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Study of Emissions and Performance of Waste Vegetable Oil Biodiesel on Single Cylinder Diesel Engine

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ABSTRACT

The energy demand is majorly fulfilled from the conventional energy resources like coal, petroleum and natural gas. Petroleum based fuel are very limited reserves and only concentrated in certain regions of the world. India is importing petroleum products from OPEC (Oil and Pertroleum Exporting Countries) and the energy demand is day by day increasing due increasing prices of petroleum products the Indian economy becomes insecure. Therefore it is necessary to find out an alternative fuel which can fulfill the energy demands. The main objective of this study is to investigate the alternative fuel i.e. Biodiesel from waste vegetable oil with an different percentage of diesel fuel such as B00, B50 & B100. The secondary aim is to check the performance and emissions of single cylinder diesel engine.

Keywords: Biodiesel, Diesel, Emissions, Performance.

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I. INTRODUCTION

In the most general sense, biodiesel refers to any diesel fuel substitute derived from renewable biomass. More specifically, biodiesel is defined as an oxygenated, sulfur-free,biodegradable, non-toxic, and eco-friendly alternative diesel oil. Chemically, it can bedefined as a fuel composed of mono-alkyl esters of long chain fatty acids derived from renewable sources, such as vegetable oil, animal fat, and used cooking oil designated asB100, and also it must meet the special requirements such as the ASTM and the European standards. For these to be considered as viable transportation fuels, they must meetstringent quality standards. One popular process for producing biodiesel istransesterification. Biodiesel is made from a variety of natural oils such as soybeans,rapeseeds, coconuts, and even recycled cooking oil. Rapeseed oil dominates the growingbiodiesel industry in Europe. In the United States, biodiesel is made from soybean oilbecause more soybean oil is produced in the United States than all other sources of fats andoil combined.

The increasing awareness of the depletion of fossil fuel resources and the environmental benefits of biodiesel fuel has made it more attractive in recent times. Its primary advantages deal with it being one of the most renewable fuels currently available and it is also non-toxic and biodegradable. It can also be used directly in most diesel engines without requiring extensive engine modifications.

The injection and atomization characteristics of the vegetable oils are significantly differentthan those of petroleum derived diesel fuels, mainly as the result of their high viscosities.

Modern diesel engines have fuel-injection system that is sensitive to viscosity change. Oneway to avoid these problems is to reduce fuel viscosity of vegetable oil in order to improve itsperformance. The conversion of vegetable oils into biodiesel is an effective way to overcomeall the problems associated with the vegetable oils. Dilution, micro emulsification, pyrolysis,and transesterification are the four techniques applied to solve the problems encounteredwith the high fuel viscosity. Transesterification is the most common method and leads tomono alkyl esters of vegetable oils and fats, now called biodiesel when used for fuelpurposes. The methyl ester produced by transesterification of vegetable oil has a high cetanenumber, low viscosity and improved heating value compared to those of pure vegetable oilwhich results in shorter ignition delay

and longer combustion duration and hence lowparticulate emissions.

Advantages of using vegetable oils as fuels

- Vegetable oils are liquid fuels from renewable sources; they do not over-burden theenvironment with emissions.
- Vegetable oils have potential for making marginal land productive by their property of nitrogen fixation in the soil.
- Vegetable oil combustion has cleaner emission spectra.
- They have simpler processing technology
- Vegetable oils can be successfully used in CI engine through engine modifications and fuel modifications because Vegetable oil in its raw form cannot be used in engines.
- Biodiesel has comparable energy density, cetane number, heat of vaporization, and air/fuel ratio with mineral diesel.
- An acceptable alternative fuel for engine has to fulfill the environmental and energy security needs without sacrificing operating performance.

Biodiesel Processing

Genereally for production of biodiesel Esterification and Transesterification processes are used. The free fatty acid percentage of waste vegetable oil is higher so for transesterification process it is necessary to reduce the free fatty acid percentage of waste vegetable oil below 2%. For reducing free fatty acid percentage esterification process is used.

Esterification Process

The free fatty acid percentage of waste vegetable oil is higher for reducing FFA the esterification process is used. During this process waste vegetable oil is reacted with methanol in presence of acid base catalyst. This reaction is carried out at 60^0 C.

Transesterification Process

Transesterification is the process of separating the fatty acids from their glycerol backbone toform fatty acid esters (FAE) and free glycerol. Fatty acid esters commonly known as biodiesel can be produced in batches or continuously by transesterifying triglycerides such as animal fat or vegetable oil. The transesterification process is carried out for reducing the viscosity of oil. During this process waste vegetable oil is reacted with methanol in presence of catalyst NaOH or KOH.

Performance and Emission Test

Performance Test

The performance and emission characteristics of engine are determined by using pure diesel, pure biodiesel and B50 (50% Biodiesel and 50 % pure diesel). These results are compared with pure diesel by representing graphs.

