A Review on Effects of Blends containing Low Ratios of Alternate Fuels - Biodiesel on Diesel Engine Performance and Exhaust Emissions

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Abstract

Emissions from diesel engines are considered to be contributing greatly to air pollution. The major pollutants released are nitrogen oxide, carbon monoxide, unburnt hydrocarbon emissions and smoke. A solution to these have been viewed in the domain of fuel-related techniques wherein number of alternatives are tested. The test can be done running engine on 100% alternative fuel or blending alternate fuel with diesel. With a view to compare the various alternatives and choose the most appropriate one, the present paper deals with results obtained with four alternatives viz. (a) Blending diesel with Ethanol (b) Blending diesel with Butanol (c) Blending diesel with vegetable oil (d) Test on 100% Biodiesel. (Methyl Ester of Mahua Oil, referred in the paper as MOME). The results are focused on emission characteristics and brake specific fuel consumption for the engine.

1. Introduction

Diesel engine have been most commonly used internal combustion engine since long. However the pollution emitted by diesel engines contribute greatly to air quality problems. Emissions produced by diesel engine contain major major amount of nitrogen oxides (NO_x), carbon monoxide (CO) unburned hydrocarbons and smoke. These components are mainly responsible for air pollution. Engine manufacturers all over the world are trying to keep these emissions inside imposed emission regulations, which every day become more stringent. These stringent emission standards, growing energy demand and finite petroleum fuel sources in the world have directed the researchers to search for clean alternative fuels like alcohols, biodiesel, LPG, CNG etc. Accordingly lot of research work have been on performance of diesel engines on various available alternatives. The paper focuses on results from three alternatives viz. Alcohols, vegetable oils and biodiesel.

Alcohols show a better tendency to decrease engine emissions since they have less carbon, sulphur content and contain more oxygen than traditional fuels. However alcohol fuels have higher octane number than cetane number which limits its use in diesel engines.

The advantages of vegetable oils as diesel fuel apart from renewability are minimal sulphur and aromatic contents, higher flash point, higher lubricity and higher biodegradability and non toxicity. Their disadvantages include very high viscosity, higher pour point, lower cetane number, lower calorific value and lower volatility.

Advantages of biodiesel as diesel fuel are renewability, minimal sulphur and aromatic content, higher flash point, higher lubricity, higher cetane number, higher biodegradability and non-toxicity. Limitations include higher viscosity (though much less than vegetable oils), higher pour point, lower calorific value and lower volatility.

The present paper deals with results of the following:

1. Diesel blend with alcohols (ethanol and butanol)
2. Diesel blend with vegetable oils (sunflower oil, cotton-seed oil, corn oil, olive oil)
3. 100% biodiesel (Methyl Ester of Mahua Oil)

Comparison of various properties of alternatives with diesel is shown in following tables:

Table 1 Comparison of Properties (Diesel and Alcohols) [2,3]

	Diesel	Ethanol	Butanol
Cetane number	50	5-8	25
Calorific Value (kJ/kg)	43000	27000	33100
Oxygen (% weight)		34.8	21.6
Latent heat of vapourization (kJ/kg)	250	840	581
Stochiometric air/fuel ratio	15:1	9:1	11:01:00

Table 2 Comparison of Properties (Diesel and Vegetable Oils) [4]

Properties	Diesel	Sunflower oil	Cottenseed oil	Corn oil	Olive oil
Density	837	920	910	915	925
Kinematic Viscousity	3	34	34	35	32
Lower calorific value	42700	36500	36800	36300	37000
Cetane number	50	37	38	38	39

Table 3 Comparison of Properties (Diesel and Biodiesel-MOME) [5]

Properties	Diesel	Methyl Ester of Mahua Oil (MOME)
Density	837	873.8
Kinematic Viscousity	3	4.39
Lower calorific value	42700	36900
Cetane number	50	62

2. Results of Smoke Emission

Smoke emissions are indicative of dry soot emissions which is one of the main components of particulate matter. They are produced by oxygen deficiency and are suspended particles in exhaust system. Smoke emissions are observed to decrease in all samples. The reason supporting the same is high amount of available oxygen.

