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Comparative Analysis of Biodiesel as a Additive with Pure Diesel in Single Cylinder Four Stroke Diesel Engine Processes

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ABSTRACT

At present, the demand of energy resources is increasing while their stocks are decreasing with high rate. Bio-diesel is an energy source which is renewable and would help in controlling the demand and supply of fuel but also in the reduction of pollution. Bio-diesel is simple to use and easy to transport. Different ratios of bio-diesel and diesel were mixed to prepare blends which showed viscosity, heat content, density, efficiency closer to diesel. The performance of various blends was tested on four stroke single cylinder compression ignition engine. Testing showed that partial substitution of diesel by bio-diesel can result in increase performance of engine. The results conclude that bio-diesel would be a better alternative to diesel in coming days.In this investigation we were planed to investigate fuel consumption, power in different loading condition, break specific fuel consumption, break mean effective pressure from bio-diesel (Blend of 5% Growdiesel + HSD, 2% Growdiesel + HSD,1% Growdiesel +HSD, .5% Growdiesel +HSD) with HSD. Planed to take 10 hr trials in cache combination and comparison of data and valuable findings related cost. The results that the performance of high percentage blends and pure bio-diesel doesn't fit the engine due to their viscosity and low thermal efficiency.

Keywords: *Biodiesel; Performance; Emissions; Diesel Engine.*

1.0 Introduction

Biodiesel is the name of a clean burning alternative fuel produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with no major modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics[1]

Biodiesel derives from vegetable oil by a process of transesterification. Alcohol, usually methanol, is added to the vegetable oil, and using sodium or potassium hydroxide a is a catalyst, the glycerin and methyl esters are separated. The glycerin is then removed to be sold and biodiesel remains. This process is economical and straightforward because it occurs at low temperature (150° F) and low pressure (20 psi).

Once the oil, methanol and catalyst are mixed, the entire transesterification process takes 3-6 minutes. In this chemical reaction, methanol substitutes for the glycerin in a chemical reaction, generally using lye as a catalyst. The final part of the process is separation of the less dense esters floating above the denser glycerol. The floating esters are usually drawn out of the primary vessel and the process is repeated, with less methanol and catalyst used in the secondary transesterification. This ensures the greatest yield of esters.[2]

Vegetable oils with low free fatty acid levels are best suited for biodiesel. Catalysts are used to free the esters from the fatty acids, and when free fatty

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acids are present in the vegetable oil, they consume catalyst without providing and energy in the form of esters. Oils can be neutralized, reducing the free fatty acids to less than 0.5% of the oil, at which catalyst consumption is acceptable.

High phosphorous content in biodiesel is also problematic because it leads to emulsification of natural rubbers, which can cause gasket failure. Phosphorous in safe in levels below 3 to 4 ppm is hazardous to use because the risk of emulsification is too high. Insolubles in the fuel will not filter out in the transesterification process, ending up in the final fuel, so no more than 0.8% of the oil may be insoluble.

The methanol used in the transesterification process is flammable and toxic, and great caution must be used in its handling. Biodiesel is more viscous than regular diesel fuel because as vegetable oils cool, wax crystals form and the oil clouds and begins to solidify.

Soy oil solidifies at –16° C. Biodiesel made with ethanol usually has a lower clouding point than biodiesel made with methanol, but ethanol is prohibitively more expensive[3].

Table 1: Biodiesel Versus Dino Diesel: Emissions

Pollutant	Percent Change in Emissions compared to Petroleum Diesel
Particulate	48 % decrease
Hydrocarbons	67 % decrease
CO	48 % decrease
NOX	10 % increase
CO2	0.2 % increase

So burning biodiesel releases a lot less smoke, hydrocarbons and carbon monoxide, but significantly more nitrogen oxides, and slightly *more* carbon dioxide.

The overall ozone (smog) forming potential of biodiesel is almost 50% less than diesel fuel. Sulfur emissions are eliminated. Substantial reductions of unburned hydrocarbons (-93%), carbon monoxide (-50%), and particulate matter (-30%).

Biodiesel NOx emissions can be efficiently eliminated as a concern. Substantial reductions of cancer-causing PAH (-80%) and nitrited PAH compounds (-90%).

1.1 The advantages of using biodiesel fuel

You might have heard a lot about biodiesel. Biodiesel is diesel than can power up your car that is made from vegetable oils and other natural sources. It does not come from the regular crude oil that usually has to be imported from oil-producing countries.