The single cylinder diesel engine was tested with B00, B50 and B100 blends of biodiesel with varying loads from 0%, 25%, 50% and 75%.

Engine Specifications

Four- stroke single cylinder water cooled diesel engine

- Make - Field Marshal, Kirloskar
- Power Rating- 5.9 KW
- Capacity- 100% load Mass 36Kg
- Dynamometer- Rope Brake Type
- Governor- Mechanical Type Governor
- Speed - 850 rpm constant
- Constant Compression Ratio- 17.5

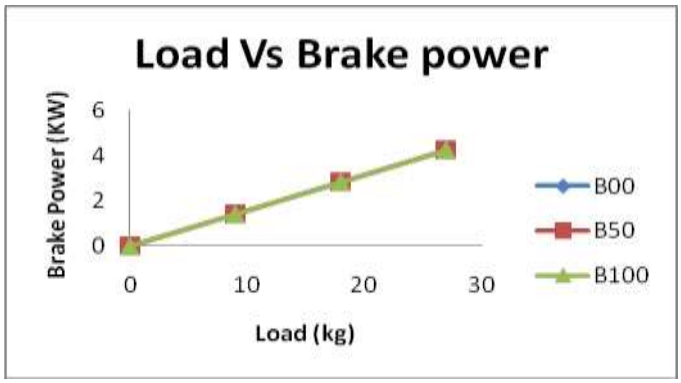
Emission Test

The 5 gas exhaust gas analyzer is connected to the exhaust pipe of the engine. This exhaust gas analyzer is able to analyze the 5 gases such as CO (Corbon Monoxide), CO_2 (Carbon Dioxide), HC (Hydrocarbon), O_2 (Oxygen) and NO (Nitrogen Oxide).

II. RESULTS AND DISCUSSION

The B00,B50 and B100 blends of biodiesel with diesel fuel are tested on single cylinder diesel engine and the following performance curves for engine parameters and emissions are plotted,

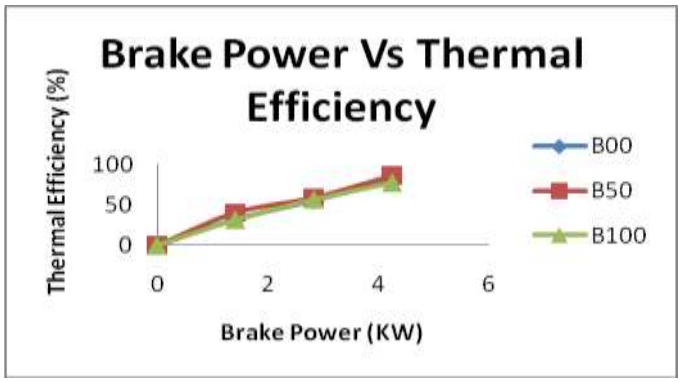
Brake Power (BP)



Graph 1 : Load Vs Brake Power

From graph 1 it is observed that, As load increases the brake power for B00, B50 and B100 is increases. The BP for all blends of biodiesel is same.

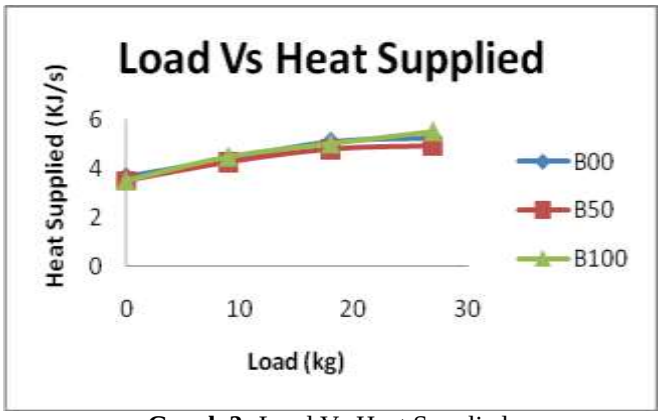
Thermal Efficiency



Graph 2 : Brake Power Vs Thermal Efficiency

Graph 2 shows that B50 blend having higher thermal efficiency as compared to B00 and B100. As BP of engine increases the thermal efficiency is goes on increases.

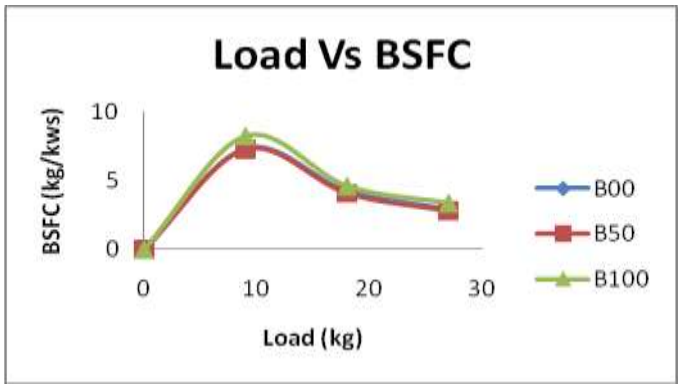
Heat Supplied



Graph 3: Load Vs Heat Supplied

Initially the heat supplied to the engine is almost same for all blends. From graph 3 it observed that heat supplied to the engine is increases as load increases. For B50 blend the heat supplied is less as compared to B100.

