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Performance Assessment of Composite Biodiesel on a Diesel Engine

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ABSTRACT:

In this study, hybrid oil was used as feedstock for biodiesel production by Heterogeneous Catalyst. The reaction in the presence of CaO as catalyst was carried out to investigate the optimum conditions and study the effect of variables on the reaction. The variables included methanol to oil molar ratios, catalyst concentrations, reaction temperature and reaction times. Gas chromatography was used to determine the fatty acid composition of mixed oil. In this study, the biodiesel sample was taken to a CI engine and the performance & emission studies were done on a computerized engine .The various parameters like BSFC, Mechanical efficiency, Brake thermal efficiency and the emission parameters are being compared with the commercially available diesel. The blend B30 has given the best values among the blends.

KEYWORDS: BSFC, BTE, BP, emission.

1 INTRODUCTION

As an alternative fuel for diesel engines, it is becoming increasingly important due to diminishing petroleum reserves and the environmental consequences of exhaust gases from petroleum-fueled engines. Fossil fuels are non-renewable energy resources and also the fossil fuels are depleting at a faster rate. Their production have raised environmental concerns and political debates. It has been shown that 98% of carbon emissions are resulted from fossil fuel combustion [1]. Biodiesel is an alternative fuel made from renewable biological sources such as vegetable oils both (edible and non-edible oil) and animal fats According to the US standard specification for biodiesel (American Society for Testing and materials (ASTM) 6751), biodiesel is defined as a fuel comprised of mono alkyl esters of long chain fatty acids from vegetable oils or animal fats [2].The concept of bio-fuel is not new. Rudolph Diesel was the first to use a vegetable oil (peanut oil) in a diesel engine in 1911. The use of bio-fuels in place of conventional fuels would slow the progression of global warming by reducing sulfur and carbon oxides and hydrocarbon emissions. Because of economic benefits and more power output, biodiesel is often blended with diesel fuel in ratios of 2, 5 and 20% [3].The process of transesterification brings about drastic change in viscosity of the vegetable oil. The high viscosity component, glycerol, is removed and hence the product has low viscosity like the fossil fuels. The biodiesel produced is totally miscible with mineral diesel in any proportion. Flash point of the biodiesel is lowered after transesterification and the cetane number is improved [4]. The FFA and moisture contents have significant effects on the transesterification of glycerides with alcohol using catalyst. The high FFA content (>1% w/w) will happen soap formation and the separation of products will be exceedingly difficult, and as a result, it has low yield of biodiesel product. One of the most important parameters affecting the yield of biodiesel is the molar ratio of alcohol to triglyceride.

Pongamia pinnata is a species of family Leguminasae, native in tropical and temperate Asia including part of India. Karanja is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. It grows about 15-20 meters in height with a large canopy which spreads equally wide. The leaves are soft, shiny burgundy in early summer and mature to a glossy, deep green as the season progresses. Flowering starts in general after 4-5 years. Cropping of pods and single almond sized seeds can occur by 4-6 years and yields 9-90 kg's of seed. The yield potential per hectare is 900 to 9000 Kg/Hectare. As per statics available pongamia oil has got a potential of 135000 million tons per annum and only 6% is being utilized. The tree is well suited to intense heat and sunlight and its dense network of lateral roots and its thick long tap roots make it drought tolerant [5,6].

Cottonseed Oil is the oil extracted from the seeds of various species of cotton plants. Generally, there is 18% oil content in cottonseeds. It is pale yellow in color and is widely used for cooking. Cottonseed comes after Soybean, Corn and Canola (rapeseed) in the list of genetically modified crops. Various species of cotton is grown all around the world. The Gossypiumherbaceum and Gossypiumhirsutum species are more generally used to extract oil. But it should be mentioned that most of the cotton production of the India is used in the textile industry [7]