Biodiesel can be considered a new technology, taking into account all the years consumers have had to settle for traditional diesel. Using biodiesel for your car has many advantages:

1. Biodiesel is not harmful to the environment. Unlike its counterpart, a car using biodiesel produces fewer emissions. If a vehicle uses traditional diesel, the vehicle emits black, stinky smoke. With biodiesel, the smoke becomes very clean indeed.
2. Biodiesel may not require an engine modification. Some cars can take advantage of biodiesel without the need to undergo engine alterations. Some mix 20% biodiesel with regular diesel. Doing so enables the car to benefit from the good points of biodiesel without the hassle.
3. Biodiesel is cheap. You can even make biodiesel in your backyard. If your engine can work with biodiesel fuel alone, then you really need not go to the gas station to buy fuel. You can just manufacture some for your own personal use.
4. Biodiesel can make the vehicle perform better. It is noted that biodiesel has a cetane number of over 100. Cetane number is used to measure the quality of the fuel’s ignition. If your fuel has a high cetane number, you can be sure that what you get is a very easy cold starting coupled with a low idle noise.
5. Biodiesel can make your car last longer. Because of the clarity and the purity of biodiesel, you can be sure it will not have too many impurities to harm your car. It is actually more lubrication. A car’s power output is unaffected by this type of diesel.
6. Biodiesel reduces the environmental effect of a waste product. Because biodiesel is made out of waste products itself, it does not contribute to nature’s garbage at all. Biodiesel can be made out of used cooking oils and lards. So instead of throwing these substances away, the ability to turn them into biodiesel becomes more than welcome.[4]

7. Biodiesel is energy efficient. If the production of biodiesel is compared with the production of the regular type, producing the latter consumes more energy. Biodiesel does not need to be drilled, transported, or refined like petroleum diesel. Producing biodiesel is easier and is less time consuming.

8. Biodiesel is produced locally. A locally produced fuel will be more cost efficient. There is no need to pay tariffs or similar taxes to the countries from which oil and petroleum diesel are sourced. Every country has the ability to produce biodiesel.

Biodiesel is surely a viable fuel alternative. Moreover, it is also a sustainable fuel. Using biodiesel not only helps maintain our environment, it also helps in keeping the people around us healthy.

2.0 Analysis of Biodiesel with Diesel

2.1. Specifications of engine used

Engine Make and type- Kirloskar (AVI-5.0)
Single cylinder, four stroke, water cooled
Vertical Engine
Bore (mm) - 80mm
Stroke (mm) - 110mm
Displacement Volume (cc) - 553cc
Compression Ratio- 16.5:1
Rated Output - 3.7KW (5.0 H.P.)

2.2 Formulae used for calculation of various engine performance parameters calculations

3.1.1 Break power

In the present case cradle type electrical dynamometer has been used.

Let S□ = Spring balance reading (kg)
Let S2 = Spring balance reading (kg)
L = Length of the force arm
N = Revolution per minute
Break Torque = 9.81(S□- S2) Reff Nm

Break power = $\frac{2\pi\ (N/60)\{9.81\times(S□ - S2)\}Reff}{1000}$ KW

= $1.027\times10^{-3}N$ (S□- S2) L KW

The load on the engine is applied by switching on the electric bulbs in turn.

3.1.2 Break Mean Effective Pressure

Bmep = $\frac{60{,}000\times\text{break power}}{L\ AN\times n}$ N/m²

Where
L = Length of stroke (m)
A = Area of piston (m²)
N = Revolution per minute (rpm)
n = no. of power stroke per cycle
= ½ for four stroke engines
= 1 for two stroke engines.
Where break power in kW.

3.1.3 Break specific fuel consumption

Break specific fuel consumption is defined as rate of fuel consumption per unit break power produced

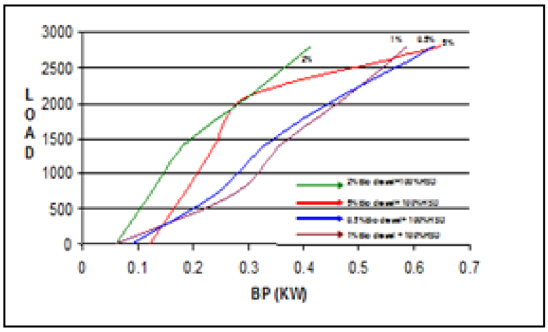
Bsfd = $\frac{\text{Fuel consumption per unit time}}{\text{Break power}}$

3.1.4 Break thermal efficiency

It is defined as the ratio of break power to the energy supplied to the engine.

