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Performance Test on Diesel-Biodiesel – Propanol Blended Fuels in CI Engine

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Abstract:-Increase in energy demand, stringent emission norms and depletion of oil resources have led there searches to find alternative fuels for internal combustion engines. On the other hand Palm oil can be used as biodiesel because of it contains more fatty acids. Also in India it is available in large amount. By transesterification process Palm oil can be used as biodiesel. Hence it was planned to increase the combustion efficiency, Performance and to reduce the exhaust emission by adding biodiesel 20%, n-propanol 10% volume with Diesel. The Performance observed while using blended fuels were analyzed and compared with that of Diesel as fuel without any additives. This experimental investigation aimed at to enhance the performance of the diesel engine with the blend of n-propane at different proportions like 10% by volume is attainable. To this, within the scope of the blending of n-propanol with diesel shows almost same brake thermal efficiency at low and medium loads, and higher percentage addition of n-propanol augments the brake thermal efficiency at high loads. The blending of n-propanol with diesel reduces the brake specific energy consumption at medium and high loads. But specific fuel consumption is increased when compare with Diesel.

Keywords:-Palm Oil, Bio-Diesel, Propanol, Transesterification, Methanol, Potassium Hydroxide.

I. INTRODUCTION

A. Need for Biodiesel

Since the commencement of industrial revolution in the late 18th and early 19th century, energy has become an indispensable factor for mankind to preserve economic growth and maintain standard of living. The most of global primary energy production derives from fossil energy. Fossil fuels accounted for 88% of the primary energy consumption, with oil (35% share), coal (29%) and natural gas (24%) as the major fuels, while nuclear energy and hydroelectricity account for 5% and 6% of the total primary energy consumption, respectively.

However, due to the limited traditional fossil energy resources and increased environmental concerns, a requirement for alternative energy sources has been paid a great attention in recent years. Developing alternative energy is an inevitable choice for sustainable economic growth in human society. In addition, it is also important for the harmonious coexistence of human and environment as well as for the sustainable development. Considerable attention was focused on the development of bio fuel, with particular referring to the biodiesel. Biodiesel offers a number of technical and environmental befits over conventional fossil-based fuels. Especially, similarities between the combustion properties of biodiesel and fossil-based diesel have made the former one of the most promising alternatives to a renewable and sustainable fuel for the automobile. increased biodiesel production is being proposed as one solution to the need to ease the impact of increased demand for crude oil and to reduce emissions of greenhouse gases.

Despite this, biodiesel has yet to reach its full commercial potential, especially in the developing countries. Besides technical barriers, there are several nontechnical limiting factors which impede the development of biodiesel such as feedstock price, production cost, and fossil fuel price and taxation policy.

B. Environmental Benefits of Bio-Diesel

Environmental benefits in comparison to petroleum based fuels include:

- Biodiesel reduces emissions of carbon monoxide (CO) by approximately 50% and carbon dioxide by 78% on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was in the atmosphere, rather than the carbon introduced from petroleum that was sequestered in the earth’s crust.
- Biodiesel can reduce as much as 20% the direct emission of particulates, small particles of solid combustion products, on vehicles with particulate filters, compared with low-sulfur diesel. Particulate emissions as the result of production are reduced by around 50% compared with fossil-sourced diesel.

- Biodiesel produces between 10% and 25% more nitrogen oxide NO_X tailpipe emissions than petro diesel. As biodiesel has low Sculpture content, there is no Sulphur di oxide emission..
- Biodiesel is biodegradable and non-toxic – the U.S. department of Energy confirms that biodiesel is less toxic than salt and biodegrades as quickly as sugar.
- The main benefit of biodiesel is that it can be described as ‘carbon neutral’. This means that the fuel produces no net output of carbon in the form of carbon dioxide (CO_2)
- This effect occurs because when the oil crop grows it absorbs the same amount of CO_2 as is released when the fuel is combusted. In fact this is not completely accurate as CO_2 is released during the production of the fertilizer required to fertilize the fields in which the oil crops are grown
- It should be noted that as biodiesel contains 11% oxygen it has a lower heating value than fossil diesel. If using 100% biodiesel 5-6% more fuel volumetrically would be expected to be used to maintain the same level of power and performance in an engine.

