Study of Performance and Emission Characteristics of Four Stroke Indirect Injection (IDI) Diesel Engine with Diesel-Used Transformer Oil (UTO) Blends

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Abstract

In the present work, an attempt has made to study the performance and emission characteristics of four stroke indirect injection diesel engines using diesel-UTO blends for varying loads. The experiments are repeated using diesel-UTO blends. The obtained results are compared with that of pure diesel. It is found that there is no much variations in the performance characteristics but the harmful emissions were comparatively reduced. Also, it is noted that there is significant reduction in the NO_x emissions. It is clear that the use of diesel-UTO blends can reduce the NO_x emissions and no much variations seen in the other emissions.

Keywords: *Indirect injection, UTO, NO_x emissions*

1. Introduction

The diesel engine was invented in 1890s by Rudolf Diesel. The diesel engine is an internal combustion engine in which ignition of the fuel is caused by the rise in temperature of the air in the cylinder due to mechanical compression. In diesel engines, there are two types of injection systems namely direct and indirect injection system. In Indirect injection (IDI) the fuel injection is not directly injected into the combustion chamber. Instead, the fuel first enters the pre-combustion chamber (or air cell) and then it spreads into the main combustion. Whereas, in direct injection system (DI) the fuel is directly injected into the combustion chamber, usually on the top of the piston which is designed to control the spread of combustion.

Pritinika Behera et al., [1] have conducted experiment to evaluate the combustion, performance and emission parameters of a single cylinder, four stroke, air cooled, direct injection diesel engine, fueled with used transformer oil (UTO) and six of its diesel blends on varying the UTO concentration from 10% to 60%, at a regular interval of 10% by volume basis. The results were analyzed and compared with diesel operation. Increase in thermal efficiency with significant improvement in reduction of smoke was observed for UTO and its diesel blends compared to diesel. NO emissions were higher for UTO and its diesel blends than that of diesel. Ignition delay was marginally shorter for UTO and its diesel blends than diesel. Pritinika Behera et al, [2] have carried out an investigation on the utilization of the UTO in a single cylinder, four stroke small powered direct injection (DI) diesel engine.

S.Prasanna Raj Yadav et al, [3] have worked on the effective utilization of WTO (waste transformer oil) in a diesel engine and thereby, reducing the environmental problems caused by its disposal into open land. The waste transformer oil (WTO) can be used after refining it by transesterification process or catalytic cracking process and then mixed with diesel fuel as a base fuel for evaluating different engine and emission parameters and to use it as an alternate source of fuel [4]. Used transformer oil (UTO) is also a waste product which is used for cooling purpose [5]. The used transformer oil can be treated to remove water, gases and other impurities. Thus, obtained treated transformer oil (TTO) can be used as an alternate fuel in diesel engines. Pramod Belkhode et al., [6] have worked on the effectiveness with using treated transformer oil (TTO) as diesel engine fuel. According to the findings of this study, blends of treated transformer oil and diesel fuel found to be a best choice for diesel engines since they have the same calorific value as diesel fuel.

From the literature survey, it is found that most of the researchers have worked with direct injection (DI) diesel engine to study the performance and emission characteristics using Diesel-UTO blends. Researchers found that there is no much variation in the performance characteristics but there is a significant drop in the harmful emissions, especially NO_X emissions. A meagre work is reported regarding study of performance and emission characteristics of IDI Diesel engines using Diesel-UTO blends.

2. Experimental setup and procedure

Diesel engine incorporated is vertical and naturally aspirated with cold start. Fuel injection timing is 18˚ before TDC with injection pressure of 160 kg/cm^2. Table 1 shows the specifications of the engine. Engine speed is control by mechanical, centrifugal governor which keeps engine speed within the range of 920-930 rpm. Fig. 1 shows the schematic diagram of the engine test rig. A single cylinder diesel engine has been used in this experiment. Vinitech EFM-2000 emission gas analyzer was used to measure NOx, CO2, SOx and CO emissions. Methanol is commonly known as methyl alcohol, contains one carbon atom. It is a tasteless, colourless liquid with a pale odour. Methanol has flash, boiling and melting points of 12˚C, -97.8˚C and 64.7˚C respectively. Ethanol is a water-soluble liquid with specific gravity 0.79. The flash point, fire point and boiling point of ethanol are 13˚C, 423˚C and 78˚C respectively [7].