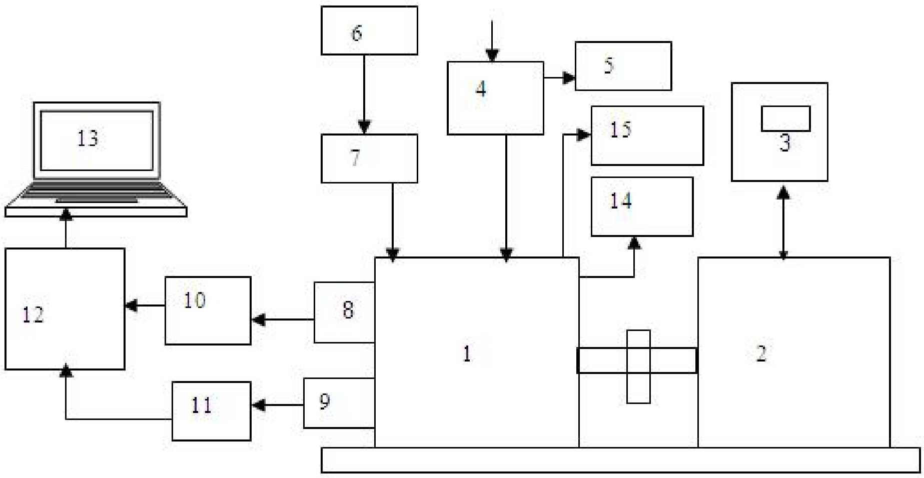
II METHODS

MATERIALS:

Cotton seed oil was obtained from the market as cotton seeds which was later converted into oil.Pongamia oil yield was produced in SIT Information and Demonstration Center, Tumkur. Cao catalyst was bought from the same institute, i.e. SIT Information and Demonstration Center, Tumkur. Methanol chemical was bought from the *Fishers Scientifics* in Bangalore.

EXPERIMENTAL METHODOLOGY:

The main purpose of this research is to perform an experiment whose results will show a significant reduction in harmful emission and also compare the performance and combustion characteristics using pongamia oil and cotton seed oil.



1.Diesel engine
2. Electrical Dynamometer
3.Dynamometer controls
4.Air box
5.U – tube manometer
6.Fuel tank
7.Fuel measurement flask
8.Pressure pickup
9.TDC position sensor
10.Charge amplifier
11.TDC amplifier circuit
12.A/D card
13. Personal computer
14.Exhaust gas analyzers
15.AVL smoke meter

Fig.1.1ENGINE LAB SETUP

The engine used in the study is a vertical single cylinder diesel engine, model TAF 1 produced by Kirloskar Engines. This engine has a compression ratio of 17.5:1. It has a power rating of 3.7 KW at 1200 rpm, 4 KW at 1500rpm,5.7 KW at 1800rpm and 6.2 KW at 2000rpm.

METHODOLOGY AND EXPERIMENTAL PROCEDURE:

1) Switch on the mains of the control panel and set the supply voltage from servo stabilizer To 220volts.

2) Open the cooling water line to the dynamometer

3) Engine is started by hand cranking under no load condition and allowed to run for a 20minutes to reach steady state condition.

4) The engine soft version V2.00 is run to go on ONLINE mode.

The engine has a compression ratio of 17.5 and a normal speed of 1500 rpm controlled by the governor. An injection pressure of 200 bar is used for the best performance as specified by the manufacturer. Between two load trials the engine is allowed to become stable by running it for 3 minutes before taking the readings. At each loading condition performance parameters namely speed, exhaust gas temperature, brake power, peak pressure are measured under steady state conditions. The experiments are repeated for various combinations of diesel, Pongamia and cotton seed oil biodiesel blends. With the above experimental results, the parameters such as total fuel consumption, brake specific fuel consumption, brake mean effective pressure, brake specific energy consumption, brake thermal efficiency are calculated. Finally graphs are plotted for brake specific fuel consumption, brake thermal efficiency with respect to loading conditions for diesel, bio-diesel and its blends [8,9]. From these plots, performance characteristics of the engine are determined.