Requirements for Biodiesel (B100) Blend Stock ASTM D6751		
Property	**Limits**	**Units**
Calcium and magnesium combined	5 max	Ppm
Flash point	93.0 min	°C
Water and sediment	0.050 max	vol %
Kinematic viscosity, 60°C	1.9-6.0	mm^2/s
Sulfated ash	0.020 max	% mass
Sulfur	0.0015 max (S15) 0.05 max (S500)	% mass
Copper strip corrosion	0.020 max	-
Cetane number	47 min	-
Carbon residue	0.050 max	% mass
Acid number	0.50 max	mg KOH/g
Free glycerin	0.020	% mass
Total glycerin	0.240	% mass
Phosphorus content	0.001 max	% mass
Distillation temperature, 90% recovered (T90)	360 max	°C
Oxidation stability	3 min	Hours

Table 1: Requirements for Biodiesel (B100) Blend Stock ASTM D6751

II. MATERIALS AND REAGENT

The palm oil available in the south region of India. Another reason for selecting palm is that it contain high free fatty acid content which increases the yield of biodiesel. Palm oil based biodiesel do not cause any ignition delay. The ignition delay decreased as the palm oil content increased. This is due to the higher oxygen content in the palm oil based biodiesel. The production capacity of palm oil is more when compared to other vegetable oils. at an average production capacity of 5000 kg oil/napalm tree oil is the most efficient energy crop,and about 2.5 times more efficient as its next closest plant/oil seed, coconut oil.Palm oil is carbon neutral, therefore harmful gases like carbon dioxide, carbon monoxide are not released, and since these are greenhouse gases their harmful impacts are prevented. it also eliminates harmful emissions. palm oil is to achieve energy independence and to protect the environment care. Methanol used in the reaction had more than 99.25% purity, sodium hydroxide used as catalyst Transesterification occur at a faster rate in the presence of an alkaline catalyst than in the presence of the same amount of acid catalyst.

III. PREPARATION OF BIODIESEL

Biodiesel is produced through a process called transesterification. This process involves altering the chemical properties of the oil by using an alcohol. There are three basic processes to produce biodiesel**.**

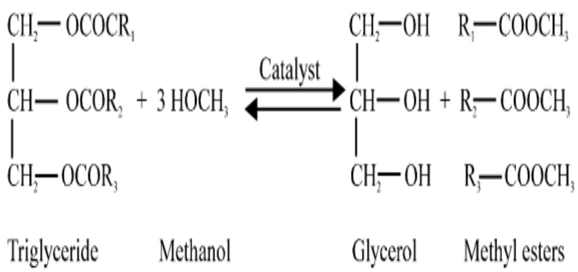
- Single step - base catalyzed reaction
- Two step- acid- base catalyzed reaction
- Two step- base - base catalyzed reaction

Among these, the single step, base catalyzed reaction is the easiest and fastest to produce biodiesel. It is suitable for palm oils with low free fatty acid content.

The transesterification reaction of palm oils with an alcohol like methyl alcohol or ethyl alcohol yields two products namely

- Fatty acid methyl ester(FAME)- called as bio diesel.
- Glycerin- used in cosmetic / pharmaceutical industries.

The general chemical equation of transesterification process is:



A. Experimental Producture

Predetermined catalyst amount was weighed using an electronic weighting machine. Methanol measured using the measuring jar according to the molar ratio was taken in a conical flask. The weighted catalyst was put in the conical flask containing methanol and was mixed well using, the magnetic stirrer for 5 minutes. The palm oil is taken in conical flaskkept in the heater to heat the oil. Then oil heat is heated to 60°c.The methanol and sodium hydroxide is mixed together and then stirrer well in the flask.The methanol and catalyst (sodium hydroxide) mixed is pour into the preheat palm oil. The reaction flask is then placed in the magnetic stirrer with hot plate and the measurement of time is started at this point.