Table 1. Specification of the experimental test rig

Make	Topland Engine Pvt Ltd, 12A
Type	Four stroke, IDI naturally aspirated
Power	8 hp
Specific fuel consumption	0.268 kg/kW-hr
Bore x Stroke (cm)	11.43 x 13.97
Compression ratio	18:1
Number of cylinders	One
Swept volume (cc)	1433

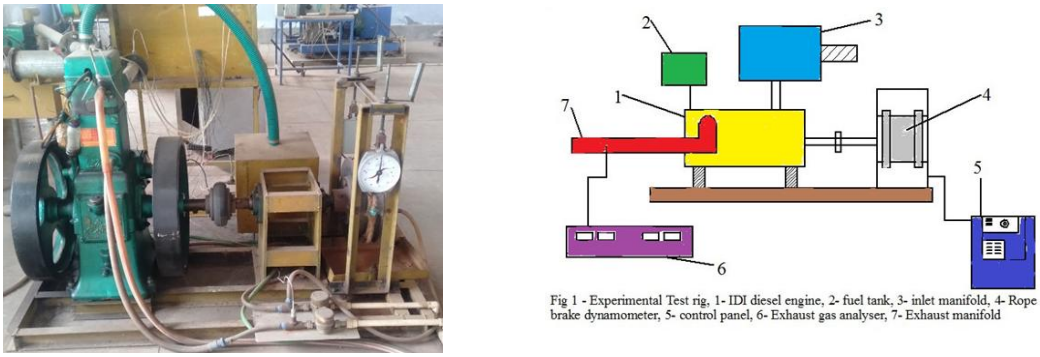

Fig. 1 Photographic and schematic representation of experimental test rig

2.1 Test fuel

All the experiments were conducted at the Engines laboratory, Department of Mechanical Engineering, Shri Madhwa Vadiraja Institute of Technology and Management, Bantakal, Udupi. A total of five test fuels were selected, there are (1) diesel fuel 100%, (2) 95% diesel + 5% UTO, (3) 90% diesel + 10% UTO, (4) 85% diesel + 15% UTO, (5) 80% diesel + 20% UTO. Using mechanical stirrer, all test fuels were mixed for 30 minutes and no phase separation was observed.

3. Results of the engine performance and emission characteristics

A well-known method of valuation of experimental data was applied to determine various errors. At the end of error analysis, it was concluded that probable errors of the measured main values and also uncertainties in the parameters were in the interval of (0.5-4%). The experiment results include comparison of engine performance and emission characteristics of diesel and UTO blends. A constant speed of 900 rpm (+/-0.5%) was maintained with help of centrifugal governor.

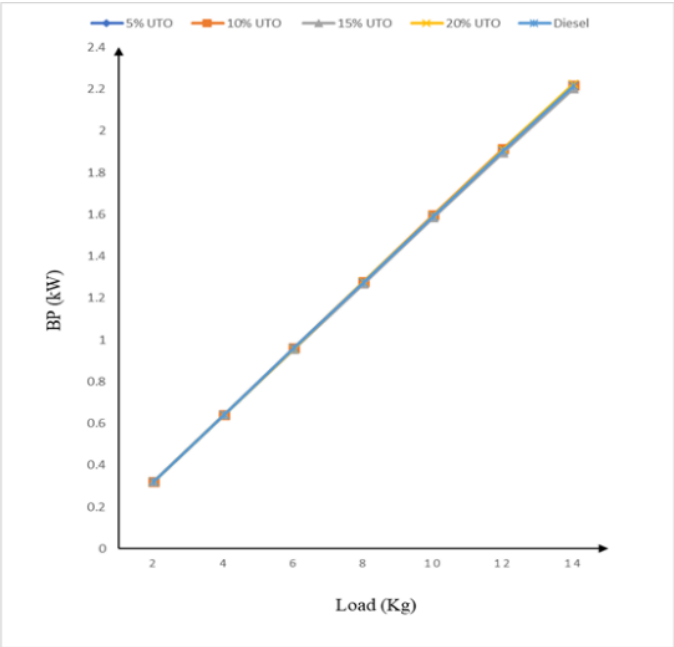

Fig.2 Plot of Brake Power against different loads for different Diesel-UTO blends and the pure diesel

