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Performance Characteristics of Four Stroke Diesel Engine using Bio Diesel obtained from Mustard Oil

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ABSTRACT

Accessibility of energy sources and climate changes are the biggest challenges that mankind facing in this century. The fast-growing population and the increasing prosperity have led to rapid raise in the energy demand and also The world consumption of fuels is undoubtedly not-stable causing world economic crisis, the worst compared to other economic recession that took place at different era. By using biodiesel, the problem could be solved. Bio fuelsderived from biomass have been gaining the attention as of highly renewable, biodegradable and locally available Biodiesel, which are obtained from vegetable oil or animal fats and Bio crude, synthetic oil. Bio fuels are carbon-neutral, nontoxic and reduce emission of volatile organic compounds. These fuels are not only green in nature but also help to reduce on imported oil.Vegetable oils are promising alternative fuel for CI engine because it is renewable, environment friendly and can be produced in rural areas. Thus, present paper relates about bio-diesel used in experimental work was prepared from Mustard oil by the process known as transesterification. The experiment is processed and the required observations are observed and analyzed. Engine performance tests will be performed on a diesel engine at various loads to determine performance curves for the following will be plotted.

KEYWORDS:Biodiesel, trans-esterification, Mustard oil, performance characteristics

1. INTRODUCTION

The increasing in industrialization andmotorization of the world led to a steep rise in the demand of petroleum products. Petroleum basedfuels are obtained from fossil fuels and these are limited in resources. Bio-Diesel is the fuel of the future, especially for the country like India where there is plenty of wasteland which can be utilized to do farming of plants which can be used as a raw material for the production of bio diesel. Bio diesel can be produced very easily and it can meet the growing petroleum requirements. In this project we are trying to illustrate the characteristics of bio diesel as an alternate fuel.Bio-dieselsare renewable fuels that can be manufactured from algae, vegetables-oils, animal fats or recycled restaurant greases. It can be produced locally in most countries. It is safe, biodegradable and reduces air pollutants, such as particulates, carbon monoxide and hydrocarbons. Blends of 20 percent bio diesel with 80 percent petroleum diesel (B20) can be generally used in unmodified diesel engines. Bio diesel can be used in its pure form (B100), but may require certain engine modificationto avoid maintenance and performance problems. Geologists throughout the world are searching for further deposits of fossil fuels. Although the present reserves seem vast, but the accelerating consumption will create achallenge so that these vast reserves will be vanished with in no time. The new reserves appear to grow arithmetically while the consumption is geometrically. Under this situation, when consumption overtakes discovery, the world will be leading to an industrial disaster.Many countries today solely dependent upon imports to meet their fuel requirements and many more will be added in future as their limited reserves of petroleum get exhausted.This situation is very grave in developing countries like India which imports 70% of required fuel, spending 30% of their total foreign exchange earnings on oil imports. This situation has created a problem to increase the prices of these oils more than two folds in last five years.so it is necessity to use biofuels.

2. LITERATURE REVIEW

Before going with the project, a brief study on papers related to Performance Analysis of Compression Ignition Engine using Biodiesel was done. Many authors portrayed different ideas related to their works on Biodiesel. The different papers reviewed are listed below:

YedilfanaSetargeMekonnen [1], investigated the production of biodiesel from three mixtures of vegetable oil and used cooking oil by alkali catalyzed transesterification. Three kinds of vegetable oils, including jatropha, roselle and coconut were tested. The effect of used cooking oil content in oil feedstock (used cooking oil/vegetable oil ratios of 0.03-0.2 v/v) on methyl ester formation was investigated and optimized. The methyl ester content from each reaction condition was determined by gas chromatography (GC). The optimum used cooking oil/vegetable oil ratio was 0.03 v/v for all three kinds of oil feedstock.

