

Characteristics comparison of Biodiesel-Diesel Blend (B20) Fuel with Alcohol Additives

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Abstract— The effect of properties like density, viscosity and flashpoint with alcohol additives in biodiesel blend fuel has been studied. Biodiesel blend fuel (B20) is used for characterization to compare with 5% and 10% of ethanol and methanol. The results indicated that flash point of B20 decrease drastically at 5% alcohols and increases at higher percentages. Increase in flash point as blend concentration increase may be considered better with respect to safety in fuel handling. In case of viscosity and density, cetane number and acid values decrease as the percentage of alcohol increases. Alcohols lower the flash point slightly and reduces the viscosity and density of blend fuel marginally, with this fuel ignition can start at lower temperature and able to burn completely. The combustion rate of fuel is increased due to more oxygen availability in alcohol that results in reducing the levels of pollutants in exhaust gases.

Keywords— Biodiesel, Properties, Ethanol, Methanol, Blend fuel, Viscosity, Density.

I. INTRODUCTION

Depletion in fossil fuel sources, increasing dependence on imported crude oil and increasing the environmental pollution have led to the use of bioenergy from biofuels as an ideal alternative to diesel fuel. Considerable attention has been paid in the development of alternative fuel sources in India on biofuels which possess an added advantage of being a renewable fuel [1]. Biodiesel is an alkyl monoester available from vegetable oils, animal fats or waste cooking oils. It will be produced by transesterification process in presence of methanol as a catalyst to remove fats from oil. Renewability of bioenergy and its carbon-neutral structure, the bioenergy utilization can contribute to reduce carbon dioxide emissions. When ethanol was added to palm oil methyl esters-diesel blends B50 has shown significant difference in low temperature performance, with a maximum decrease in pour point temperature [2]. Recently biodiesel has received a great deal of attention because of

the advantages associated with its biodegradability, environment friendly and big resource of energy availability in nature [3].

The availability and sustainability of biodiesel feed stocks will be the crucial determinants in the popularization of biodiesel. Triacetin additive can be used as an antiknock agent to reduce engine knocking, to improve cold flow and viscosity properties of biodiesel. From the experiments it was concluded that 10% of Triacetin with biodiesel gives encouraging results [4]. Ethanol-biodiesels have lower cloud points for all blends compared to cloud points obtained for diesel fuel alone [5]. Bio-fuel consumption decreases by 3.5% at moderate loading conditions as compared to diesel [6]. In particular, biodiesel has received wide attention as a replacement for diesel fuel because it is biodegradable, nontoxic and emit less pollutant gases. Alcohols used as additives with biodiesel to dilute, achieve similar properties and performance characteristics as conventional diesel fuel [7, 8]. Increase in the quantity of alcohol additive in B50 improves in density, viscosity, pour point and cloud point and with slight decrease in energy content. The test fuel viscosity and density were decreasing by 41%, 2.73%, respectively with 20% ethanol in blend fuel. The flash and fire points were 51°C and 54°C slightly lower than the flash and fire points of the conventional diesel and 18.3% of energy content decreases as compared to the blend fuel.

The results of diesel-biodiesel mixture with methanol as an additive could reduce the exhaust gas temperature due to the higher oxygen content and increase heat of evaporation of the blended fuel, hence reduces the HC, NO_x emission and soot compared to diesel fuel [9]. Lower density of fuel is required to control fuel flow in the injection pump and minimize the smoke formation when operates with maximum power at higher loads [10]. The objective of this study is to determine the fuel properties of biodiesel B100, B20, B20-alcohol blend fuels at 5% & 10% and compare with mineral diesel as a baseline fuel.

These properties provide important data to further investigate the engine operation in terms of performance, combustion and emission characteristics with these fuels.

