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Performance emission and Combustion Characteristics of a Low Heat Rejection Engine Fuelled with Diesel-CNSO-EEA Blend

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ABSTRACT

In the present study, the performance, emission and combustion characteristics of a conventional diesel engine and a low heat rejection engine have been evaluated using diesel and diesel-CNSO-EEA blended fuel. Study was carried out in the LHR engine with wide range of engine load conditions. During the study, performance, emission and combustion characteristics of both the fuels were tested and compared. The results showed that the blended fuel in LHR engine offers higher brake thermal efficiency and lower fuel consumption compared to conventional engine. The emission parameters are low in LHR engine. The ignition delay of the diesel-CNSO-EEA fueled LHR engine is very low compared others and the maximum pressure is very high.

Keywords - Cashew nut shell oil, 2 Ethoxy ethyl acetate, diesel engine, zirconia, low heat rejection.

1. INTRODUCTION

Diesel engines are major contributors of many air polluting exhaust gasses like Carbon monoxide, Unburnt hydrocarbons, Oxides of Nitrogen, etc. It has been shown that formation of these air pollutants can be significantly reduced by blending oxygenates into the base diesel [1, 2]. Various oxygenates like Dimethyl Ether (DME), Dimethyl Carbonate (DMC), Diethyl Ether (DEE), 2 Ethoxy Ethyl Acetate (EEA), etc. has been already nominated as a potential alternative fuel due to no carbon-carbon bond. Though the use of alternate fuels (vegetable oils, animal fats, oxygenated additives, etc.) in diesel engines decreases the level of harmful compounds in the exhaust emissions, the main disadvantage is it decreases the efficiency of the engine [3].

The efficiency of the engine can be increased by reducing the heat loss to the surroundings by means of coolant and the surroundings. This can be achieved by means of thermal barrier coatings to the engine components [4]. The use of thermal barrier coatings to increase the temperature in diesel engines has been pursued for over 20 years. Increased combustion temperature can increase the efficiency of the engine; decrease the CO and NOx emission rate. The most common TBC system is Yttrium Partially Stabilized Zirconia (Y-PSZ) which has shown good performance in turbine blade coatings where temperatures approach 1100°C [5, 6].

Ruijin Zhu et al [7] investigated the particulate emission characteristics of a compression ignition engine fuelled with diesel–Dimethyl carbonate blends and reported that the smoke opacity, the particulate mass concentration as well as the total number of particulates are all reduced with the use of Dimethyl Carbonate as additive in diesel fuel. Senthil et al [8] investigated the effect of 2 Ethoxy Ethyl Acetate as a blend component in compression engine and reported that the engine runs smoothly with emission level comparably lower than diesel.

Balkrishna et al [9] investigated the performance and combustion characteristics on a single cylinder low heat rejection engine using diesel and multi-blend biodiesel. They reported that Al_2O_3 coated engine achieved better performance than conventional diesel engine in terms of brake power, engine efficiency and specific fuel consumption. Parlak et al [10] studied the performance and emission characteristics of LHR diesel engine with low compression ratio and found that satisfactory engine performance was obtained at compression ratios of 17.50 and 16.80 in the LHR engine and the specific fuel consumption and NOx emissions also reduced at these compression ratios compared to the unmodified diesel engine.

In this study, the effect of 2-Ethoxy Ethyl Acetate blend with diesel and cashew nut shell oil was evaluated experimentally in conventional and low heat rejection diesel engine and the results were compared with neat diesel fuel.

2. MATERIAL AND METHODS

Cashew nut shell oil was purchased from the local market in Panruti, Cuddalore district. Diesel was purchased from the local bunk. The properties of diesel, cashew nut shell oil and 2-Ethoxy Ethyl Acetate are given in table 1.

Table 1 Properties of the test fuels

Property	Diesel	CNSO	2-EEA
Viscosity (cSt)	3.42	9.45	3.79
Density (kg/m^3)	840	952	0.94
Calorific value (MJ/kg)	42.8	40.6	24.35
Flash point (°C)	61	256	51
Fire Point (°C)	70	264	58

The engine used for testing is Kirloskar make, single cylinder, water cooled engine coupled with electrical dynamometer. Specification of the test engine is given in Table 2. The exhaust gas temperature was measured with k-type thermocouple. The CO, UBHC and NOx were measured by NELTEL exhaust gas analyzer. The piston, cylinder head, inlet and outlet valve of the engine was coated with a zirconia material through plasma spray process. Engine performance and emission tests were carried out with and without ceramic coating.