$\eta bth = \frac{\text{break power}}{\text{Mass of fuel/s} \times \text{calorific value of fuel}}$

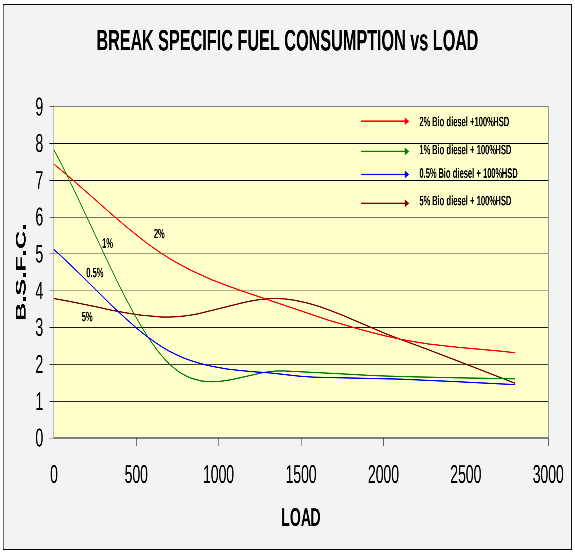
Fig.-1: Load Vs Break Power



In figure 1, shows the break power at different load condition. At no load condition, the blend of 1% biodiesel (miracle) +100% pure diesel gives minimum break power (.061 kw), the blend of 2% biodiesel (miracle) + 100% pure diesel gives break power of .062 kw, the blend of .5% biodiesel (miracle) + 100% pure diesel gives break power of .091 kw, the blend of 5% biodiesel (miracle) + 100% pure diesel gives maximum break power (.122 kw).

At max load condition, the blend of 2% biodiesel (miracle) + 100% pure diesel gives minimum break power (.415 kw), the blend of 1% biodiesel (miracle) +100% pure diesel gives break power of .588 kw, the blend of .5% biodiesel (miracle) + 100% pure diesel gives break power of .638 kw, the blend of 5% biodiesel (miracle) + 100% pure diesel gives maximum break power (.650 kw).

Fig .2: Load vs Fuel Consumption



In figure 2, shows the fuel consumption at different load condition. At no load condition, the blend of 0.5% bio diesel (miracle) + 100% pure diesel gives minimum fuel consumption (461ml/hr), the blend of 5% bio diesel + 100% pure diesel and 2% bio diesel + 100% pure diesel gives equally fuel consumption (461.5ml/hr) and the blend of 1% bio diesel + 100% pure diesel gives maximum fuel consumption (477.70ml/hr). At maximum load condition (2800 watt), the blend of 0.5% bio diesel + 100% pure diesel gives minimum fuel consumption (923ml/hr), the blend of 1% bio diesel +100% pure diesel gives fuel consumption of 946.37ml/hr, the blend of 2% bio diesel +100% pure diesel gives fuel consumption of 960ml/hr and the blend of 5% bio diesel + 100% pure diesel gives maximum fuel consumption. In figure 3 the break specific fuel consumption at different load condition. At no load condition, the blend of 5% bio diesel + 100% pure diesel gives minimum break specific fuel consumption (3.782 lr/kw hr), the blend of 0.5% bio diesel + 100% pure diesel gives break specific fuel consumption (5.12 lr/kw hr), the blend of 2% bio diesel + 100% pure diesel gives break specific fuel consumption (7.44 lr/kw hr), the blend of 1% bio diesel + 100% pure diesel gives maximum break specific fuel consumption (7.83 lr/kw hr).At maximum load condition (2800w), , the blend of 0.5% bio diesel + 100% pure diesel gives minimum break specific fuel consumption (1.45 lr/kw hr), the blend of 5% bio diesel + 100% pure diesel gives break specific fuel consumption (1.48 lr/kw hr), the blend of 1% bio diesel + 100% pure diesel gives break specific fuel consumption (1.61 lr/kw hr), the blend of 2% bio diesel + 100% pure diesel gives max break specific fuel consumption (2.31 lr/kw hr). In figure 4 the break mean effective pressure at different load condition. At no load condition, the blend of 1% bio diesel + 100% pure diesel gives minimum break mean effective pressure (2089. 2 N/ m²), the blend of 2% bio diesel + 100% pure diesel gives break mean effective pressure(2103.5N/ m²), the blend of 2% bio diesel + 100% pure diesel gives break mean effective pressure(3146.4N/ m²)and the blend of 5% bio diesel + 100% pure diesel gives max break mean effective pressure (4191.62 N/ m²) At maximum load condition (2800w), the blend of 2% bio diesel + 100% pure diesel gives minimum break mean effective pressure(14628.7N/ m²), the blend of 1% bio diesel + 100% pure diesel gives break mean effective pressure (20889.7 N/ m²), the blend of 5% bio diesel + 100% pure diesel gives break mean effective pressure (22987.3 N/ m²), and the blend of 0.5% bio diesel + 100% pure diesel gives max break mean effective pressure (23012.5 N/ m²)

