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Performance Analysis of a Diesel Engine Fuelled with Blends of Neem and Simarouba Oils

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Abstract

The high demand of energy and limitations of fossil fuel has increased interest in renewable fuels dramatically in recent years. Biodiesel, biodegradable and non-toxic fuel extracted from any vegetable oil can also be considered as an alternative for the diesel fuel. In the present investigation Simarouba and Neem biodiesel was extracted by the combination of Sodium Hydroxide and methanol, the joint base catalyst by trans-esterification method. The properties like density, viscosity and calorific value are measured for dual biodiesel blends. The obtained values are meeting as per the properties of biodiesel standards. The extracted dual biodiesels was blended with diesel (0-40 %) and were experimented in a 4 stroke single cylinder diesel engine at varying loads.

Results shows that the brake thermal efficiency decreases and specific fuel consumption increases with percentage increase in biodiesel blends. Emission characteristics like carbon dioxide, carbon monoxide, oxides of nitrogen and Hydrocarbon with varying blends and varying loads are evaluated and plotted. It was found that the HC and CO emission reduces with percentage increase in biodiesel blends.

Keywords: Biodiesel, Methanol, Neem Oil, Performance and Emissions, Simarouba oil, Sodium Hydroxide, Trans-esterification

1. Introduction

In the present scenario the diesel engine plays a major role in transportation and industrial experiments. In recent years the demand in energy has increased dramatically. The production of biodiesel, biodegradable and non-toxic fuel, extracted from vegetable oil is a substitute fuel for CI engine. In[1] says that vegetable oil has to be modified to run the engine otherwise the engine has to be modified. Hence for smooth running the vegetable oil has to be converted into biodiesel by a process called trans-esterification. Few potential oils suitable for biodiesel production are Mahua oil with high free fatty acids, Neem and Simarouba, etc[2,3]. The biodiesel is having high flash and fire point temperatures than diesel fuels, so it is safest among all alternative fuels[4,5]. This work involves the production of biodiesel from Neem and Simarouba oils and testing this dual biodiesel blends in the diesel engine.

1.1 Simarouba (Simarubaceae) and Neem (Melliaazadirachta)

Simarouba belongs to simarubaceae family. This tree grows to a height of 7-15 m. These trees are found in Western Ghats and it can produce 2000-2500 kg seed/hector-year. Neem belongs to family azadirachtaindica. Neem oil is not used for cooking purpose so it can be used in different methods like extracting biodiesels, preparing cosmetics, etc.

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2. Experimental Work

2.1 Extraction of Biodiesel Oil

The manual oil expeller was used to extract the oil from the seeds which is having high pressure screw press. Then the extracted oil was kept at room temperature in order to settle the solid particles down. Then the oil is filtered and heated to remove the unwanted particles in the oil. Finally, the oil is kept in the conical flask and sealed.

2.2 Measurement of Free Fatty Acid

Islam et al.[4] did measurement of free fatty acid to measure the acid content in the oil. For measuring the FFA 1 g NaOH is added with 1 L of distilled water and taken in burette. Then 1 g of sample oil in 10 ml isopropyl alcohol in conical flask and add few drops of phenolphthalein is added. Titrate the sample till pale pink color appears. 3.5 g of NaOH per litre of oil is required.

2.3 Trans-esterification Process

Biodiesel is prepared by trans-esterification process. In this process methanol is made to react with oil in the presence of sodium hydroxide to convert the triglyceride molecule into monoesters[6]. Trans-esterification mainly reduces the viscosity of oils and to remove the impurities. In this process 1000 ml of Simarouba or Neem oil is taken in a beaker and then the amount of methanol and NaOH is calculated. Add the catalyst in the beaker containing oil and place on the automatic magnetic stirrer and it should be stirred continuously. Figure 1 shows the stirring process. Simultaneously the oil should maintain the temperature of 500-600°C. Allow the mixture to settle down and then transfer in separating funnel and leave it for 24 hours. Allow the mixture to settle down for 24 hours. Two layers can be seen, one layer is biodiesel and other is glycerol. Remove the biodiesel and collect in separate flask. Figure 2 shows settling process. Biodiesel is prepared by trans-esterification process. In this process methanol is made to react with oil in the presence of sodium hydroxide to convert the triglyceride molecule into monoesters. Trans-esterification mainly reduces the viscosity of oils and to remove the impurities. The main procedure is to take 1000 ml of both Simarouba and Neem oil in a beaker. Then calculate the amount of methanol and NaOH is called as methoxide. Add the catalyst in the beaker containing oil and place on the automatic magnetic stirrer and the process should be stirred continuously. Simultaneously the oil should maintain the temperature of 500-600 c. Allow the mixture to settle down and then transfer in separating funnel and leave it for 24 hours After the mixture to settle down for 24 hours, two layers was obtained. One layer is biodiesel and other is glycerol. Remove the biodiesel and collect in separate flask.