The reaction mixture remained for 30-40 minutes in the water bath at a temperature of 60°c and with a constant stirring. heating and stirring are continued for different reaction time at atmospheric pressure. It is then stirred well for 40 minutes using magnetic stirrer.60°c of the mixture it is then transferred to the separating funnel and kept for some minutes (20minutes) for the separation of glycerol from biodiesel. After the completion of the transesterification reaction, the reaction mixture was filtered for the separation of catalyst and the filtrate was transferred into a separating funnel for phase separation.the ester mixture formed the upper layer and the glycerol form in the lower layer.

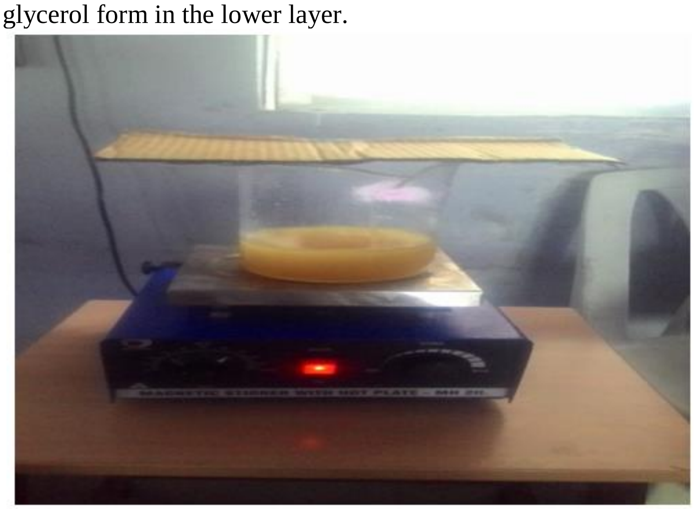


Fig. 1Transesterification Process

Fig. 2 Separation Process

Properties	**Biodiesel**	**ASTM standard for biodiesel**
Density (kg/m^3)	882	830-900
Kinematic viscosity @ 40°C (10^{-6} m^2/sec)	4.63	1.9-6
Flash point (°C)	128	>110
Fire point (°C)	136	>120

Table 2: Properties of Biodiesel

B. Experimental Procedure

A single cylinder four stroke diesel engine is coupled with the alternator having the provision of electrical loading.The specifications of the engine used for the experimentation is given in the Appendix 1 Continuous water supply is given to the engine for the cooling. The air box with orifice meter and water manometer is used to measure the flow rate of air supplied to the engine .Two separate fuel tanks were used; one for diesel and the other for biodiesel The volumetric flow of fuel is measured using burette and a stop watch. The specifications of the alternator coupled with the engine is given in the Appendix 2.

The performance of a constant speed, single cylinder 5 hp diesel engine was determined using various fuel blends. The engine performance such as Brake specific fuel consumption, total fuel consumption, brake thermal efficiency and exhaust , were determined.

The engine was coupled to an electrical dynamometer consisting of a loading rheostat to provide the brake load. Two separate fuel tanks were used for the diesel and biodiesel-alcohol blends. The fuel consumption was determined by measuring the time taken for a fixed volume of fuel to flow into the engine. The air was supplied to the engine through an air box with an orifice plate placed on one of its sides.

The air flow rate to the engine was determined by measuring the pressure across the orifice plate with the aid of a U-tube manometer .The observations made during the test included the brake load, engine speed, and time taken for consumption of fuel, drop in air pressure across the orifice meter.

The performance parameters such as brake specific fuel consumption and brake thermal efficiency were calculated.