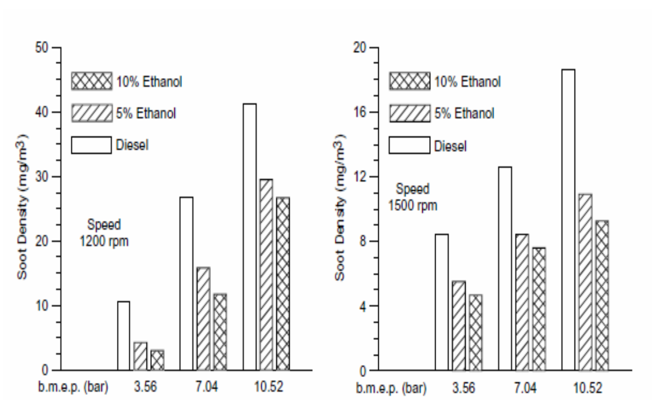


Figure 1 Smoke Emissions for Ethanol-Diesel Blend [2]

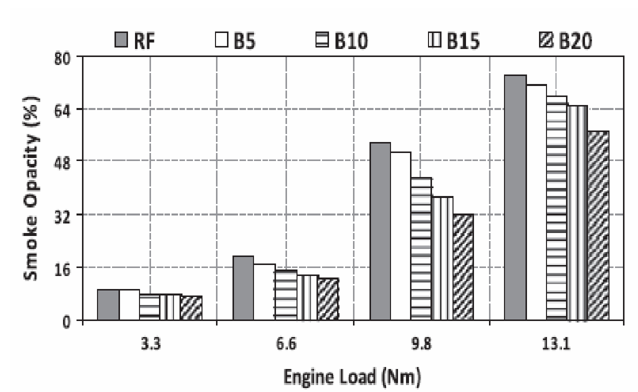
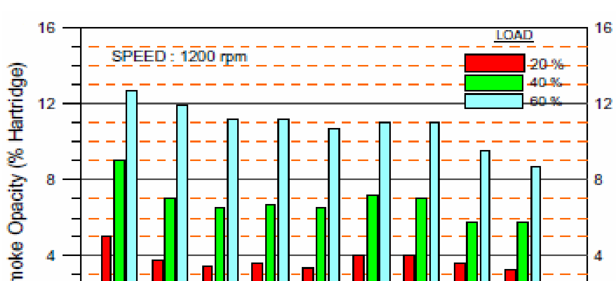


Figure 2 Smoke Emissions for Butanol - Diesel Blend [3]



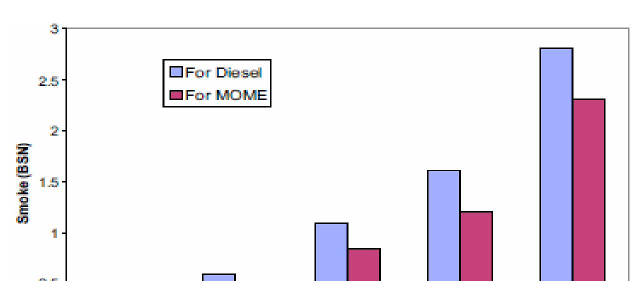


Figure 3 Smoke Emissions for Vegetable Oil -Diesel Blend [4]

Figure 4 Smoke Emissions for 100% Biodiesel - MOME [5]

3. Results of Carbon Monoxide Emission

Carbon monoxide emissions are due to incomplete combustion of fuels mainly because of less oxygen amount available. Alcohols and MOME are rich in oxygen in the structure itself and hence the emissions were seen to reduce during their performance. However carbon monoxide emissions were seen to rise for vegetable oils. The reason attributed to same is higher premixed combustion period due to its low cetane number. The results are shown in the following figures.

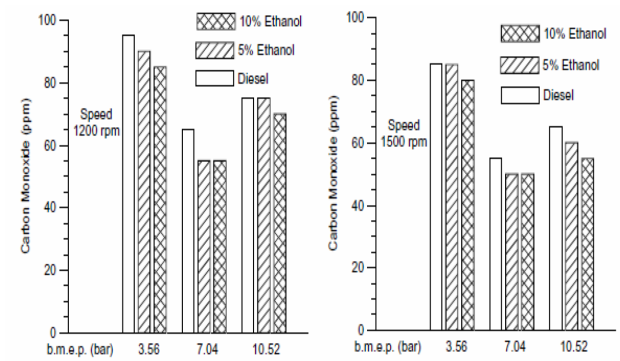


Fig. 5: Carbon monoxide emissions for Ethanol-Diesel Blend [2]