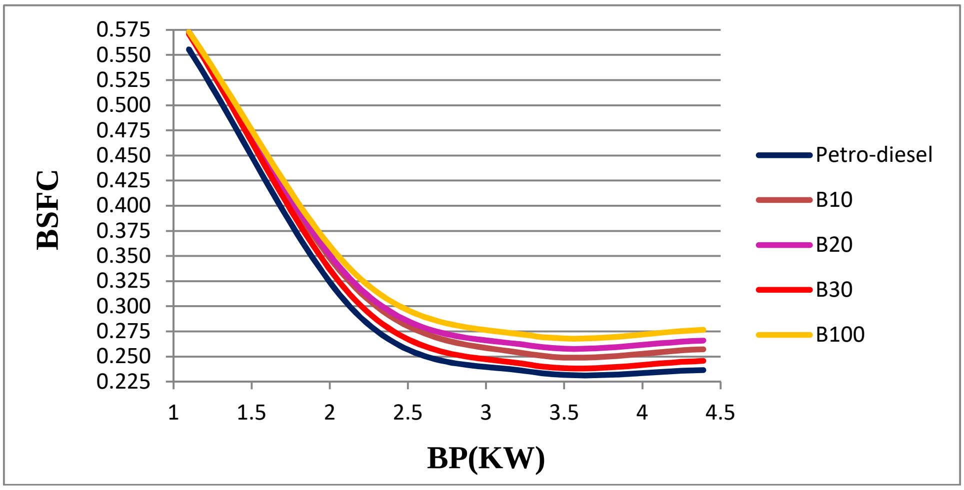
III RESULTS AND DISCUSSION

The experiments were conducted on a direct injection compression ignition engine for various brake power and various blends (Biodiesel-B10, B20, B30 and B100) of biodiesels. Analysis of performance like brake specific fuel consumption, brake thermal efficiency, Exhaust gas temperature and emission characteristics like hydrocarbon, oxides of nitrogen, carbon monoxide and carbon dioxides are evaluated. The biodiesel used is as per ASTM standard, there is no modification in the engine. The experiment is carried out at constant compression ratio of 17.5:1 and constant injection pressure of 200bar by varying brake power [10].

ENGINE PERFORMANCE:

BRAKE SPECIFIC FUEL CONSUMPTION

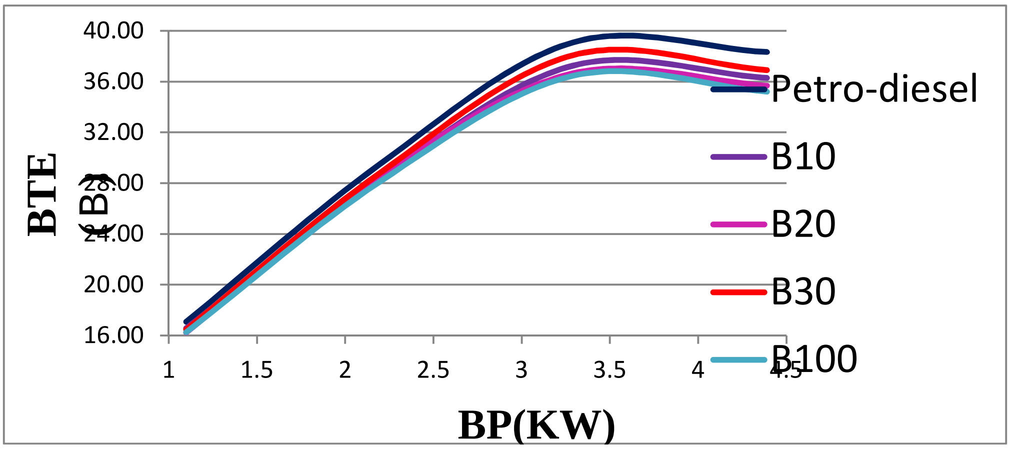
Specific fuel consumption is defined as the amount of fuel consumed for each unit of brake power developed per hour. It is a clear indication of the efficiency with which the engine develops power from fuel.The variation of Brake Specific Fuel Consumption with Brake Power for different ratio of bio-diesel for injection pressure 200bar are represented in Graph 6.1



Graph 1.7SHOWS BSFC (BRAKE SPECIFIC FUEL CONSUMPTION) CURVE VS BP (BRAKE POWER)

The variation of specific fuel consumption with respect to brake power is presented in Graph 1.7 for different blends & diesel. The oxygen content in the bio-diesel is more at low load which helps in easy combustion of fuel. Hence graph shows maximum fuel consumption at low load. At higher brake power the BSFC decreases. This may be due to fuel density, viscosity and heating value of the fuels. The curve B30 is almost tracing the path of diesel curve & this indicates blend B30 can be a favorable to existing diesel engine.

