with diesel fuel. By 2017, 20% blend of biofuels with diesel has been approved by the Gov. of India in 2009. About 38 million tons of petroleum products are consumed in India in the year 2007. It is expected that it may be doubled by the end of 2030. This implies a larger scope of production and use of biofuels in India (Arjun, *et al.*, 2008). The process used to produce biodiesel is called Transesterification (Mahfuzah, 2009).

Again, the rise in the price of virgin vegetable oil has contributed to the problems of biofuel production companies. Hence, the greatest possibilities is in the use of waste cooking oil recycling, which involves a variety of processes like pyrolysis and catalytic cracking, designed to transform waste cooking oil into hydrocarbon products for use in the preparation for refined chemicals or fuels (Khalisanni, *et al.*,2008).

The aim of used WCO as biofuel feedstock is to reduce the cost of biofuel production since the feedstock costs constitutes approximately 70-95% of the total cost of biofuel production. Hence, the use of waste cooking oils and non-edible oils should be given higher priority over the edible oils as biofuel feedstock. The fuel properties and the combustion characteristics of used cooking oil methyl ester (UCME) are found to be similar to those of diesel. A minor reduction in thermal efficiency with considerable improvement in reduction of particulates, carbon monoxide and unburnt hydrocarbons is practical compared to diesel.

In addition the waste cooking oil is renewable and greener to the environment, so the use of Transesterified used cooking oil and its blends as fuel for diesel engines will reduce reliance on fossil fuels and also reduces substantially the environmental pollution (Lakshmi Narayana Rao, *et al*., 2008), as a result that plants and vegetable oils and animal fats are renewable biomass sources.

Biodiesel has lower emission of pollutants comparing to petroleum diesel, it is biodegradable and enhances the engine lubricity and contributes to sustainability. Biodiesel has a higher cetane number than diesel fuel, no aromatics, no sulfur, and contains 10–11% oxygen by weight (Enweremadu and Rutto, 2010)..

1.3 Objectives

The objectives of this study are:

1. To prepare fuel from waste cooking oil by Transesterification, this refers to a catalyzed chemical reaction involving vegetable oil and an alcohol to yield fatty acid alkyl esters (biodiesel) and glycerol.

2. To study the combustion characteristics of biodiesel using cooking oil methyl ester (UCME), To be compared with pure diesel in order to determine the optimum Transesterification reaction conditions that produce methyl ester content or purity and biodiesel yield

1.4 Problem Statement

Transesterified vegetable oils (biodiesel) are promising alternative fuel for diesel engines. Waste cooking oil eliminated from restaurants in large amounts. But it cannot be used direct in diesel engines because of its higher viscosity.

The performance, combustion and emission characteristics of waste cooking oil Methyl Ester (UCME) and its blends with diesel are analyzed in a direct injection C.I. engine. The fuel properties and the combustion characteristics of UCME will be compared to those of diesel. A minor decrease in thermal efficiency with significant improvement in reduction of particulates, carbon monoxide and unburnt hydrocarbons is observed compared to diesel. The use of Transesterified used cooking oil and its blends as fuel for diesel engines will reduce dependence on fossil fuels and also reduce considerably the environmental pollution.

1.5 Scope of the Study

In this context, an experimental investigation will be conducted on single cylinder diesel engine fuelled with the blends of waste cooking oil and Diesel. Engine performance, combustion, and emission characteristics are also evaluated using WCO blended with the fuel in a present engine. The working scope will consist of a literature review on studying the combustion characteristics and emission measurement for different biodiesel fuels and an experimental setup for engine testing using single cylinder engine, natural aspirated, direct injection engine as test engine and instrumentation for combustion and emission measurement.

This research will be conducted by performing experiments with the use of four waste cooking oil based blended-biodiesel fuels in the ratio of 2%, 5%, 7% and 10% and diesel fuel designate as the reference fuel to characterize their combustion and emission profile under different engine loads. The time frame to conduct this study ranges from 30, 40, 50 and 60 minutes.