The photograph of the experimental setup is given in the Fig 3

Fig. 3 Photograph of Experimental Setup

IV. FORMULA USED

- Brake Power = 2ΠNT/(60*1000)in kw N = Speed in RPM

  T = Torque in N-M

  T = S*R (R=0.32m)

  S = Load in Newton

- Fuel Consumption (FCH) =10CC*Specific gravity*3600 /t*1000 in kg/hr

  Specific gravity for diesel =0.85

- Specific fuel consumption(SFCH) = FCH/BP
- Indicated power(IP) =BP+FP in kw(FP=2.5kw)
- Mechanical efficiency = BP/IP
- Indicated thermal efficiency = IP*3600*100%FCH*CV

  CV= 45000 for Diesel

- Break thermal efficiency = BP*3600*100%FCH*CV

V. RESULT AND DISCUSSION

A. Properties of Fuel Blends

The properties of various fuel blends were determined and presented in Table 5.1. The viscosity was found to decrease by adding propanol. The viscosity of biodiesel is 4.63 centi stokes @ 60^0 C. In biodiesel (80) - propanol (20) combination the viscosity reduces to 3.80 centi stokes @ 60^0 C.

The property of the blends which is calculated is given in the Table 3.

Fuel	**Density (kg/m^3)**	**Flash point (°C)**	**Kinematic viscosity (x $10^{-6} m^2/sec$)**
Diesel	840	60-80	3.35
Biodiesel	882	128	4.63
D(70) B(20) P(10)	879	85	4.12

Table 3: Properties of the Fuels

B. Performance Test In CI Engine

a). Break Power Vs SFC

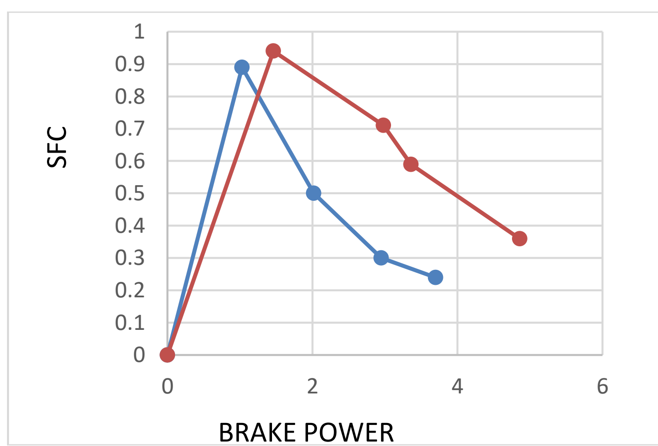


Fig. 4 Brake Power vs. Specific Fuel Consumption

Fig. 4 shows the variation of specific fuel consumption (SFC) for the engine using diesel, biodiesel, biodiesel-propanol blend with Brake power(BP). Due to the reduction effect of propanol on the energy content of the blends, there is usually increase in

SFC. Among the fuels tested the lowest BSFC values are obtained with diesel fuel due to low fuel consumption rate and high brake power. Here are significant increases in BSFC especially when the engine is fueled 2with blends having high propanol content because of higher fuel consumption rates and reduction in brake power.

b). Brake Power Vs Mechanical Efficiency

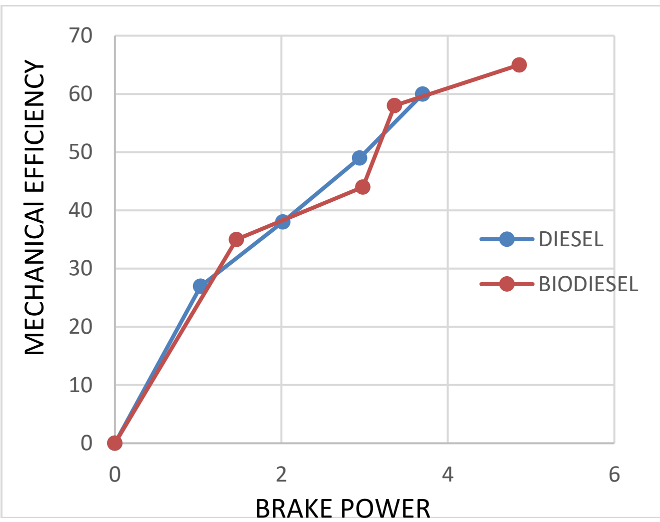


Fig. 5 Brake Power vs. Mechanical Efficiency

Fig 5 shows that variation of mechanical efficiency for the engine using diesel, biodiesel, propanol blend with Brake power (BP). There is gradual increase in mechanical efficiency with respect to brake power. When compare with diesel and blended fuel, blended has higher mechanical efficiency.