Figure 1. Trans-esterification setup.

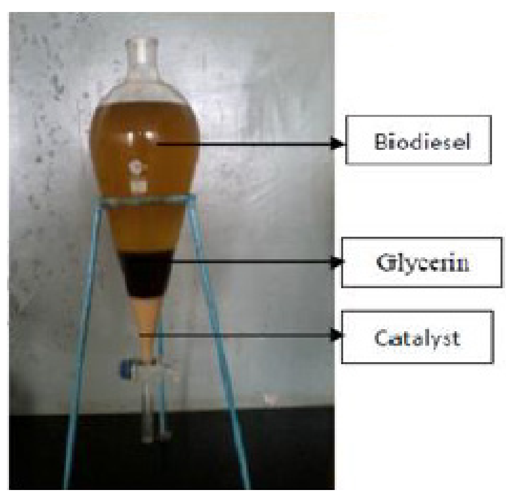

Figure 2. Settling process.

2.4 Blending

The pure biodiesel is denoted as B0 and the produced dual biodiesels is blended with diesel at different proportions as 0%, 10%, 20%, 30% and 40% and they are denoted as B10, B20, B30 and B40 respectively.

2.5 Emission specifications

The emission testing is done for all dual biodiesel blends. Smoke meter and five gas analyzer are used to measure the emission contents in the present study. The exhaust gas to be analyzed is fed into the smoke chamber and smoke density is measured. Non-Dispersive Infra-Red (NDIR) principle was used in this five gas analyzer for measuring the emissions.

2.6 Engine Specifications

The tests were conducted on Kirloskar AV-1, 4-stroke single cylinder diesel engine. The different biodiesel blends were tested 2 times on this diesel engine and readings of speed, time for 20 ml fuel consumption were taken. The compression ratio used is 16.5:1.

3. Results and Discussions

The test were conducted to estimate the performance of 4 stroke diesel engine for different loads with biodiesel blends prepared by the trans-esterification process and diesel at increasing percentage of 10%, 20%, 30% and 40%. Biodiesel blends are tested as per the biodiesel standard and used without making any changes in the engine. Performance parameters include specific fuel consumption and brake thermal efficiency. Emission contents like smoke density, HC, NO_X, CO and CO_2 are measured using smoke meter and five gas analyzer. These parameters are plotted against load and compared with pure diesel.

3.1 Performance Characteristics

3.1.1 Brake Thermal Efficiency (BTE)

The Figure 3 shows the effect of brake power on brake thermal efficiency for different blends. It shows that the brake thermal efficiency decreases with percentage increase in blend. The highest value for diesel was 38% and for B10 biodiesel blends was 36%. B10 gives better combustion because of inherent oxygen. The lower heating value and increase in density and viscosity may be the reason for the decrease in brake thermal efficiency for increase in the percentage of biodiesel blends.

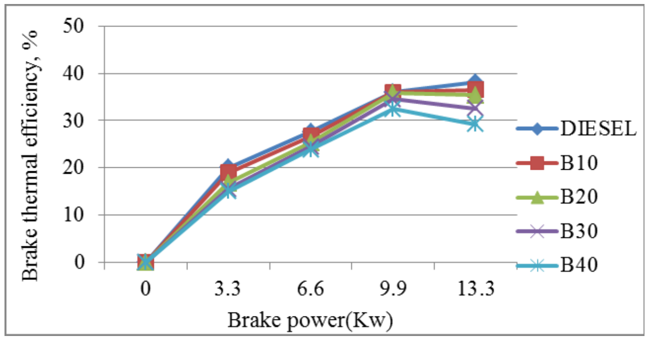

Figure 3. Variation of brake thermal efficiency with brake power.

3.1.2 Brake Specific Fuel Consumption (BSFC)

The effect of specific fuel consumption on brake power is plotted in Figure 4 for varying blends. It was observed that the brake specific fuel consumption decreases with increase in brake power and the reason for the decrease of BSFC may be, at high load the cylinder wall temperature becomes higher and lowers the ignition delay. Thus, lowering of ignition delay may reduce the specific fuel consumption and gives better combustion. It shows that the SFC of percentage increase in blends biodiesel was more with compared with pure diesel. Therefore, in[5] says that biodiesel is having oxygen content and leads to lower calorific value. This is the reason for increase in fuel consumption of blends percentage than diesel.