II. MAKING OF BIODIESEL

Straight Vegetable Oils (SVO) can be used directly as a fossil diesel fuel substitute, but using this fuel can lead to serious engine problems. Due to high viscosity of SVO, atomization of fuel in the cylinder is poor which leads to incomplete combustion and choking of the fuel injectors [11]. To overcome these problems transesterification process is used to produce biodiesel from SVO. Filtered karanja oil is heated at 105°C to remove water from the oil after that acid treated with methanol and sulfuric acid to remove part of glycerol from the karanja oil.

In base treatment sodium methoxide (mixture of NaOH and methanol) is added and the mixture is stirred while heating at a temperature below 65°C and cooled for settlement. After separating glycerol, the formed methyl ester is bubble washed with water and orthophosphoric acid to remove soap contents. The production process of biodiesel and reaction are shown in figures 1 and 6. The Karanja Oil Methyl Ester (KOME) is heated to remove water content in order to use in diesel engine [12, 13].

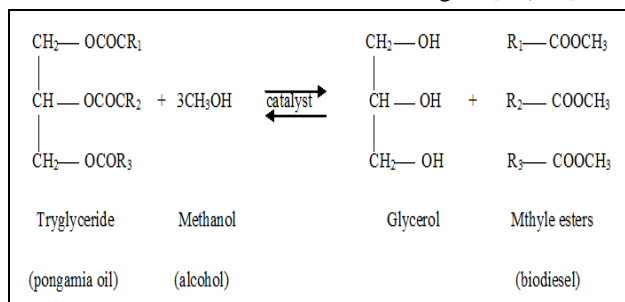


Fig. 1 Chemical reaction of biodiesel formation



Fig.2 Acid treatment Fig. 3 Glycerin separation



Fig. 4 Soaps separation Fig. 5 Clean water in washing



Fig. 6 Biodiesel (PPME)

III. METHODOLOGY USED

The required biodiesel was produced from karanja oil by transesterification process to prepare the blend fuel. The B20 (20% biodiesel and 80% diesel by volume) blend fuels with ethanol and methanol were prepared to study the properties. Ethanol and B20 blend fuel is inherently immiscible and needs an effective emulsifier to produce homogenous mixture of fuel. The mixtures was stirred continuously for 20 minutes and left for 30 minutes to reach equilibrium at room temperature before testing. The emulsifier would reduce interfacial tension force leading to emulsion stability. Biodiesel is known to act as an emulsifier due to its low polarity and long fatty acid carbon chain has potential to improve miscibility of ethanol and diesel over limited range. The fuels shown in table 1 with their percentages Diesel (D100), Biodiesel (B100), B20, B20E5, B20E10, B20M5 and B20M10 were tested to compare their properties.

The properties like flash point, viscosity, density, acid value and cetane number were measured and compared the results with normal diesel fuel as per standard ASTM procedures recommended by manufacturers. These tests were conducted in a controlled room temperature, pressure and relative humidity to ensure that the result will not be influenced with change in environment.

Table.1: Tested Fuels (B20+Alcohol)

S. No	Type of Fuel	Percentages in Blend Fuel
1	Diesel	100% Diesel
2	B100	100% Biodiesel
3	B20	20% Biodiesel+ 80% Diesel
4	B20E5	B20 with 5% Ethanol
5	B20E10	B20 with 10% Ethanol
6	B20M5	B20 with 5% Methanol
7	B20M10	B20 with 10% Methanol

3.1 Flash point: Flash point is the lowest temperature of fuel measured at which the test causes flash flame on the surface of fuel inside the cup due to formation of vapours. The temperature at which the test flame causes burning for a period of about five seconds continuously is called fire point. Samples of 75ml fuel were poured into a flash point cup which was connected to the regulator bath and increases the temperature from 20°C to a maximum of 200°C.

