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Emission Characteristics Using Alternative Fuels Ethanol and Biodiesel in Turbo Charging Diesel Engine

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ABSTRACT-

The main purpose of fuel is to store energy in a form that is stable and can be easily transported from the place of production to the end user. There is an immediate need of alternative clean fuels, which is abundantly available as well as has lower impact of pollution than the present fossil fuels & conserves conventional fuel. In this regards the various alternative fuels like CNG, LPG, Propane, Bio-diesel, Ethanol, Hydrogen, Fuel cells etc. will help in the reducing oil import bills of an oil-dependent country like India and also help in reducing environmental pollution. In the current market scenario, every nation in the world is busy finding the substitute for the conventional fuels diesel and petrol.

Keywords – Biodiesel**,** NOx Emissions, Fuel Testing, environmental pollution, CNG, LPG, Propane

Introduction

The large increase in number of automobiles in recent years has resulted in great demand for petroleum products. With crude oil reserves estimated to last only for few decades, there has been an active search for alternate fuels. The depletion of crude oil would cause a major impact on the transportation sector. Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to conventional diesel fuel (derived from fossil fuels; hereafter just “diesel”) due to the following reasons.

• Biodiesel can be used in existing engines without any modifications.
• Biodiesel is made entirely from vegetable sources; it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues.
• Biodiesel is an oxygenated fuel; emissions of carbon monoxide and soot tend to be reduced compared to conventional diesel fuel.
• Unlike fossil fuels, the use of biodiesel does not contribute to global warming as CO2 emitted is once again absorbed by the plants grown for vegetable oil/biodiesel production. Thus CO2 balance is maintained.
• The Occupational Safety and Health Administration classify biodiesel as a non-flammable liquid.
• The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel.
• Biodiesel is produced from renewable vegetable oils/animal fats and hence improves fuel or energy security and economy independence.

A lot of research work has been carried out using vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable. The high viscosity of vegetable oils and the low volatility affects the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. Methods such as blending with diesel, emulsification, pyrolysis and transesterification are used to reduce the viscosity of vegetable oils. Among these, the transesterification is the most commonly used commercial process to produce clean and environmentally friendly fuel. A large number of studies on performance, combustion and emission using raw vegetable oils and methyl/ethyl esters of sunflower oil , rice bran oil, palm oil , mahua oil, jatropha oil, karanja oil , soybean oil, rapeseed oil and rubber seed oil have been carried out on Compression Ignition(CI) engines. The purpose of this paper is to review previous studies that look into the effect of bio-diesel on CI engine from the viewpoint of performance, combustion and emissions.

Objectives of the project:

Objective of the project is to check the effect of various ethanol blends with diesel on the diesel engine without modification for investigating the performance and emission characteristics. Performance Curve and emission characteristics Using Alternative Fuels Ethanol And Biodiesel in Turbo charging Diesel Engine .

Project Methodology

1. Study of physical and chemical properties of diesel, ethanol and biodiesel fuels and their blends.
2. Ethanol is not miscible with diesel hence co-solvents like biodiesel is used to mix it and magnetic stirrer is used to mix all fuel-blends together

3. Diesel-ethanol-biodiesel blends are prepared in different proportions with magnetic stirrer and all blend samples are tested for physical and chemical properties.

4. These blends are compared with base diesel fuel to check its feasibility to use in existing diesel engine.

5. Blended fuels are tested in diesel engine to check the performance parameters like brake power, brake torque and specific fuel consumption and CO, HC, NO_x CO_2 emissions characteristics using 8 mode cycle. Performance and Emission characteristics plots are compared for conclusion.

Result :

To find out engine performance parameters there is requirement of engine observation data. This data is used to calculate different performance parameters like brake power, specific fuel consumption, emission etc. With the help of this performance parameters, the performance plots are plotted which gives characteristics of the engine under different load and speed conditions. In this chapter results are obtained for neat diesel fuel and ethanol blended fuel and comparison is made between two.

Effect of various blends on brake power

Brake power of diesel engine increases as load increases and this trend is similar for all blends. As shown in fig. 5.2. Brake power decreases slightly when blends are used because of lower heating value of ethanol and biodiesel. For neat diesel fuel maximum brake power is found to be 58.6 BHP. For blend DB10, it found to be 56.92. A drop of 2.86 percent is found using 10 percent biodiesel. For blend DBE10, there is drop of about 4.94 percent compared with neat diesel fuel; this is high due to lower calorific value of blend DBE10 than Blend DB10. For blend DBE20 reduction in brake power is found to be 7.37 percent, which is again lower than remaining two blends. Blend DBE20 has minimum calorific value amongst the all blends.