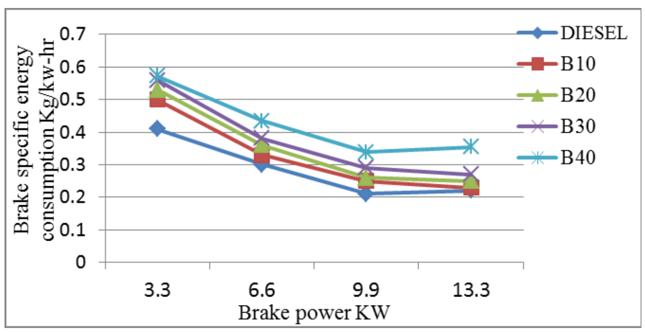

Figure 4. Variation of brake specific fuel consumption with brake power.

3.1.3 Exhaust Gas Temperature (EGT)

The effect of brake power and percentage biodiesel blend on exhaust gas temperature is shown in Figure 5. Here we can observe in increase in exhaust gas temperature with increase in both biodiesel blends and the brake power[6]. The reason for increase in exhaust gas temperature with the percentage increase of biodiesel blends is because of increase in combustion efficiency. At lower loads of all diesel and biodiesel blends the exhaust gas temperature was lower. The oxygen content is higher in biodiesel and by increasing the blends percentage gives the higher exhaust gas temperature than diesel.

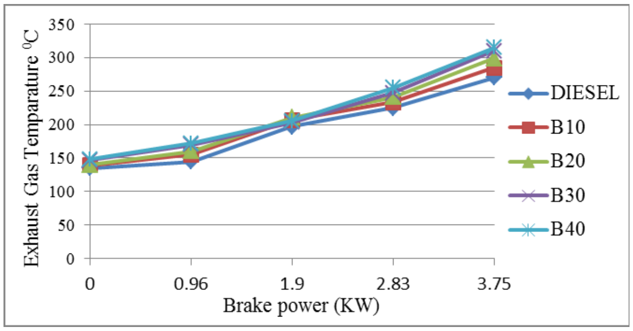

Figure 5. Variation of exhaust gas temperature with brake power.

3.2 Emission Characteristics

3.2.1 Hydrocarbon (HC)

The effect of load on the unburnt hydro carbon emission for varying biodiesel blends is shown in Figure 6. It shows that at higher brake power and at higher percentage blends the hydrocarbon emissions reduces. At higher load by increasing the blends percentage may reduce the hydrocarbon emissions because the biodiesel has more oxygen so it helps to take the complete combustion. At full load condition, the blends B10, B20 and B40 give lower hydrocarbon emissions than other blends[6].

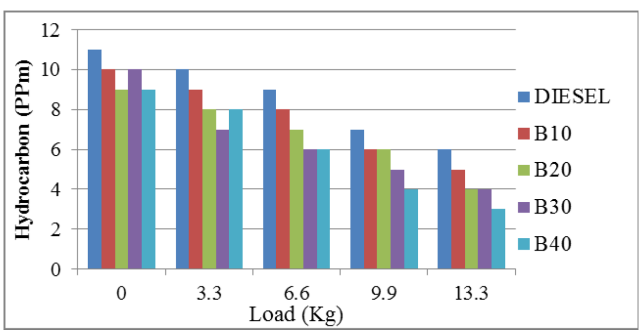

Figure 6. Effect of load and blends on hydrocarbon emission.

3.2.2 Smoke Density

The Figure 7 shows the change in smoke density with loads for varying biodiesel blends and diesel. Increase in smoke density with the load as well as increase in percentage blends is observed in the figure. The main reason for greater smoke emissions may be because of higher fuel consumption at higher loads.

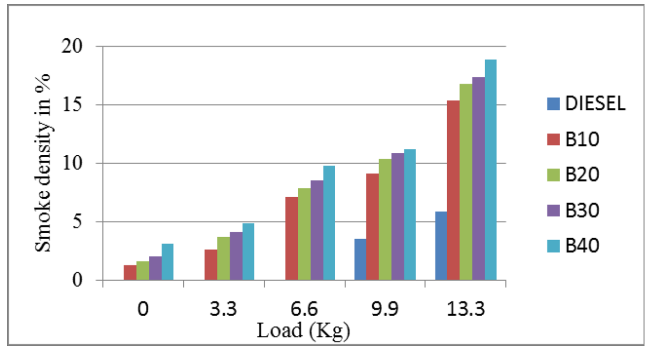

Figure 7. Effect of load and blends on smoke density.