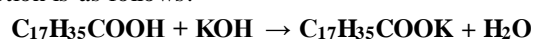
3.2 Viscosity: Viscosity can be defined as the resistance of oil to flow by overcoming the internal friction. Vegetable oils have very high viscosity to use as fuel in diesel engine. This can be significantly reduced to form as biodiesel by using transesterification process. Biodiesel viscosity is also higher as compared to diesel fuel, but it can be used as a substitute to diesel fuel at lower viscosity with minimum environmental pollution. Under low temperatures viscosity has a greater impact on fuel to flow smoothly from the storage tank into the engine. Higher viscosity causes poor atomization of the fuel spray and inaccurate fuel injectors operation causes improper combustion in the engine cylinder.

Redwood Viscometer was used to measure viscosity of fuel. The apparatus oil cup was cleaned with a suitable solvent and dried. Orifice was closed with the ball then filled fuel in the cup up to the mark. For all blend fuels time for collection of 50cc was recorded with the help of stop watch at room temperature. The values of kinematic viscosity were determined with the help of recorded time.

3.3 Acid value: The amount of potassium hydroxide (KOH) in milligrams that is necessary to neutralize free fatty acids (FFAs) contained in 1 gram of oil is called as acid value number. The maximum value of this number is 0.5mg KOH/g and it is an important factor to monitor the oil degradation during storage period.

Acid value of diesel, biodiesel and biodiesel blend with ethanol/methanol were measured by ASTM method (ASTM – D7467). According to this 0.2 to 0.5gm of fuel under test was taken into a 250ml conical flask and 50ml of neutral alcohol added to it. The flask is heated for some time, after that cooled it to room temperature, then few drops of phenolphthalein solution were added. The formed solution was titrated with N/10 KOH solution

until it turns into permanent pink color. The chemical reaction is as follows.



The acid value of diesel, biodiesel and biodiesel blends with ethanol/methanol can be determined by using the following formulae.

$$\text{Acid value} = 100 \times \frac{\frac{N}{10} \text{ KOH solution used (ml)}}{\text{Weight of test fuel (gms)}}$$

For example: In case diesel fuel, Where 5.6 represents the amount of KOH in mg present per each ml of N/10 KOH solution (1000 ml of 1N KOH= 56 gm of KOH).

3.4 Density: The density of biodiesel is higher than diesel fuel. Biodiesels density can be decreased with the addition of additives for better performance of the engine. The density is measured by using Portable Density/Gravity Meter. High viscosity of fuel leads to problem in pumping and spray characteristics such as atomization, penetration and combustion etc. The improper mixing of fuel with air contributes to incomplete combustion that leads to low power output and exhaust with pollutants.

3.5 Cetane number: Ignition quality of fuel is identified by Cetane number. This number defines that whether the fuel has longer or shorter ignition delay during the combustion period. Higher the Cetane number means that fuel is with longer carbon chain. Normally diesel engines accept the Cetane number between 40 and 55 while below 38, ignition delay occurs more rapidly. In general, compared to diesel and biodiesel alcohol has lower Cetane number. When the engine is operated with lower Cetane number fuel produces noise and increase in ignition delay period. Alcohols are very poor C I engine fuels in performance as their cetane number is very low. Furthermore, the cetane number of B20 blend fuel with alcohol is dependent on the diesel ignition quality and the percentage of alcohol in the blend fuel along with the addition of cetane improver additives. The objective of the study is to determine the fuel properties B100, B20 and B20 with alcohols at 5% and 10% in volume.

IV. RESULTS AND DISCUSSION

The general observation is that the addition of ethanol and methanol improves the properties of biodiesel - diesel blend fuel. Hence alcohols can be used as an additive to decrease the density/viscosity of biodiesel-diesel blend fuel for better performance than diesel fuel.

i) Flash points of different fuels shown graphically in figure 7. The observation is that flash point of biodiesel is much higher, followed by B20 and alcohol blend fuels. The flash point of biodiesel and B20 are 143% and 43% more than diesel fuel. Biodiesel can be stored easily with higher flash point, but initially high temperature is required to burn in the combustion chamber. As the flash

and fire points of ethanol are very less when compared to diesel and biodiesel, the flash and fire points of the blends decreases with increase in percentage of ethanol. The blend fuels with 5% and 10% of ethanol additive decreases the flash point by 32.8% and 25% similarly with methanol additive 29.8% and 20.3% when compared with diesel fuel.