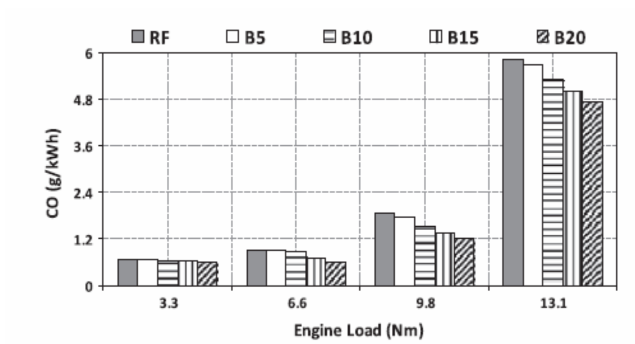


Fig. 6: Carbon monoxide emissions for Butanol-Diesel Blend [3]

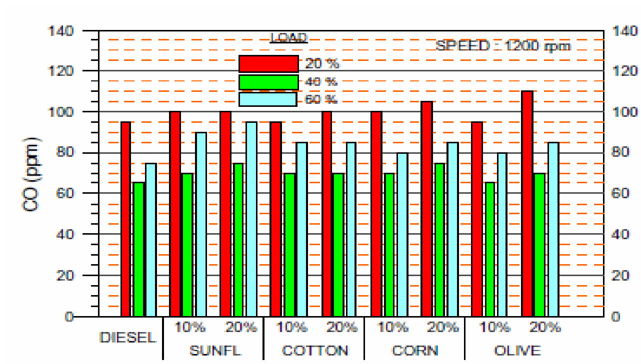


Fig. 7: Carbon monoxide emissions for Vegetable Oil - Diesel Blend [4]

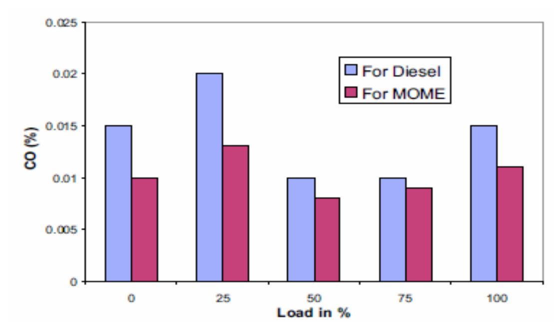


Fig. 12: NOx emissions for 100% Biodiesel (MOME) [5]

4. Results of NO_x Emissions

NO_x emissions are formed through high temperature oxidation of nitrogen in combustion chamber. The formation of NO_x highly depends on in-cylinder temperatures, the oxygen concentration and residence time for reaction to take place. For alcohol blends, higher oxygen content and lower cetane number increases possibility of NO_x formation. However, less latent heat lowers combustion temperatures and hence reduce NO_x formation. However, the emissions are seen to reduce to alcohols and biodiesel. Vegetable oils show increase in NO_x emissions due to higher ignition delay(Low cetane number)

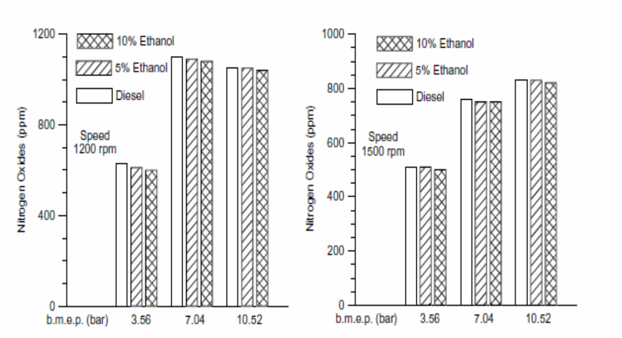


Figure 9 NO_x emissions for Ethanol-Diesel Blend [2]

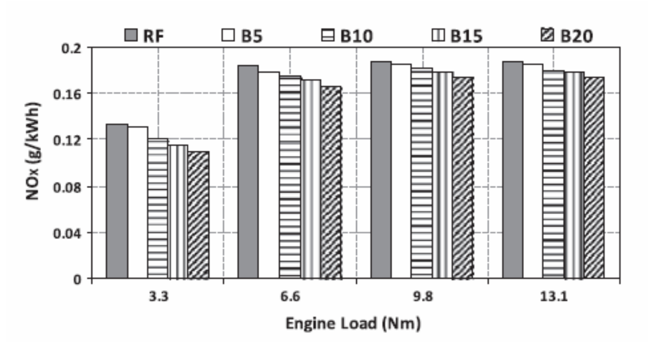


Figure.10 NOx emissions for Butanol-Diesel Blend [3]