Table 2 Specification of the test engine

Make	Kirloskar
No. of cylinders	One
No, of strokes	Four
Bore	87.5 mm
Stroke	110 mm
Speed	1500 rpm
Cooling	Water cooling
Dynamometer	Eddy current dynamometer

3. RESULTS AND DISCUSSIONS

Fig. 1 shows the variation of brake thermal efficiency with respect to load. In all cases, brake thermal efficiency has the tendency to increase with increase in applied load. This is due to the reduction in heat loss and increase in power developed with increase in load. From the figure, it is clear that the brake thermal efficiency of the engine for both diesel and diesel-CNSO-EEA blend are slightly increased after coating. At maximum load condition, the brake thermal efficiency of the engine increased 3.2% after coating for diesel fuel. For the same load, the brake thermal efficiency increased for 6.1% diesel-CNSO-EEA blend.

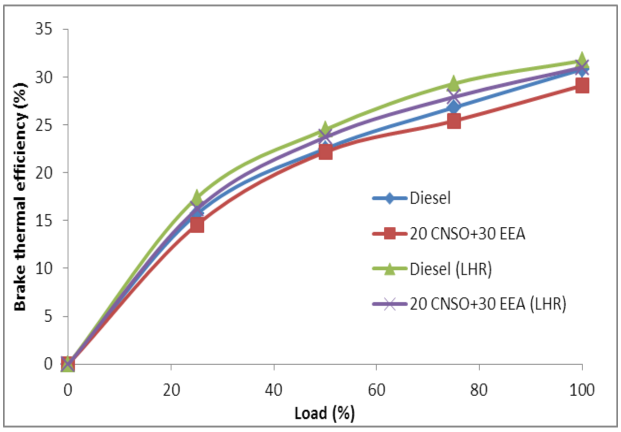

Fig. 1 Brake thermal efficiency

Fig. 2 shows the variation of specific fuel consumption with respect to load. From the figure, it is clear that specific fuel consumption of both the fuels decreasing after the coating due to the reduction of the heat loss to surroundings from the engine. At maximum load, the specific fuel consumption of LHR engine fuelled with diesel is 9.5% lower than conventional engine fuelled with neat diesel fuel. At maximum load, the specific fuel consumption of LHR engine fuelled with diesel-CNSO-EEA blend is 2.91% and 5.6% lower than conventional engine fuelled with neat diesel fuel and diesel-CNSO-EEA blend respectively.

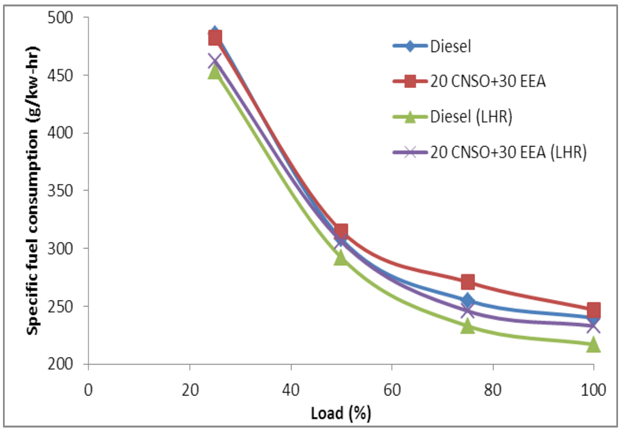

Fig. 2 Specific fuel consumption

Fig. 3 shows the variation of variation of hydrocarbon emission of the engine with respect to load. Hydrocarbon emission is low in LHR engine when compared with conventional engine for all the test fuels.

The decrease in the hydrocarbon in the LHR engine may be due to the increase in after combustion temperature due to decrease in heat rejected to cooling and heat loss to atmosphere due to the zirconia coating. In LHR engine unburned hydrocarbons were added to the combustion. Thus the results clearly indicate that the ceramic coating lowers the hydrocarbon emission compared with uncoated engine. From the figure, it is clear that the hydrocarbon emission of both the fuels decreasing after the coating due to the reduction of the heat loss to surroundings from the engine. At maximum load, the HC emission of LHR engine fuelled with diesel is 7.04% lesser than conventional engine fuelled with neat diesel fuel. At maximum load, the HC emission of LHR engine fuelled with diesel-CNSO-EEA blend is 13.11% and 9.80% lesser than conventional engine fuelled with neat diesel fuel and diesel-CNSO-EEA blend respectively.