BRAKE THERMAL EFFICIENCY

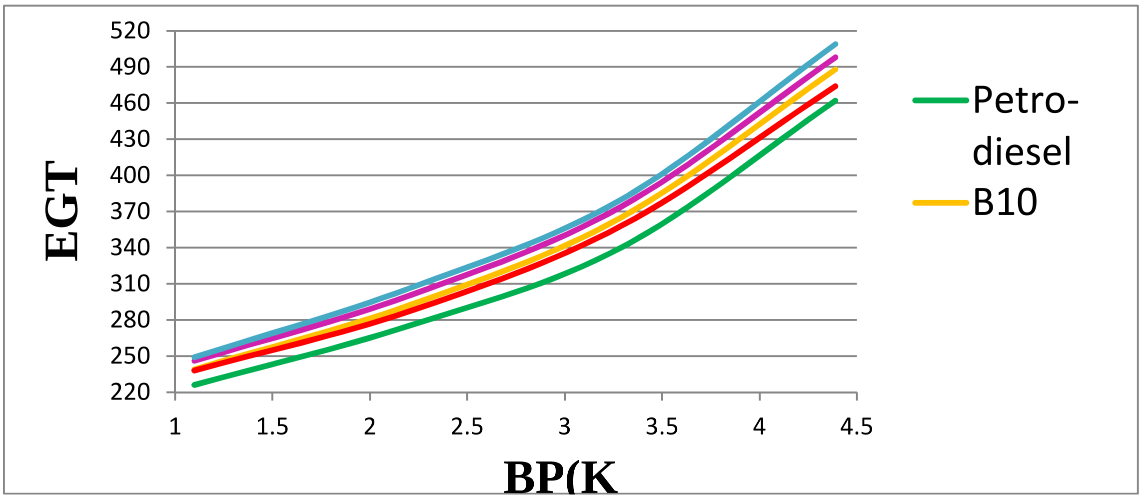


Graph1.8SHOWS BTE (BRAKE THERMAL EFFICIENCY) CURVE VS BP (BRAKE POWER)

Graph 1.8 shows that the variation of brake thermal efficiency (BTE) with Brake power for different blends. Brake thermal efficiency is defined as the ratio between the brake power output and the energy of the fuel combustion. Graph shows as the Brake power increases the brake thermal efficiency increases to an extent and then decreases slightly at the end. The decrease in brake thermal efficiency for higher blends may be due to the combined effect of its lower heating value and increase in fuel consumption. The curve B30 is running nearer to the Diesel curve, which shows B30 blend can be a favorable to existing diesel engine.

EXHAUST GAS TEMPERATURE

The variation of exhaust gas temperature with applied load for different blends is shown in Graph 1.9. The result indicates that the exhaust gas temperature decreases for different blends when compared to that of diesel. The highest temperature obtained is 455 °C for standard diesel for full load. Lower exhaust loss may be a possible reason for higher performance.



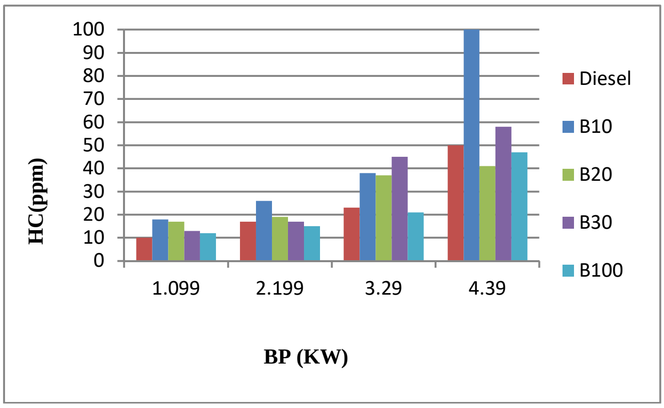
Graph 1.10SHOWS EGT (EXHAUST GAS TEMPERATURE) VS BP (BRAKE POWER)

The variation of Exhaust gas temperature with respect to brake power is presented in graph 1.10 for different blends & diesel. This rise of temperature is because of continuous flow of exhaust gas through outlet port.

EXHAUST EMISSION:

HYDRO CARBON EMISSION

Unburnt hydro carbons emission is the direct result of incomplete combustion. It can be observed from, HC emissions of Pongamia and cotton seed oil blends are highly lower than diesel fuel. Because the diesel is having an incomplete combustion of the tested fuels. The biodiesel blends, generally exhibit lower HC emission at lower engine loads and higher HC emission at higher engine loads. This is because of relatively less oxygen available for the reaction when more fuel is injected into the engine cylinder at a high engine load. The variation of hydrocarbon emission for different blends is shown in graph 1.11

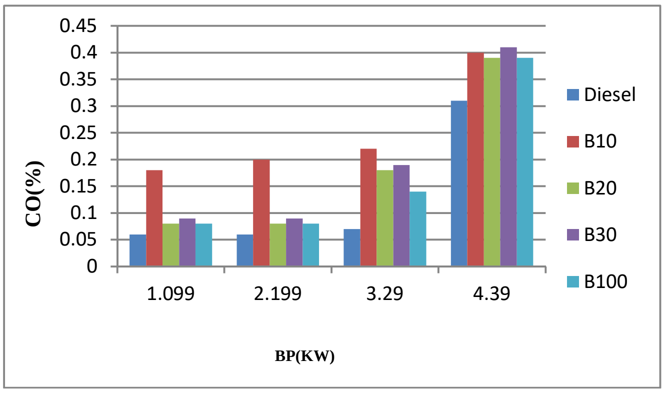


Graph 1.11 HC (HYDROCARBON) V/S BP (BRAKE POWER) FOR DIESEL AND PONGAMIA AND COTTON SEED OIL BIO-DIESELS BLENDS

For Pongamia and cotton seed oil blends HC emission is more for B10 (100 ppm) at higher loads when compared with B20 and B30. It is very less for B20 and is 40ppm.