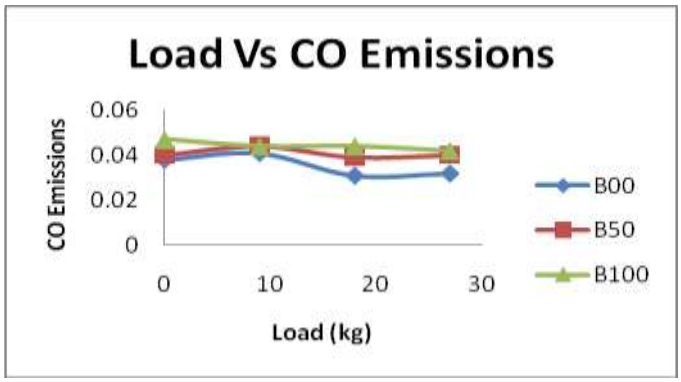
Brake Specific Fuel Consumption (BSFC)



Graph 4 : Load Vs Brake Specific Fuel Consumption

It is observed from graph 4, Due to higher viscosity of pure biodiesel i.e. B100 the fuel consumption is also more as compared to pure diesel and B50 blend.

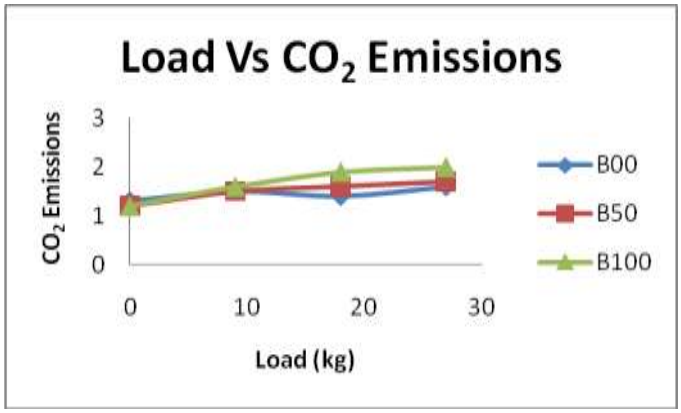
Carbon Monoxide (CO)



Graph 5 : Load Vs Carbon Monoxide (CO)

From graph 5, it is shown that CO emissions of B00 i.e. pure diesel are less as compared to B100. Due to incomplete combustion CO emissions are increases.

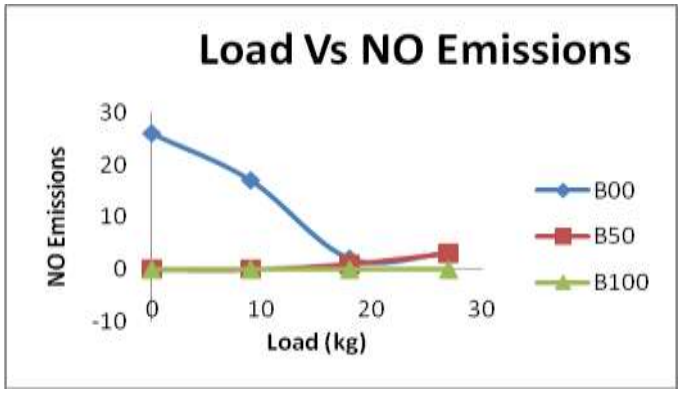
Carbon Dioxide (CO_2)



Graph 6 : Load Vs Carbon Dioxide (CO_2)

It is observed from graph 6, At some extent CO_2 emissions are constant for all blends after that it increases as load increases as compared to diesel fuel.

Nitrogen Oxide (NO)



Graph 7 : Load Vs Nitrogen Oxide

Higher temperature of exhaust gases favors to formation of nitrogen oxide. It is observed from graph 7 initially for B00 the exhaust gas temperature is higher so NO formation is also more. Simultaneously the exhaust temperature is less for B100 and B50 blends so NO formation is less as compared.

III. CONCLUSION

The performance of waste vegetable oil biodiesel is similar as that of diesel fueled engine. Based on experimental results and performance curves, the following conclusions are made,

- The brake power of biodiesel is approximately same as that of diesel.
- Due to high viscosity of biodiesel the brake specific fuel consumption is higher than diesel
- Brake thermal efficiency of blend B50 is higher than pure diesel and biodiesel.

- Flash point, Fire point of biodiesel is higher so it is easy for transportation purpose.
- NO formation is less in biodiesel as compared to diesel fuel.

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