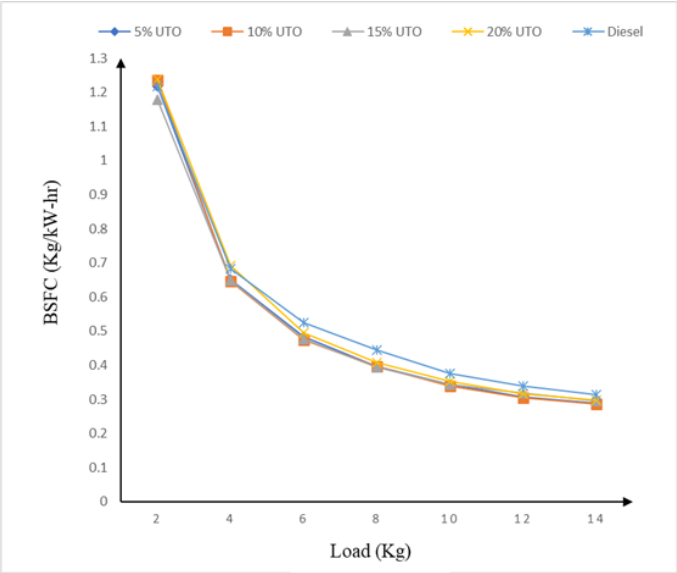

Fig. 3 Plot of BSFC against different loads for different Diesel-UTO blends and the pure diesel

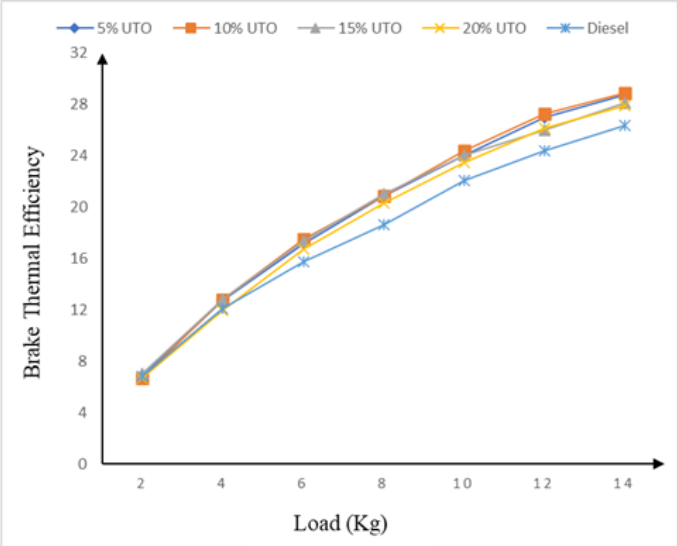

Fig. 4 Plot of Brake Thermal Efficiency against different loads for different Diesel-UTO blends and the pure diesel

3.1 Brake power vs load

Fig. 2 shows plot of Brake Power against different loads for different diesel-UTO blends and the pure diesel. It is found from the results that all Brake Power v/s Load curves are almost converging for different diesel-UTO blends with that of pure diesel. This indicates that the output power of the engine remains almost same with diesel-UTO blends and the pure diesel.

3.2 Brake Specific Fuel Consumption (BSFC) vs load

It is observed from the performance characteristic in Fig. 3, that the Brake Specific Fuel Consumption (BSFC) of the engine decreases with load. At lower loads, it is found that the BSFC of the diesel-

UTO blends is almost same as that of the pure diesel. But at higher loads, there is a slight decrease in the BSFC in the case of diesel-UTO blends compared to the pure diesel.

3.3 Brake thermal efficiency vs load

It is observed from the performance characteristic in Fig. 4, that the Brake thermal efficiency of the engine increases with load. At lower loads, it is found that the Brake thermal efficiency of the diesel-UTO blends is almost same as that of the pure diesel. But at higher loads, there is a slight increase in the Brake thermal efficiency in the case of diesel-UTO blends compared to the pure diesel.

3.4 Emission characteristics of diesel-UTO blends

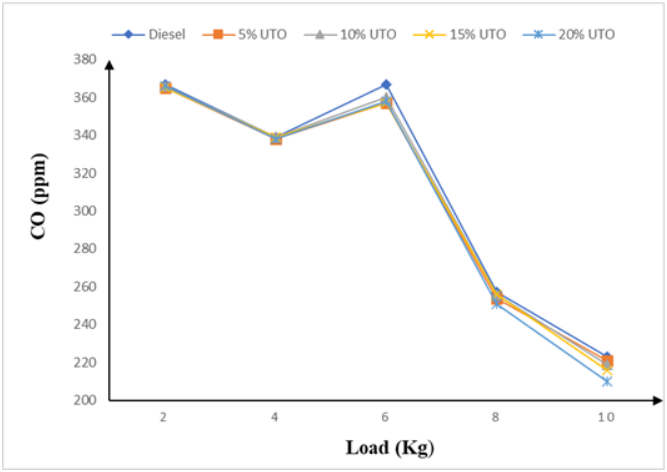

Fig. 5 Plot of CO emissions against varying loads for different Diesel-UTO blends and the pure diesel