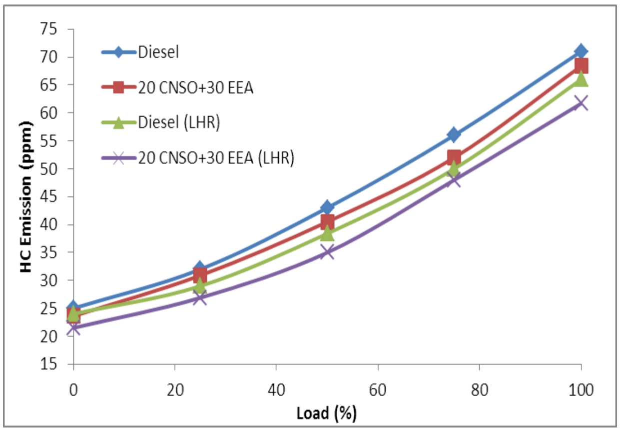

Fig. 3 Undurned hydrocarbon emission

The variation of oxides of nitrogen emission with respect to load for diesel and diesel-CNSO-EEA blend with and without zirconia coating is shown in Fig 4. From the figure, it is clear that the oxides of nitrogen emission of both the fuels decreasing after the coating due to the reduction of the heat loss to surroundings from the engine. At maximum load, the oxides of nitrogen emission of low heat rejection engine fuelled with diesel is 7.28% lesser than conventional engine fuelled with neat diesel fuel. At maximum load, the oxides of nitrogen emission of LHR engine fuelled with diesel-CNSO-EEA blend is 2.61% and 7.43% lesser than conventional engine fuelled with neat diesel fuel and diesel-CNSO-EEA blend respectively.

The variation of smoke emission with respect to load for diesel and diesel-CNSO-EEA blend with and without zirconia coating is shown in Fig 5. From the figure, it is clear that the smoke emission of both the fuels decreasing after the coating due to the reduction of the heat loss to surroundings from the engine. At maximum load, the smoke emission of low heat rejection engine fuelled with diesel is 12.91% lesser than conventional engine fuelled with neat diesel fuel. At maximum load, the smoke emission of LHR engine fuelled with diesel-CNSO-EEA blend is 18.46% and 11.69% lesser than conventional engine fuelled with neat diesel fuel and diesel-CNSO-EEA blend respectively.