Murat Kadir Yesilyurt, Mevlüt Arslan & Tanzer Eryilmaz [2],in the present study, response surface methodology (RSM) involving central composite design (CCD) was applied to optimize the reaction parameters of biodiesel production from yellow mustard (Sinapisalba L.) seed oil during the single-step transesterification process. A total of 30 experiments were designed and performed to determine under the effects of variables on the biodiesel yield such as methanol to oil molar ratio (2:1–10:1), catalyst concentration (0.2–1.0 wt.% NaOH), reaction temperature (50–70°C), and reaction time (30–90 min). The second order polynomial model was used to predict the biodiesel yield and coefficient of determination (R2) was found to be at 0.9818. The optimum biodiesel yield was calculated as 96.695% from the model with the following reaction conditions: 7.41:1 of methanol to oil molar ratio, 0.63 wt. % NaOH of catalyst concentration, 61.84°C of reaction temperature, and 62.12 min of reaction time.

Chatpalliwarl et al. [3], described the brief overview of the Biodiesel production plant. Various issues- sources, opportunities, challenges, plant design, and evaluation etc., are discussed related to the Biodiesel production. The contribution of the work is that it discusses the important issues concerned with the Biodiesel production plant design, the fundamental details required for the formulation of Biodiesel plant and also it presents possible approach for the mathematical model to evaluate the Biodiesel plant design.

Avinash Kumar Agarwal [4], reported the technical feasibility of using straight vegetable oils (Jatropha oil), into a constant speed direct injection compression ignition engine. Vegetable oils have very high viscosity, which make their direct usability in engines questionable. In this investigation, SVO's were preheated by using waste heat from engine exhaust, in order to reduce their viscosity. The effect of using these oils on typical engine problems such as injector coking, piston ring sticking, lube oil dilution etc. was investigated in detail. Long-term endurance test (For a duration of 512 hours) of SVO fueled engine vis-à-vis mineral diesel fueled engine was executed and the results are compared.

3. PREPARATION OF BIODIESEL FROM MUSTARD OIL

Initially, oil is filtered from suspended particles and poured in a beaker. For removal of residual water particles in the oil, it is placed on electrical heater and heated till 60 degrees centigrade is attained and again the oil is filtered so that the residual water particles present in oil gets evaporated and oil gets cleaned. After than the oil is maintained at 50-60 degrees centigrade for some time.

A. *Trans-esterification Process*

In this, fatty acids (esters) present in the Mustard oil is converted into required biodiesel in the presence of a acid based or base based catalyst. Trans-esterification reaction is carried out in a flask with overall volume of 300 ml flask was placed on a hot plate equipped with a controlled magnetic stirrer and temperature sensor. Mustard oil was preheated to the required reaction temperature before methanol and the catalyst were added into the reaction flask. The calculated amount of methanol to oil ratio was poured into the reactor. Then the KOH catalyst was added in a range between 0.5 to 5% by weight with respect to mass of the mustard Oil, and then the formed reaction mixture was mixed for 10 minutes. 500 ml of mustard oil was added and temperature of the mixture was set from 50 to 60 °C, 5 °C interval. The mixture was stirred well for 5 minutes.

B. Purification

After stirring, the solution is poured into the separating funnel and is allowed to settle for 24 hours. A major part of the separation takes place in the initial hours after the reaction and so a separation progress can be seen. Within 24 hours the glycerol will fall to the bottom of the separating funnel and the layer above glycerol is methyl esters which is lighter in color than the bottom layer. The bottom layer comprises of glycerol, Potassium hydroxide (KOH) and methanol. The stopcock at the bottom of the separating funnel drains the glycerol out in a container. When the glycerol is fully drained the valve is shut. The glycerol left in the biodiesel sample comprises of soap which emulsifies when hot water is poured and forms a milky layer which is drained through the stopcock. In this process, glycerol is the by-product which is mainly used for soap manufacturing.