ii) From the figure 8 it is observed that the viscosity of biodiesel is 33.5% more than diesel fuel because of free fatty acid (FFA) concentration. Due to higher viscosity of biodiesel the blend fuel B20 is also at 7% more than diesel fuel. On other hand, small amount of alcohol addition in the blend fuel reduces the viscosity by 25.4%, 26.6% and 22%, 23.4% for 5% and 10% of ethanol and methanol respectively in comparison with diesel fuel.

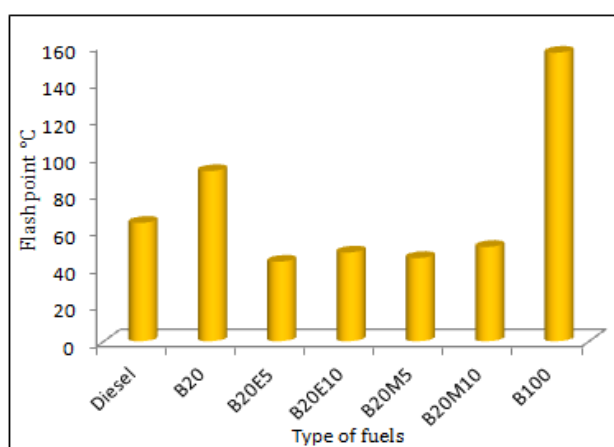


Fig.7 Flash point values of B20 with alcohols

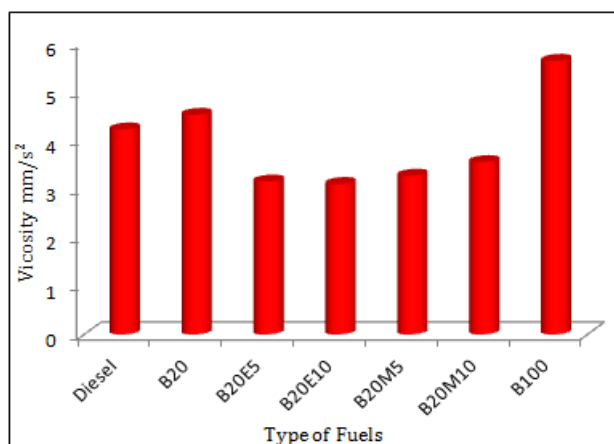


Fig.8 Viscosity values of B20 with alcohols

iii) Figure 9 shows the density of diesel, biodiesel; B20 and B20 with ethanol/methanol blend fuels. It is observed that the density of biodiesel is the higher at 0.878 kg/m³ and density of diesel is the lowest at 0.837 kg/m³. The removal of the glycerol from vegetable oil has significantly reduced the density biodiesel fuel and it is 4.92% higher than diesel fuel. Increase in biodiesel percentage in diesel fuel increases the density of blend

fuel and mostly conventional diesel fuel and biodiesel have very similar density values.

iv) Figure 10 represents the acid values of fuels tested. It is observed from the figure that the acid value for biodiesel is at 0.3 and for diesel is lower at 0.24mg KOH/g. The acid values of B20 blend with ethanol/methanol increases and are much higher than biodiesel. B20 blend with ethanol increase in acid value and decreases where as with methanol increases. The acid values of B20 blend with ethanol/methanol at 5% and 10% obtained are 0.54, 0.52 and 0.69, 0.75mg KOH/g respectively.