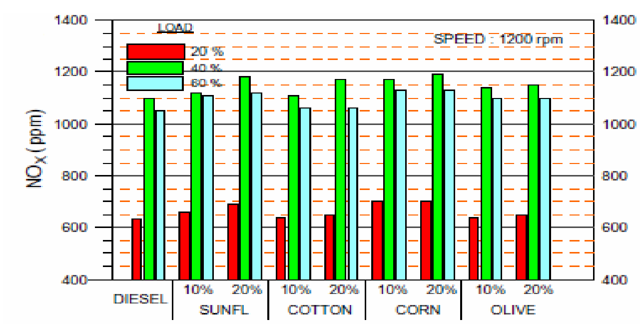


Fig. 11: NOx emissions for Vegetable Oil -Diesel Blend [4]

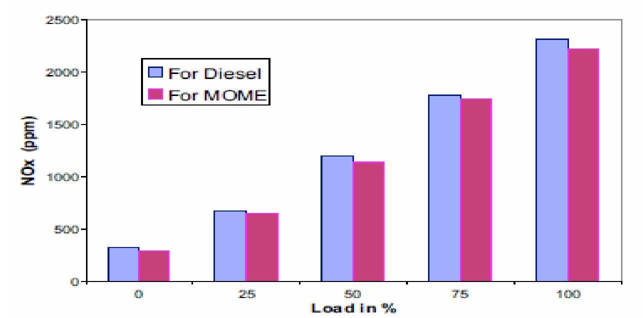
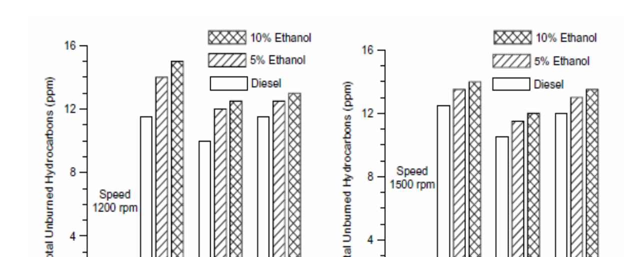


Fig. 12: NOx emissions for 100% Biodiesel (MOME) [5]

5. Result of Hydrocarbon Emission

Hydrocarbon emissions are primarily a result of engine configuration, fuel structrue, combustion temperature, oxygen availability and residence time. For alcohol blends, the emissions are seen to increase. The reasons attributed to the same are lower cetane number(longer ignition delay) and higher heat of evaporation (slower evaporation). For vegetable oils, the emissions are also seen to increase, the prominent reason being higher ignition delay. However, the emissions are observed to be less for MOME, the reason being higher oxygen content.



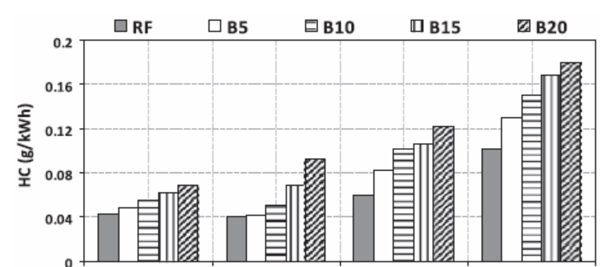
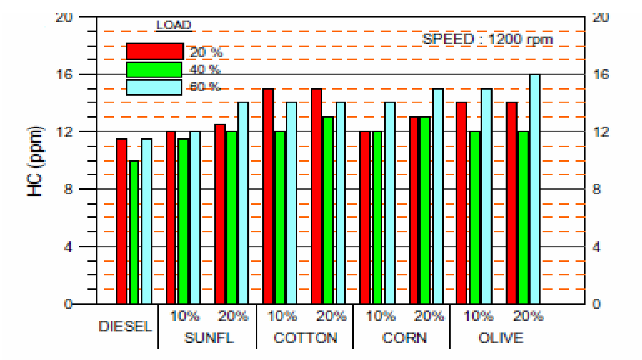


Fig. 13: Hydrocarbon emission for Ethanol-Diesel Blend [2]

Fig. 14: Hydrocarbon emission for Butanol-Diesel Blend [3]