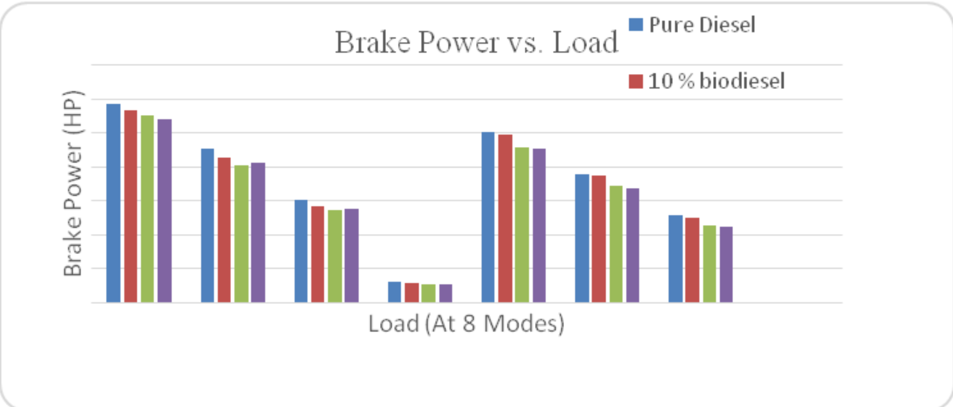

Fig. 1 Brake power vs. Load comparison for various 8 loads using different blends

5.3 Effect of Various blends on BSFC

As shown in fig. Specific fuel consumption decreases as load increases and it is maximum at 10 percent load. This trend is similar for all blends. Fuel consumption increases as load increases. For neat diesel fuel maximum SFC is 457.48 gms/hp-hr at 10 percent load. For blend DB10 it is found to be 473.49 gms/hp-hr, increase in SFC of about 3.37 percent due to lower heating value of blend DB10 compared with neat diesel fuel. For blend DBE10 increase in SFC is 10 percent. For blend DBE20 increase in SFC is 13 percent which is largest amongst all blends due to lower calorific value of that blend. For medium load there is slightly difference in BSFC for all blends due to part load efficiency of diesel engine is high in this range.