c). Brake Power Vs Indicated Thermal Efficiency

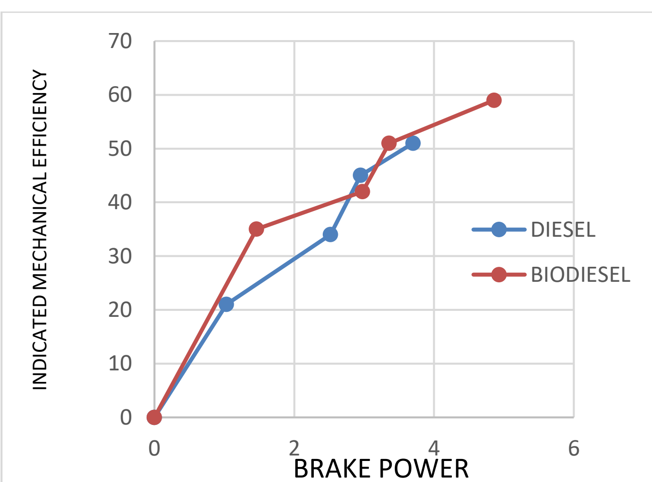


Fig. 6 Brake Power vs. indicated Thermal Efficiency

Fig. 6 shows that variation of indicated thermal efficiency for the engine using diesel, biodiesel, propanol blend with Brake power (BP). There is gradual increase in mechanical efficiency with respect to brake power. When compare with diesel and blended fuel , blended has higher indicated thermal efficiency.

d). Brake Power Vs Brake Thermal Efficiency

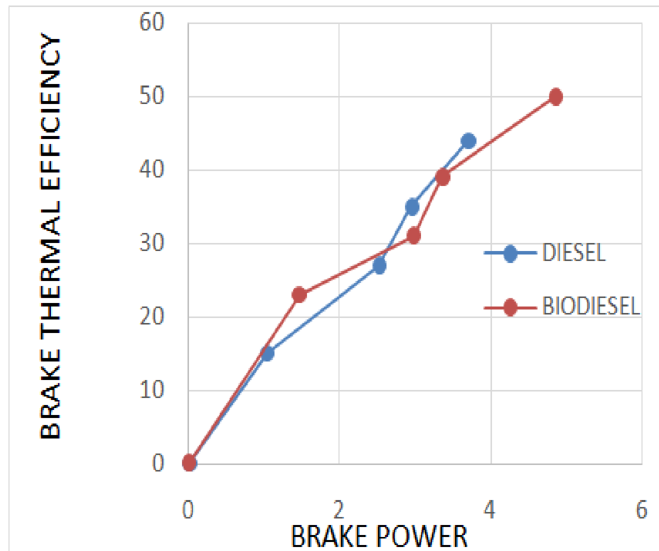


Fig.7 Brake Power vs. Brake Thermal Efficiency

Fig 7 shows that blending of n-propanol with diesel shows almost same brake thermal efficiency at low and medium loads, and higher percentage addition of n-propanol augments the brake thermal efficiency at high loads. The blending of n-propanol with diesel reduces the brake specific energy consumption at medium and high loads.

VI. CONCLUSION

This experimental investigation aimed at to enhance the performance of the diesel engine with the blend of n-propanol at different proportions like 10% by volume is attainable. From theexperimentation,The blending of n-propanol with diesel shows almost same brake thermal efficiency at low and mediumloads, and higher percentage addition of n-propanol augments the brake thermal efficiency at high loads.

The blending of n-propanol with diesel reduces the brake specific energy consumption at medium and high loads.From the above discussions, the blending of n-propanol with diesel at optimum percentage may be recommended and further researches in this area by advancing the injection timing and introducing the exhaust gas recirculation techniques will turn out to be highly efficacious..

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