FIG1: Purification of Biodiesel

4. EXPERIMENTAL PROCEDURE

1. Check the fuel and lubricating oil systems before starting the engine.
2. Connect water supply to the engine and brake drum and remove all load on the brake drum.
3. Keep 3way cock in horizontal position so that fuel flows from the tank to engine filling burette.
4. Start the engine by hand cranking and allow the engine to pick up rated speed.
5. Allow the engine to run for some time in idle condition.
6. Put the 3-way cock on vertical position and measure the fuel consumption rate by noting the time taken for 10 cc of fuel flow.
7. Experiment repeated at different loads.
8. Engine is stopped after detaching load from the engine.

Basic Data

Rated brake power of engine "BP"—5HP

Speed of the engine— 1500RPM

Effective radius of break drum "R"—0.12m

Stroke length —110*10-3 meter

Diameter of cylinder bore —0.08 meter

Model Calculation

Considering D80 blend

Specific gravity of fuel = 0.853gm/cc

Calorific Value of fuel CV = 35700kJ/kg

Maximum load $= \frac{Rated\ \ B.P\times 60000}{2\pi NR\times 9.81}$

$= \frac{3.7\times 60000}{2\pi\times 1500\times 0.213\times 9.81} = 11.27$ kg

Brake power (B.P) $= \frac{2\pi N\,(W-S)\times 9.81\times R}{60000}$

$= \frac{2\pi\times 1500\times 1.7\times 9.81\times 0.213}{60000} = 0.558$ kW

Fuel consumption (F.C) =

$\frac{10}{t}\times\frac{specific\ \ gravity\ \ \times 3600}{1000}\ kJ/\mathrm{hr}$

$= \frac{10}{67}\times\frac{0.853\times 3600}{1000}\ kJ/hr = 0.458$ kJ/hr

Frictional power from graph (F.P) = 2.5 kW

Indicated power (I.P) = B.P + F.P =0.558+2.5 =3.058kW

Specific fuel consumption (S.F.C) $= \frac{F.C}{B.P}\ kJ/kW.hr$

$= \frac{0.458}{0.558} = 0.816kJ/kW.hr$

Brake thermal efficiency $\eta_{Bth} = \frac{B.P\times 3600}{FC\times CV}$

$= \frac{0.558\times 3600}{0.458\times 33600}$

= 13.25%

Indicated thermal efficiency $\eta_{Ith} = \frac{I.P\times 3600}{FC\times CV}$

$= \frac{2.958\times 3600}{0.451\times 33600} = 56.2$ %

Mechanical efficiency $\eta_{mech} = \frac{B.p}{I.p}$

$= \frac{0.558}{2.958} = 18.86\ \%$

Indicated mean effective pressure (IMEP)=$\frac{I.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

$= \frac{3.058\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}} = 4.28\text{bar}$

Break mean effective pressure (BMEP) = $\frac{B.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

$= \frac{0.558\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}} = 0.81\text{ bar}$

5. Result and Discussions

Flash point and Fire Point

TABLE 1 :FLASH POINT AND FIRE POINT TABLE

BLENDS	FLASH POINT	FIRE POINT
D100	51	55
D95	49	53
D90	46	49
D85	44	48
D80	43	47

Viscosity Results

The viscosity of biodiesel is typically higher than that of Petro diesel often by factor two, the viscosity increases as the percentage of biodiesel increases. Viscosity is greatly affected by temperature, many of the problems resulting from high viscosity are most noticeable under low ambient temperature and cold start engine condition. Viscosity increases with chain length of either the fatty acid or alcohol moiety in a fatty ester or in an aliphatic hydrocarbon. The increment in viscosity over a certain number of carbons is smaller in aliphatic hydrocarbons than in fatty compounds.