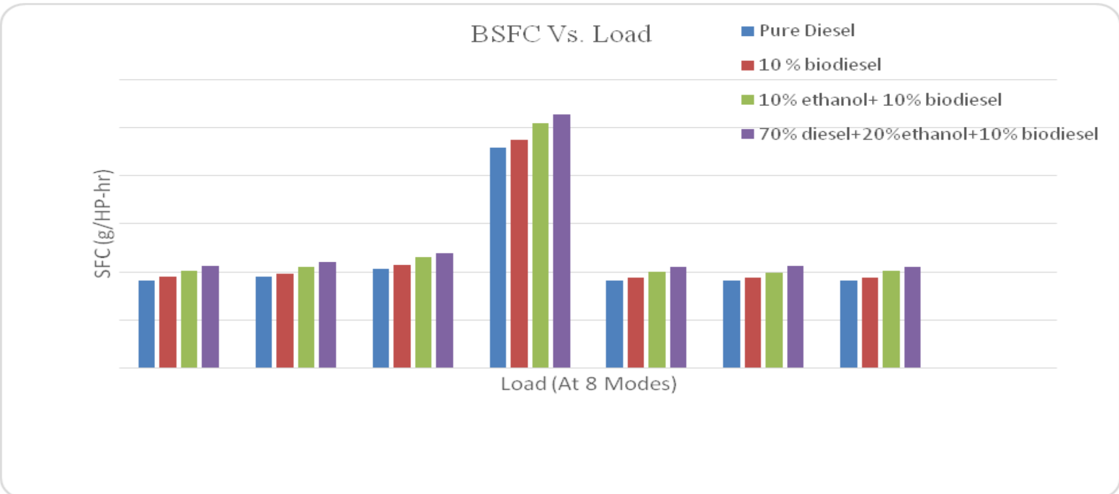

Fig. 2 BSFC vs. Load for various loads using different blends

Effect of various blends on CO emissions

As load increases CO emissions reduces for diesel fuel for all loads at 2400 rpm and 1600 rpm as shown in fig. 5.4 but for idle it is lower compared with 50 % load at 1600 rpm due to incomplete combustion. For blend DB10, CO emissions reduces by 12.24 % at maximum power and 7.33 % at maximum load compared with neat diesel fuel. For remaining 6 modes it reduces slightly. It is due to inbuilt oxygen content present in the biodiesel helps in complete combustion. For blend DBE10, CO emissions are increasing as load reduces compared with Blend A but it is lower than neat diesel fuel for first two modes. Similar is the case with other modes namely 5, 6, 7 and 8. For blend DBE20, CO emission are more (by 1.1%) compared with blend DB10 but lower (by 11.24 %and 13.63%) for first two modes compared with neat diesel fuel.This happens due to temperature lowering effect of ethanol in cylinder. This is dominant at light load than high load. At high load mixing is better, that's why CO emissions are high only at remaining two modes.

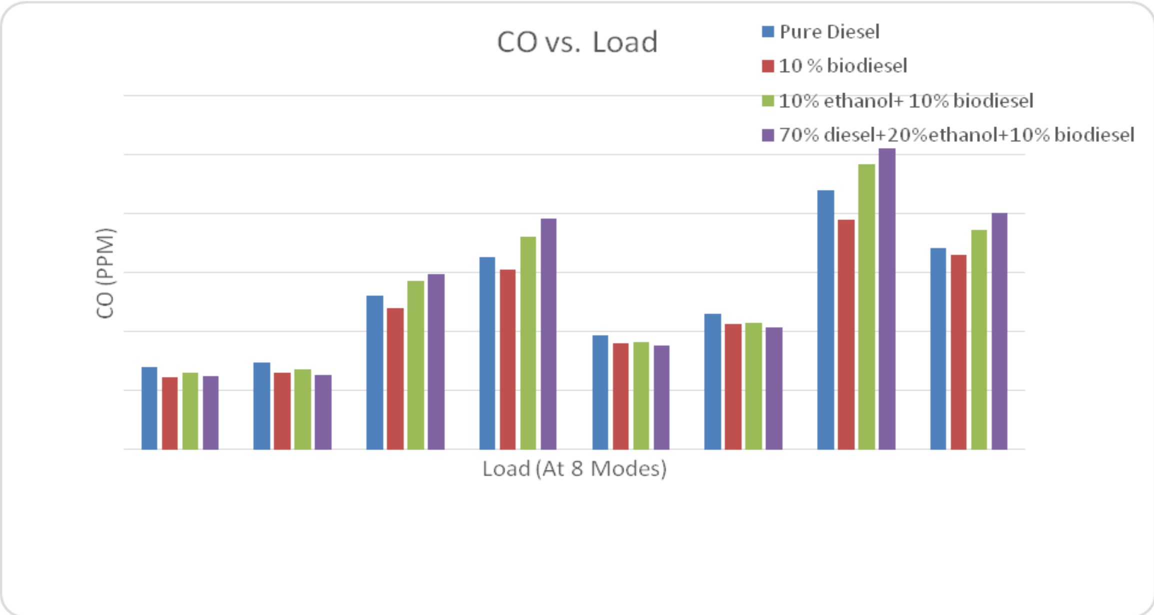

Fig. 3 CO vs. Load for various loads using different blends

Effect of various blends on CO_2 emissions

Fig. shows the effect of various fuel blends on CO_2 emission at different loads. It is found that as load increases CO_2 emissions increases as more and more fuel burns at high load and complete combustion is achieved at high loads due to high temperature. This trend is similar for all fuel blends. For blend DB10, CO_2 emissions are higher at all modes and maximum increase is found out to be 35.69 % at mode number 4. CO_2 emissions are higher due to more complete combustion and more fuel consumption due to lower calorific value of biodiesel. For blend DBE10, CO_2 emissions are higher at all modes and maximum increase was 15.09 % at mode number 5. This blend has more CO_2 emissions amongst all blends. For blend DBE20, CO_2 emissions are lower at all modes except at mode number 4 due to incomplete combustion caused by high percentage of ethanol. The maximum reduction is 15.20 % at mode 1.