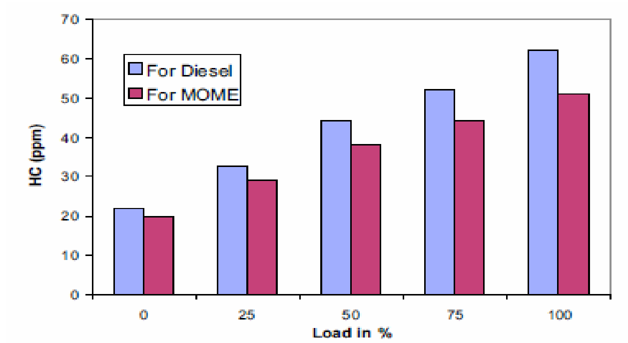
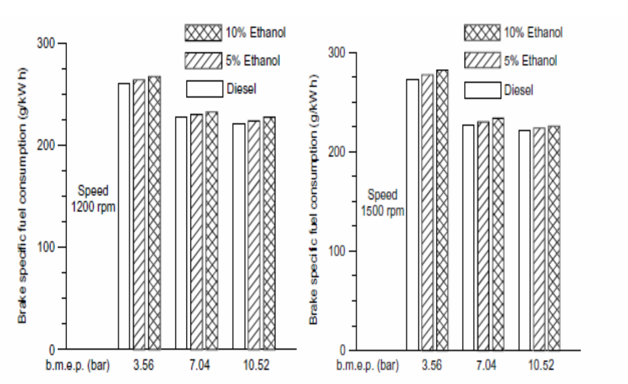


Fig. 15: Hydrocarbon emission for Vegetable Oil - Diesel Blend [4]

Fig. 16: Hydrocarbon emission for 100% (Biodiesel)MOME [5]

6. Results of Brake Specific Fuel Consumption

Brake Specific Fuel Consumption (BSFC) is defined as ratio of mass fuel consumption to the brake power. To obtain the same power output for every test fuel, lower the calorific value, higher will be BSFC. As seen from table 1, 2 & 3 calorific value of each sample is less than diesel, hence BSFC is seen to increase for every sample.



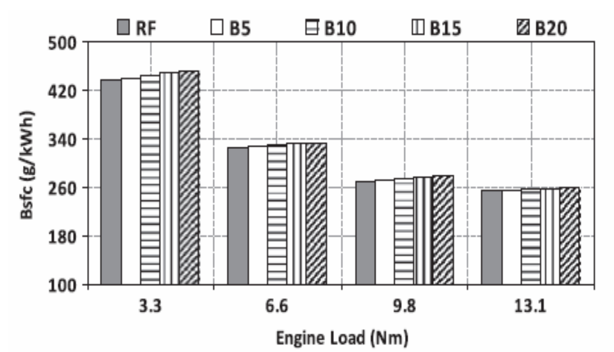
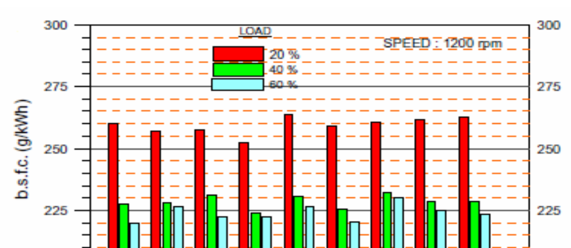


Fig. 17: BSFC result for Ethanol-Diesel Blend [2]

Fig. 18: BSFC result for Butanol-Diesel Blend [3]



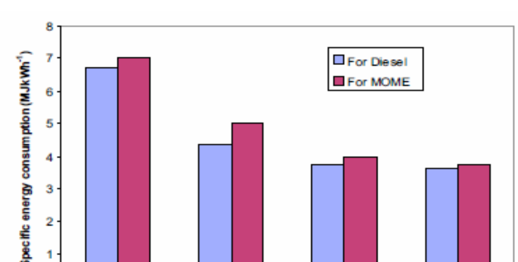


Figure19: BSFC result for Vegetable Oil -Diesel Blend [4]

Figure 20: BSFC result for 100% Biodiesel (MOME) [5]

7. Conclusions

On the basis of above results, followings can be concluded:

- Blending alcohol with diesel reduces smoke, carbon monoxide and nitrogen oxide emissions. However there is increase in hydrocarbon emissions and brake specific fuel consumption.
- Blending vegetable oils with diesel reduces smoke emissions. There is increase in carbon monoxide, nitrogen oxide and hydrocarbon emissions. Also brake specific fuel consumption increases.
- Owing to its most properties similar to diesel, biodiesel (MOME) is the best alternative. All emissions are observed to reduce. However there is increase in brake specific fuel consumption.

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