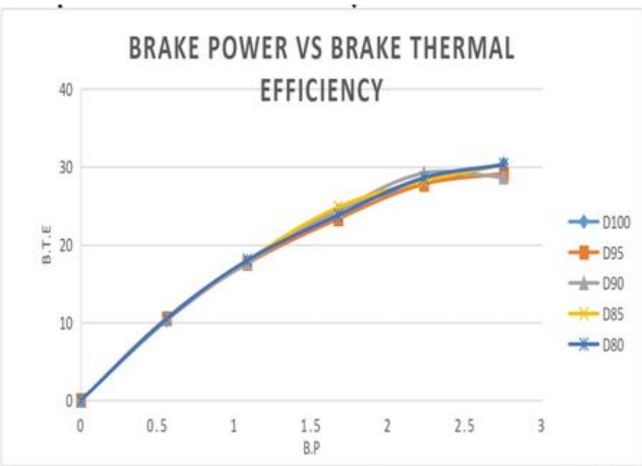
Performance characteristics of load test:

The values of brake power, mechanical efficiency, specific fuel consumptions, indicated thermal efficiency, brake thermal efficiency are set to be the parameters of performance of the engine. Engine performance is an indication of the degree of success with which it is doing its assigned job, i.e., the conversion of the chemical energy contained in the fuel into the useful mechanical work.

1. Specific fuel consumption.
2. Brake mean effective pressure.
3. Indicated mean effective pressure.
4. Indicated thermal efficiency.
5. Mechanical efficiency.
6. Brake thermal efficiency.

Performance characteristic graphs

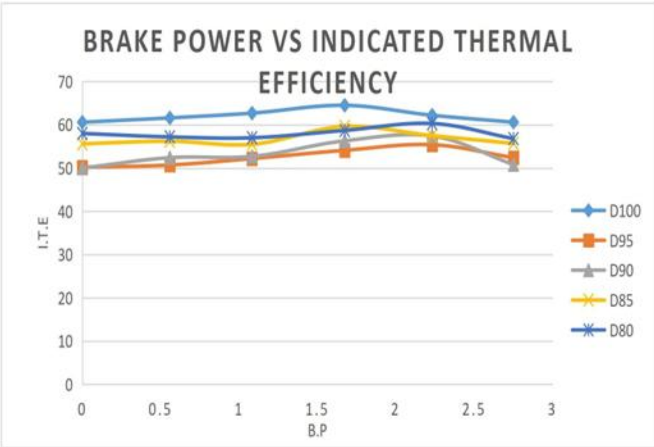
A.Comparison of Brake thermal efficiency



GRAPH1: Variation of Brake Power Vs Brake Thermal Efficiency

Brake Thermal Efficiency is defined as Brake Power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy. The values of Brake Thermal Efficiency at different brake powers are plotted. D90 offers least Brake Thermal Efficiency.

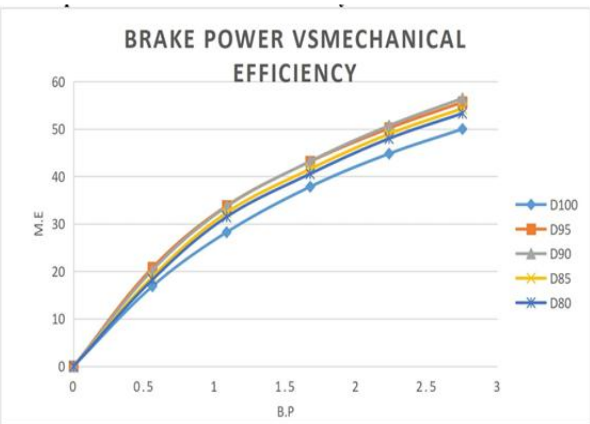
B. Comparison of Indicated thermal efficiency



GRAPH2: Variation of Brake Power Vs Indicated Thermal Efficiency

The values of Indicated Thermal Efficiency at different brake powers are plotted. D80 blend offers the maximum Indicated Thermal Efficiency of all the mixtures and it seems to be the best mixture, while D90 offers the minimum Indicated Thermal Efficiency.