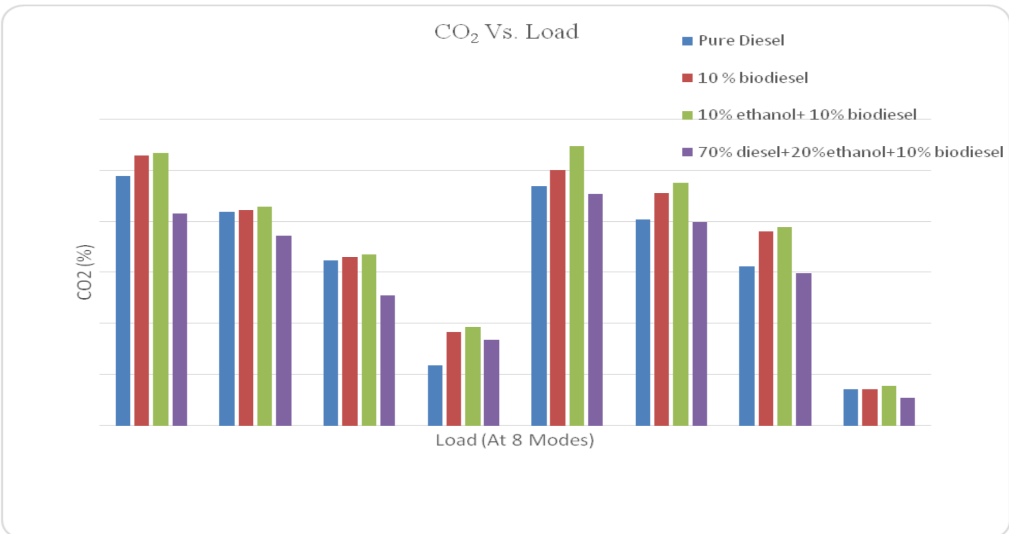

Fig.4 CO_2 vs. Load for various loads using different blends

Effect of various blends on NO_x emissions.

NO_x increases as load increases for diesel as well as for all blends as shown in fig. 6.6.The factors which are responsible for NO_x emissions are temperature of combustion and oxygen content in the combustion. Out of which temperature is the dominant factor. As load increases combustion temperature increases which leads to high NO_x at high loads. For blend DB10 NO_x emissions increases at all modes except idle. Maximum increment of NO_x is found to be 30.14 % at mode number 6. The reason for increase in NO_x is due to oxygen content in the fuel blend. For Blend DBE10 NO_x emissions are seen to be reduced for all modes except mode number 5 and 6. Maximum reduction of NO_x is about 14.28 % at mode 1. For Blend DBE 20 NO_x emissions are reduced at all modes and maximum reduction is about 56.12 % compared with neat diesel fuel. It happened due to high ethanol percentage in the blend caused temperature lowering effect in the combustion. NO_x emission is complex phenomenon which is not only depend on fuel but also depend on loading conditions.

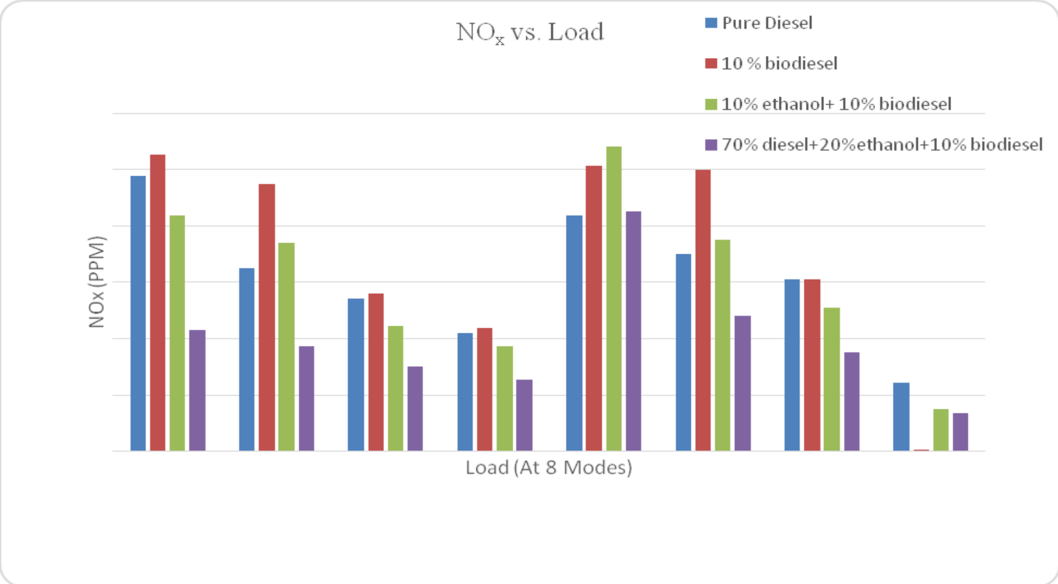

Fig. 5 NO_x vs. Load for various loads using different blends

Effect of various blends on HC emissions.