CARBON MONOXIDE

The carbon monoxide emission is shown here for different blends and compared with diesel. With increase in load the CO emission increases. As the load increases the rich mixture is supplied hence incomplete combustion takes place and more carbon monoxide is produced. The carbon emissions are more for diesel when compared to other blends, while it is less for B30 at higher load condition.

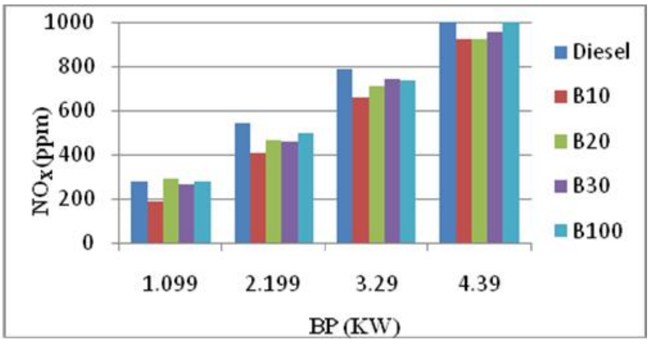


Graph1.12 SHOWS CO (CARBON MONOXIDE) V/S BP (BRAKE POWER) FOR DIESEL AND PONGAMIA AND COTTON SEED OIL BIO-DIESELS BLENDS

The carbon emissions are shown in graph 1.12 for different blends and compared with diesel. The CO emission is increasing with increase in load. Is as the load increases the rich mixture is supplied hence incomplete combustion takes place and more carbon monoxide produced. CO emission is more for B10 (about 0.1%) when compared with all other blends.

NITROGEN OXIDES

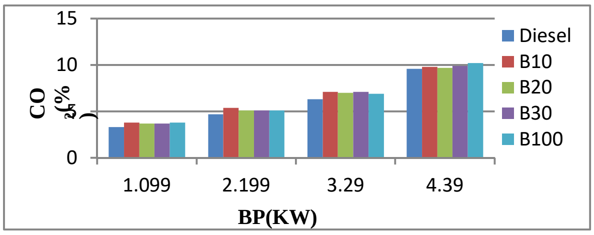
The variation of NOx emission for different dual biodiesel blends is indicated in below graph 1.13 Oxides of nitrogen in the engine exhaust are a combination of nitric oxide (NO) and nitrogen dioxide (NO_2). It is well known that the biodiesel contains a small amount of nitrogen. NOx emission of the B10, B30 is lower than diesel at lower Brake power and intermediate level Brake power and it increases at maximum load.



Graph 1.13 NOX (NITROGEN OXIDE) V/S BP (BRAKE POWER) FOR DIESEL AND PONGAMIA AND COTTON SEED OIL BIO-DIESELS BLENDS

For full load the NOx emission from the blend B10, B20 is higher than that of diesel. The other blends closely follow standard diesel. The reason for higher NOx emission for blends is due to the higher peak temperature.

CARBON DIOXIDE



Graph 1.14CO_2 (CARBON DIOXIDE)V/S BP(BRAKE POWER) FOR DIESEL AND PONGAMIA AND COTTON SEED OIL BIO-DIESELS BLENDS

Graph 1.14 shows the variation of CO_2 emissions with brake power for different blends & diesel. The CO_2 emission for biodiesel and its blends is higher than that of standard diesel at all brake powers. As the load increases the supply of fuel increases which causes the emission of CO_2 at full brake power. In the figure B10, B20 and B30 blends showing similar values but blend B30 is preferred.

IV CONCLUSIONS

- HOME satisfies the important fuel properties as per ASTM specification of Biodiesel.
- The existing diesel engine performs satisfactorily on biodiesel fuel without any significant engine modifications.
- Among the blends, B30 gave better results as Brake thermal efficiency, brake specific fuel consumption, hydrocarbons and NOx without any modification in the diesel engine..
- In view of the petroleum fuel shortage, B30 blend biodiesel can certainly be considered as a potential alternative fuel.
- The use of CaO catalyst yields more biodiesel (920ml-950ml) and the catalyst will be used 4 to 5 times.
- The cost of Cao catalyst is less as compared to the homogeneous catalyst like KOH, NaOH.

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