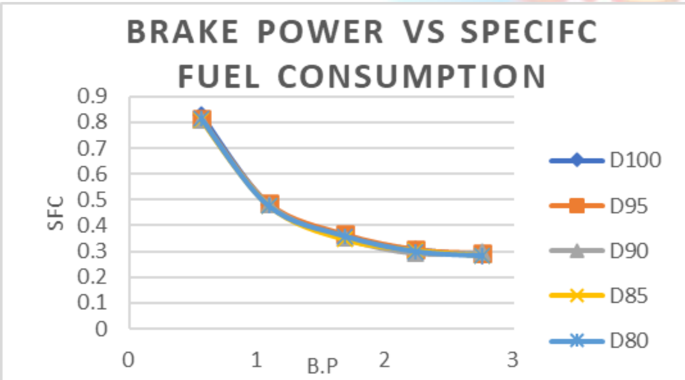
C. Comparison of Mechanical efficiency



GRAPH3: Variation of Brake Power Vs Mechanical Efficiency

Mechanical efficiency indicates how good an engine is inverting the indicated power to useful power. The values of Mechanical Efficiency at different Brake Powers are plotted as shown in D90 blend offers the best Mechanical Efficiency of all the mixtures and therefore seems to be the best mixture with regards to the minimum Frictional Power. Diesel gives the least Mechanical Efficiency.

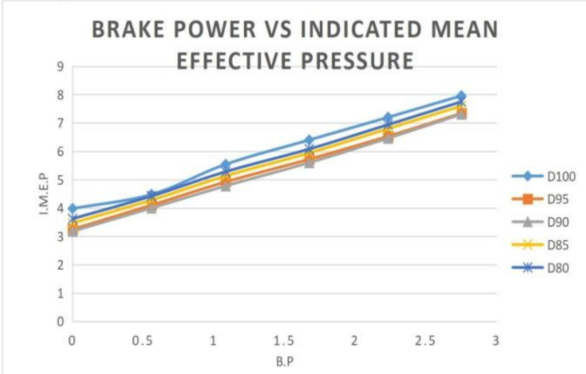
D. Comparison of Specific Fuel Consumption



GRAPH4: Variation of Brake Power Vs Specific Fuel Consumption

Specific fuel consumption is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft power. It is typically used for comparing the efficiency of IC engines with a shaft output. It is a rate of Fuel consumption with respect to power produced. The variations of Specific Fuel consumption with respect to Brake Power for different fuel blends are plotted. D80 blend offers the least Specific Fuel Consumption of all the mixtures while D95 has the maximum Specific Fuel Consumption.

E. Comparison of Indicated Mean Effective Pressure



GRAPH5: Variation of Brake Power Vs Indicated Mean Effective Pressure

Indicated Mean Effective Pressure is defined as the average pressure produced in the combustion chambers during the operation cycle. IMEP is equal to the brake mean effective pressure plus friction mean effective pressure. The variations of Indicated Mean Effective Pressure with respect to Brake Power for different fuel blends and Diesel are shown. D90 blend offers the minimum Indicated Mean Effective Pressure of all the mixtures and it seems to be the best mixture with regards to minimum Frictional Power while D80 offers the maximum Indicated Mean Effective Pressure.

6. CONCLUSION

The experimental study is conducted to evaluate and compare the blends of Mustard oil biodiesel to conventional diesel fuel in single cylinder naturally aspirated vertical diesel engine.

The series of tests are conducted using each of fuels with the engine working at a constant speed of 1500 rpm and at different loads starting from no load. In each test fuel consumption, specific fuel consumption, thermal efficiency, mechanical efficiency and mean effective pressure are computed from measured flow rate and calorific value.

From the performance characteristics it is observed that when mechanical efficiency values are considered it is better to use D90 blend. But conventional diesel fuel still remains a economically viable option as price being lesser than the other blends. When specific fuel consumption is considered, it is found that D80 has low specific fuel consumption than other blends. When indicated thermal efficiency is considered D80 is more preferable than other blends. Flash point is high for D95 and it's low for D80 and Fire point is high for D95 and it's low for D80.The viscosity is low for D95 and it is high for D80.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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