HC emissions goes on reducing as load increases for diesel as well as for all blends as shown in fig. 5.7. Trend for diesel and fuel blends are similar in nature. For blend DB10 HC emissions are lower at all 8 modes. Maximum reduction (by 50.70%) in HC is at seventh mode (50% load @1600 rpm).For high loads it is slightly reduced. Reduction in HC is due to high cetane number of biodiesel and complete combustion. For blend DBE10 HC emissions are slightly higher at all modes compared with neat diesel and blend DB10. Maximum increment is 14.13% at 10% load at 1600 rpm. For blend DBE20 HC emissions increases at all modes compared with all blends. Maximum increase in HC emission is found out to be 23.08 % at idle condition. HC emission are higher due to temperature lowering effect of ethanol and higher ignition delay of ethanol.

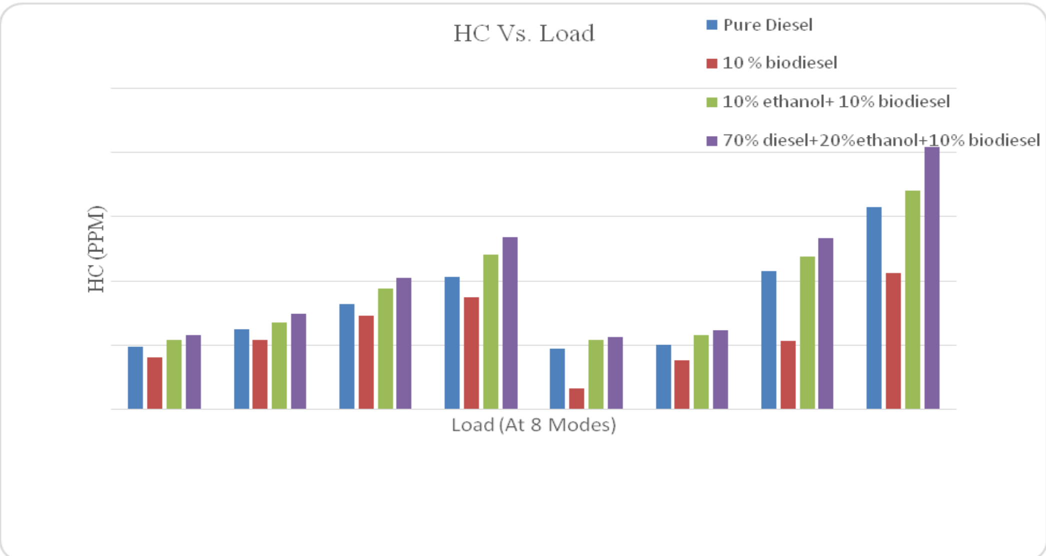

Fig. 6 HC vs. Load for various loads using different blends

Overall emission results using weightage factor

Table No. 1 Overall emissions for blends

	Neat Diesel	Blend DB10	Blend DBE10	Blend DBE20
HC (ppm)	83.245	60.35	92.915	104.27
CO (ppm)	252.8575	232.709	263.47	271.46
CO_2(ppm)	6.52	7.114	7.352	5.945
NO_x(ppm)	310.03	345.83	298.7	189.75

HC emissions are found to be increased by 10.40 % and 42.12 % for DBE10 and DBE20 respectively. CO emissions are slightly increased by 4.03 % for DBE10 blend and reduced slightly by 6.85 %. NO_x emissions are reduced slightly by 3.65 % for DBE10 blend but increased by 38.8 % for DBE20 blend. CO_2 emissions are increased by11.31 % for DBE10 blend and reduced by 8.8 % for DBE20 blend. For DB10 blend HC, CO, CO_2 reduced slightly but NO_x increased substantially.