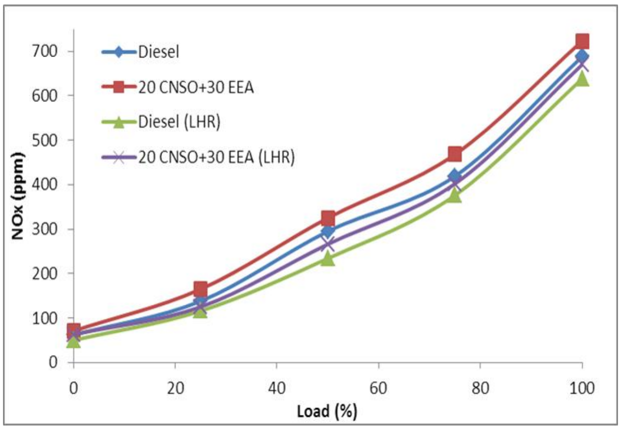

Fig. 4 Oxides of nitrogen emission

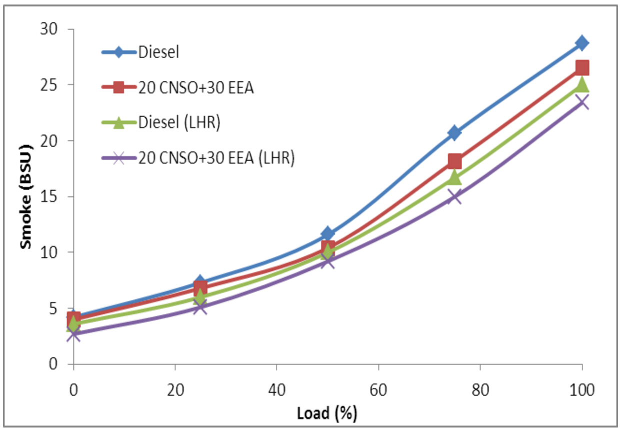

Fig. 5 Smoke emission

The variation of ignition delay with respect to load for diesel and diesel-CNSO-EEA blend with and without zirconia coating is shown in Fig 6. From the figure, it is clear that the ignition delay of both the fuels decreasing after the coating due to the reduction of the heat loss to surroundings from the engine. At maximum load, the ignition delay of low heat rejection engine fuelled with diesel is 21.90% lesser than conventional engine fuelled with neat diesel fuel. At maximum load, the ignition delay of LHR engine fuelled with diesel-CNSO-EEA blend is 30.01% and 22.63% lesser than conventional engine fuelled with neat diesel fuel and diesel-CNSO-EEA blend respectively.

The variation of maximum cylinder pressure with respect to load for diesel and diesel-CNSO-EEA blend with and without zirconia coating is shown in Fig 7. It may be noticed that the maximum cylinder pressure for CNSO-EEA blend with are higher than the diesel at all the load conditions in both conventional as well as low heat rejection engine. At full load, the maximum cylinder pressure of low heat rejection engine fuelled with diesel is 4.65% higher than conventional engine fuelled with neat diesel fuel. At maximum load, the ignition delay of LHR engine fuelled with diesel-CNSO-EEA blend is 7.71% and 6.02% higher than conventional engine fuelled with neat diesel fuel and diesel-CNSO-EEA blend respectively.

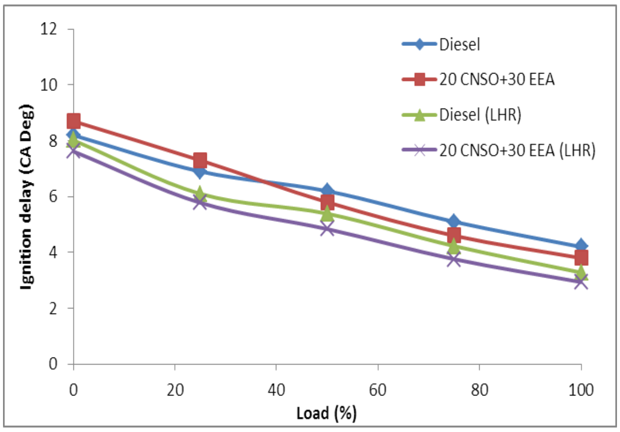

Fig. 6 Ignition delay

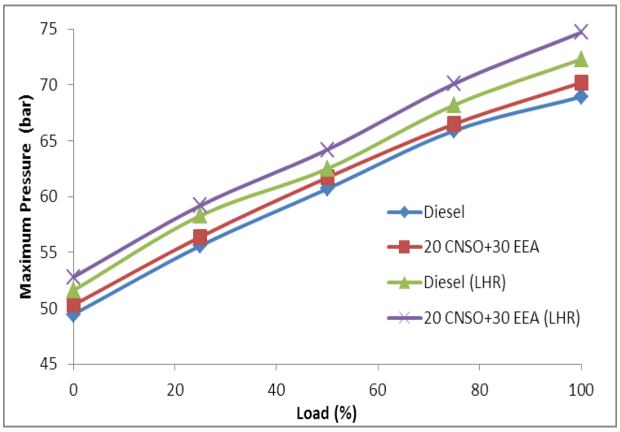

Fig. 7 Maximum cylinder pressure

5. CONCLUSION

This paper discussed the detailed study of the performance, emission and combustion characteristics of a single cylinder, direct injection diesel engine with and without ceramic coating. The following conclusions can be drawn.

- In ceramic coated engine, both the fuels gave higher efficiency than the standard engine due to reduction in heat loss.
- The specific fuel consumption of LHR engine is low value for both the test fuels when compared to conventional engine.
- The UBHC and smoke emission of a zirconia coated engine is low compared to the conventional engine.
- The ignition delay of a zirconia coated engine is low compared to the conventional engine.
- The maximum cylinder pressure of a zirconia coated engine is high compared to the conventional engine.

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