Fig 3: Break Specific Fuel Consumption vs Load

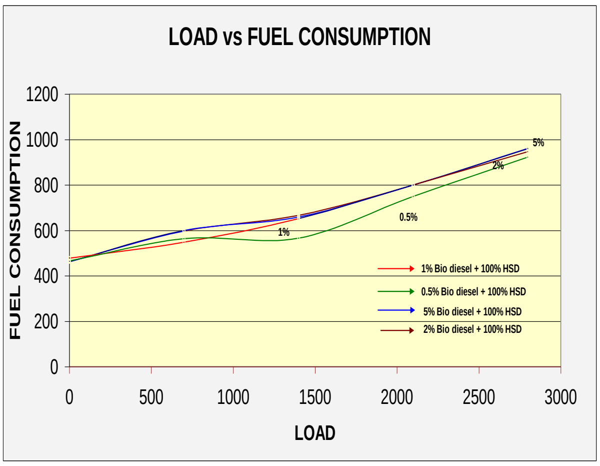


Fig 4: Load vs Break Mean Effective Pressure

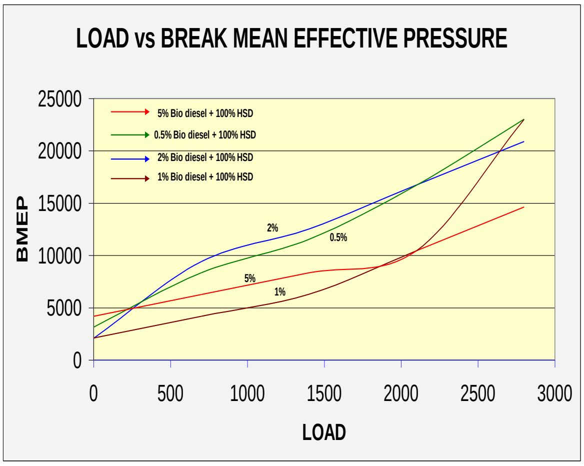
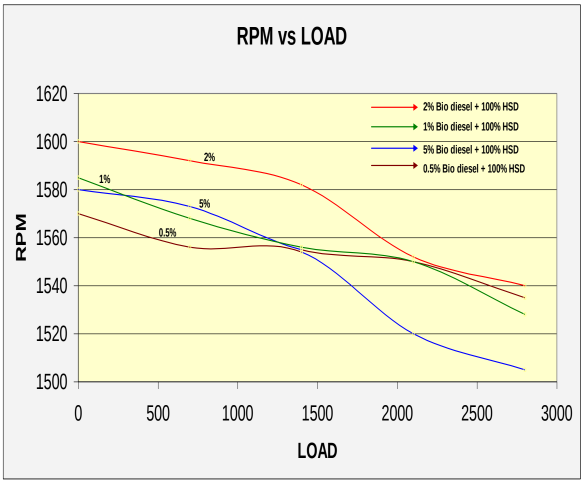


Fig -5: RPM vs Load



In figure 5 the RPM at different load condition. At no load condition, the blend of 0.5% bio diesel + 100% pure diesel gives minimum RPM (1570), the blend of 5% bio diesel + 100% pure diesel gives RPM (1580), the blend of 1% bio diesel + 100% pure diesel gives RPM (1585), And the blend of 2% bio diesel + 100% pure diesel gives max RPM (1600).

At maximum load condition (2800w), the blend of 0.5% bio diesel + 100% pure diesel gives minimum RPM (923), the blend of 1% bio diesel + 100% pure diesel gives RPM (946.7), the blend of 2% bio diesel + 100% pure diesel gives RPM (960) and the blend of 5% bio diesel + 100% pure diesel gives max RPM (961).

4.0 Conclusions

The ozone forming potential of the speciated hydrocarbon emissions is 50 percent less than that measured for diesel fuel. The exhaust emissions of sulfur oxides and sulfates (major components of acid rain) from biodiesel are essentially eliminated compared to diesel.

Tests show the use of biodiesel in diesel engines results in substantial reductions of unburned hydrocarbons, carbon monoxide, and particulate matter. Emissions of nitrogen oxides stay the same or are slightly increased. The exhaust emissions of carbon monoxide (a poisonous gas) from biodiesel are on average 48 percent lower than carbon monoxide emissions from diesel. Breathing particulate has been shown to be a human health hazard. The exhaust emissions of particulate matter from biodiesel are about 47 percent lower than overall particulate matter emissions from diesel.

The exhaust emissions of total hydrocarbons (a contributing factor in the localized formation of smog and ozone) are on average 67 percent lower for biodiesel than diesel fuel. Nitrogen Oxides**(**NOx)emissions from biodiesel increase or decrease depending on the engine family and testing procedures. NOx emissions (a contributing factor in the localized formation of smog and ozone) from pure (100%) biodiesel increase on average by 10 percent.

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