Concluding Remark

Blend DB10 is giving approximately same power and SFC because there is no large variation in calorific value between them, also blend DB10 is giving higher $NO_{x\ and}$ CO_2 emission but it lowers CO, HC emissions compared with neat diesel fuel. Blend DBE10 slightly reduces brake power and slightly increases SFC. Blend DBE10 lowers CO emissions at 4 modes and increases HC emissions very slightly at all modes. A NOx emission lower marginally at 5 modes and remains approximately equal for remaining modes. CO_2 Emissions are slightly higher at all modes. For Blend DBE20, CO and HC increase for almost all modes. NO_x and CO_2 emissions reduces at all modes. From above discussion it is clear that NO_x emissions cannot be predicted exactly. Blend DBE10 has optimum performance and emission characteristics.

Conclusion

Engine is tested for 8 modes cycle and effect of various blends on maximum brake power and maximum BSFC is as follows

1. Maximum Brake power for blend DB10, DBE10, DBE20 dropped by 2.86%, 4.94% and 7.37 % respectively compared with neat diesel fuel.
2. Maximum BSFC for blend DB10, DBE10, DBE20 increased by 3.37 %, 10%, 13 % respectively compared with neat diesel fuel.

Similarly emissions are measured for 8 modes for DB10, DBE10, DBE20 blends and percentage increment and reduction in emission with respect of diesel fuel are tabulated as follow

Table No. 2 Engine is tested for 8 modes cycle

	Mode	1	2	3	4	5	6	7	8
Blend A	HC	-17.28	-13.07	-10.68	-15.77	-66.12	-24.02	-50.70	-32.64
	CO	-12.75	-11.39	-7.99	-6.33	-7.33	-7.35	-11.40	-3.22
	CO_2	+7.5	+1.07	+2.26	+3.56	+6.38	+11.37	+18.11	+0.69
	NO_x	+7.19	+31.5	+3.21	+3.66	+17.15	+30.33	+0.32	+1.53
Blend B	HC	+10.60	+8.37	+12.77	+14.13	+12.37	+12.67	+9.73	+9.83
	CO	-7.2	-6.79	+8.8	+9.83	-6.51	-6.53	+9.27	+8.38
	CO_2	+8.41	+2.44	+3.57	+3.9	+14.5	+15.09	+20	+8.33
	NO_x	-14.28	+11.94	-18.08	-11.42	+22.65	+6.66	-1.67	-39.32
Blend C	HC	+16.04	+16.62	+19.79	+21.21	+16.26	+17.97	+19.35	+23.08
	CO	-11.25	-13.64	+12.52	+16.51	-9.58	-10.95	+13.8	+17.52
	CO_2	-15.2	-10.86	-21.17	+30.18	-2.98	-1.23	-3.85	-23.07
	NO_x	-56.12	-42.6	-44.74	-40.05	+1.62	-31.57	-42.38	-45.06

HC emissions are found to be increased by 10.40 % and 42.12 % for DBE10 and DBE20 respectively. CO emissions are slightly increased by 4.03 % for DBE10 blend and reduced slightly by 6.85 %. NO_x emissions are reduced slightly by 3.65 % for DBE10 blend but increased by 38.8 % for DBE20 blend. CO_2 emissions are increased by11.31 % for DBE10 blend and reduced by 8.8 % for DBE20 blend. For DB10 blend HC, CO, CO_2 reduced slightly but NO_x increased substantially.

Amongst the blends which are tested on the single cylinder DI diesel engine, blend DBE10 is found the best from performance and emission point of view because

- Blend DB10 has higher viscosity (856 kg/m^3) which do not satisfy the IS 1448 regulations. Because of high viscosity fuel injector and filters can choke-up. Power consumption increases as high power is required to pump the fuel due to heavy oil. NO_x emissions regulations are in narrow range than other emissions and biodiesel blend has high NO_x emission than other blends.
- Blend DBE10 has optimum viscosity and calorific value which gives slightly less brake torque and brake power. Slightly increase in BSFC is found. It has cetane index 42.04 which is satisfactory. It has optimum emission performance for HC, CO, NO_x andCO_2 emission.
- Blend DBE20 has lower calorific value amongst the all blends. It has lower cetane index (25.58) which is very low. It increases ignition delay and degrades performance of the engine. Drop in brake torque and and brake power is high. BSFC is high due to lower heating value of blend.

In general it can be said that diesel-ethanol-biodiesel blends reduces NO_x, PM, Smoke with slight increment in HC emissions while keeping CO emissions at same level compared with diesel fuel.

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