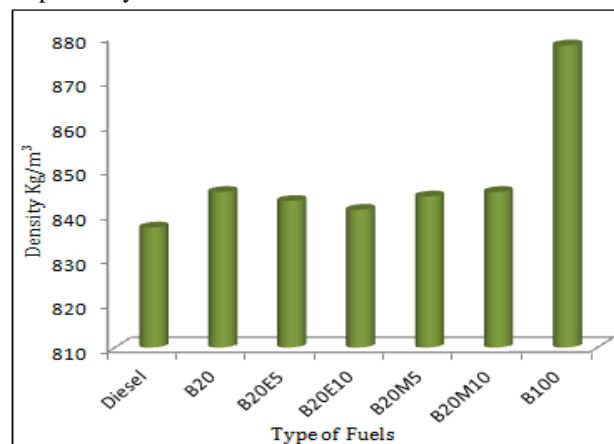


Fig.9 Density values of B20 with alcohols

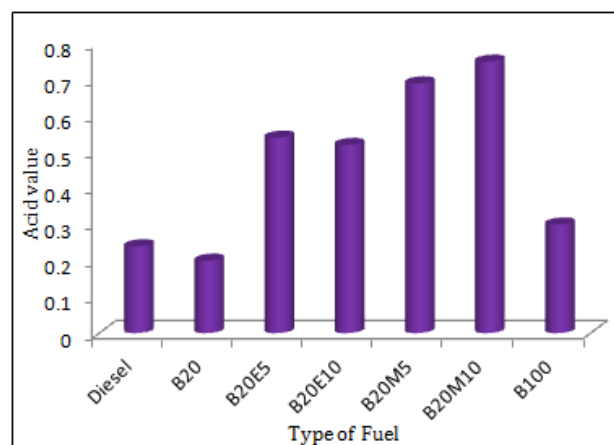


Fig.10 Acid values of B20 with alcohols

v) The Cetane number of biodiesel is significantly very high when compared to mineral diesel. Figure 11 shows that the Cetane number of different fuels tested. The observation from the figure is that the mineral diesel has the lowest Cetane number of 71.6 while the biodiesel (B100) has the highest value at 98. The Cetane number is found to be increased when the percentage of biodiesel in the blend is increasing. This is because of the fatty acids distribution or fat in the original oil. The longer the fatty acid, carbon dioxide (CO₂) chains and the more saturated the molecules, the higher the Cetane number value.

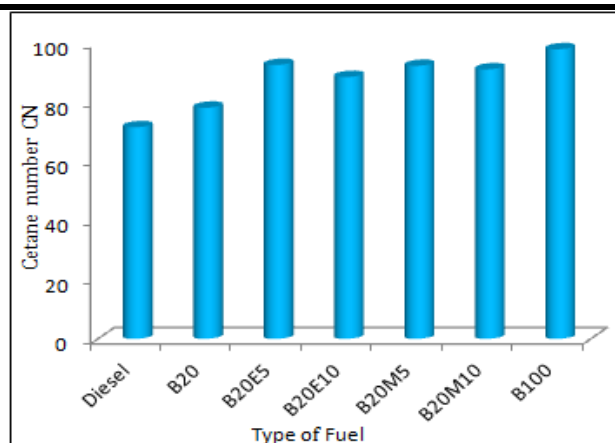


Fig.11 Cetane number values of B20 with alcohols

V. CONCLUSION

The following conclusions are drawn after studying the properties of biodiesel and its blends with ethanol and methanol as compared with diesel fuel.

- Blend fuels of biodiesel (B20) with ethanol or methanol has decreased density and viscosity than diesel fuel.
- Small quantity addition of ethanol or methanol in 5% and 10% by volume diluted the blend fuel significantly hence the viscosity and density were reduced at the cost of increase in flash point and Cetane number.
- The reduction in properties improves the engine operation in terms of performance, combustion and emission characteristics with these blend fuels.
- Blend fuel can be stored easily with higher flash point, but initially high temperature is required to burn in the combustion chamber.
- The blend fuel Cetane number is higher with low viscosity, which enhances the burning rate to improve power output of the engine.

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