The effect of these fuel blends is studied experimentally using 3.75 kW DI diesel engine. Experiments were conducted for different blends and its effect on brake power, fuel consumption, break thermal efficiency, volumetric efficiency exhaust gas temperature etc. variation with the load on the engine are reported. Previous studies related to the effect and characteristics of WCO as a new renewable energy resource will be investigated from the literature with the hope of directing this research work to the new fields of this topic.

Theoretical study should be achieved by the burning process with the new components of the fuel and their effects on the characteristics of the engine will be reported. Data analysis consist of identifying and quantifying parameter pertaining to exhaust emission content and also evaluation of combustion characteristics according to analysis of in-cylinder data.

1.5 Project Flow Chart

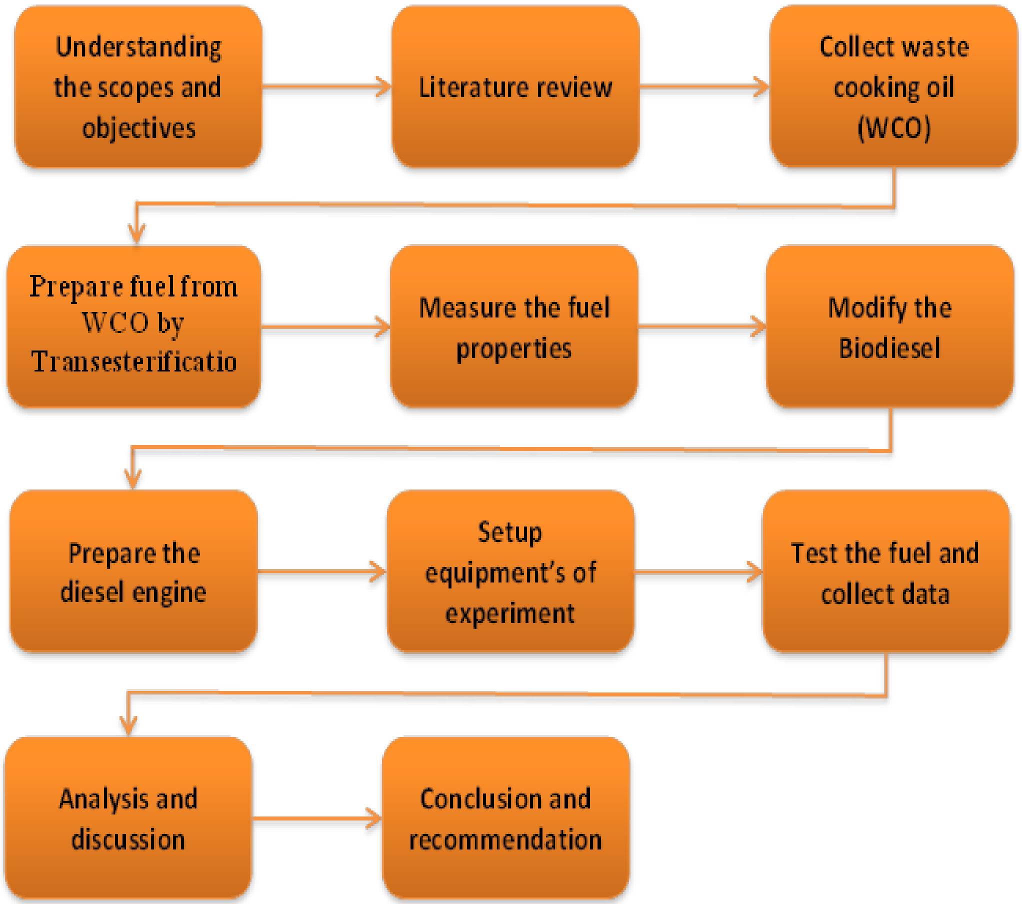

Figure 1.1 Project Flow Chart

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