3.2.3 Carbon Monoxide (CO)

The Figure 8 shows the change of carbon monoxide with loads for varying biodiesel blends and diesel. It shows that CO emissions for biodiesel fuels are lower than diesel. On average, the CO emissions for biodiesel blends are decreased compared with diesel fuels. Because the biodiesel is an oxygenated fuel which helps to cause lower CO emissions. At higher blending percentage and higher loads, it shows that the carbon monoxide emission is less.

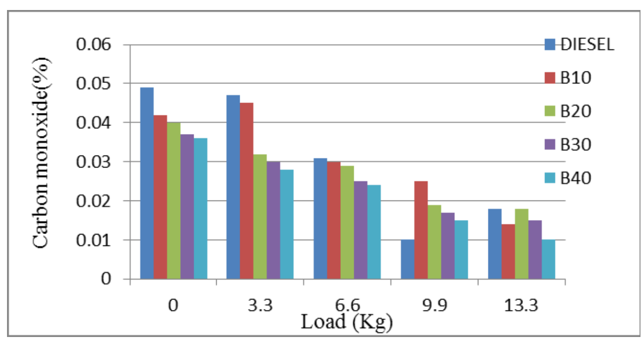

Figure 8. Effect of load and blends on carbon monoxide,

3.2.4 Carbon Dioxide (CO_2)

The Figure 9 shows the change of CO_2 emissions on various loads for varying biodiesel blends and diesel. The carbon dioxide emission increases by increasing the load and increase in the percentage of biodiesel blends. This is because of higher combustion efficiency. The blend B10 gives less emission than other blends[9].

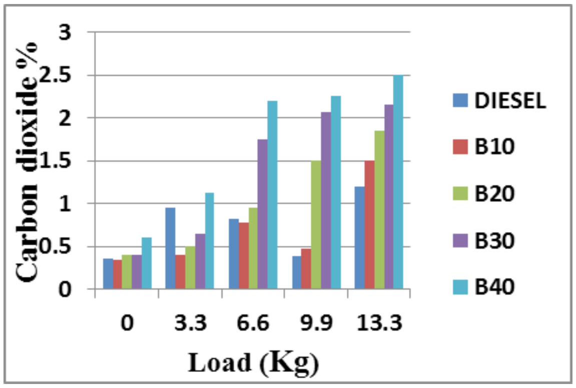

Figure 9. Effect of load and blends on carbon dioxide.

3.2.5 Oxides of Nitrogen (NOx)

NOx emissions on various loads for varying biodiesel blends and diesel are depicted in the Figure 10. The formation NOx in the cylinder is mainly because of oxygen and flame temperature. Increase in nitrogen oxides with the increase in the percentage of biodiesel blends and the load was observed during the tests. The higher cylinder temperature and oxygen in the biodiesel are the causes for higher nitrogen oxides emissions at higher load and higher percentage blends[10].

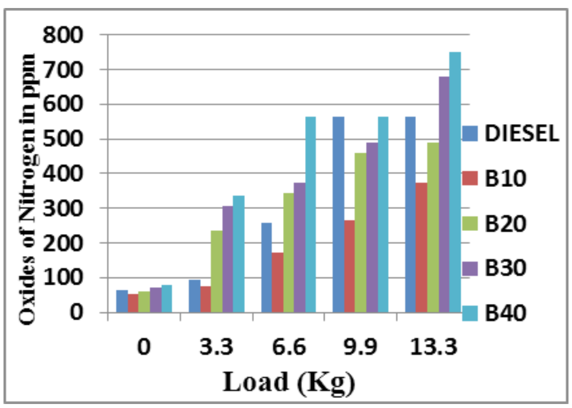

Figure 10. Effect of load and blends on oxides of nitrogen.

4. Conclusion

The analysis of performance and emissions characteristics of single cylinder diesel engine fuelled with higher percentage of dual biodiesel blends have been examined and compared with pure diesel fuel. The following are the conclusion made from the study:

The properties of dual biodiesel blends satisfy the biodiesel standards. The brake thermal efficiency reduces with higher percentage of biodiesel blends. B10 blend showed better BTE when compared with other blends. The BSFC increases with increase in blends percentage of biodiesel because of the lower heating value of biodiesel blends. The blend B10 having same engine output and lower emissions compared to diesel. Thus, the conclusion of this research is blend B10 which is having same engine output and better combustion with less emission in CO and HC compared with pure diesel can be selected as an alternative fuel for the CI engine.

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