From the obtained results, an average CO emission for sample-1 (Pure diesel) is found to be 310.6 ppm, for sample-2 (95% diesel + 5% UTO) it is 307 ppm, for sample-3 (90% diesel + 10% UTO) it is 308 ppm, for sample-4 (85% diesel + 15% UTO) it is 306.6 ppm and for sample-5 (80% diesel + 20% UTO) it is 304.6 ppm. Hence it is clear that there is slight reduction in the CO emissions when the engine is operated with diesel-UTO blends compared to the pure diesel. Fig. 5 shows the plot of CO emissions against varying loads for different Diesel-UTO blends and the pure diesel.

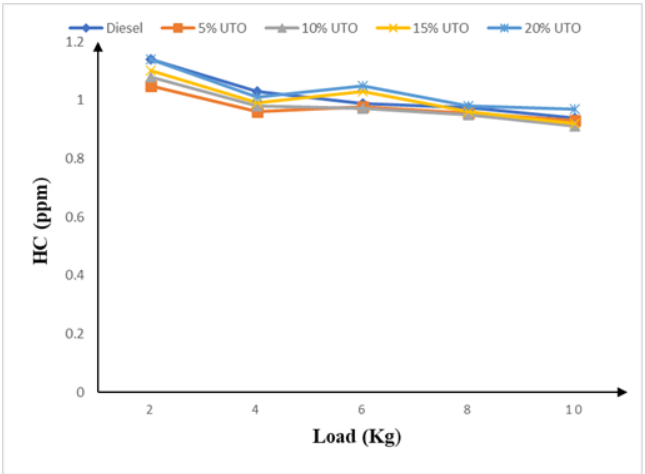

Fig. 6 Plot of Hydrocarbon emissions against varying loads for different Diesel-UTO blends and the pure diesel

From the obtained results, an average HC emission for sample-1 (Pure diesel) is found to be 1.01 ppm, for sample-2 (95% diesel + 5% UTO) it is 0.974 ppm, for sample-3 (90% diesel + 10% UTO) it is 0.978 ppm, for sample-4 (85% diesel + 15% UTO) it is 1.00 ppm and for sample-5 (80% diesel + 20% UTO) it is 1.03 ppm. Hence it is clear that there is no much variation in the HC emissions when the engine is operated with diesel-UTO blends compared to the pure diesel. Fig. 6 shows the plot of HC emissions against varying loads for different Diesel-UTO blends and the pure diesel.

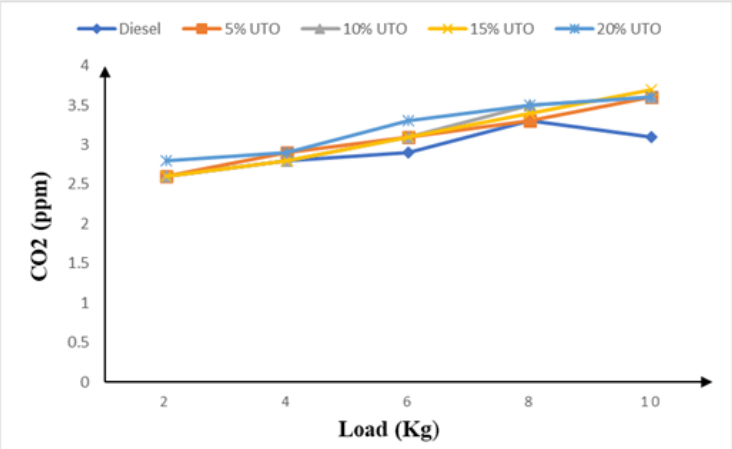

Fig. 7 Plot of Carbon dioxide emissions against varying loads for different Diesel-UTO blends and the pure diesel

From the obtained results, an average CO_2 emission for sample-1 (Pure diesel) is found to be 2.94 ppm, for sample-2 (95% diesel + 5% UTO) it is 3.10 ppm, for sample-3 (90% diesel + 10% UTO) it is 3.12 ppm, for sample-4 (85% diesel + 15% UTO) it is 3.12 ppm and for sample-5 (80% diesel + 20% UTO) it is 3.22 ppm. Hence it is clear that there is slight increase in the CO_2 emissions when the engine is operated with diesel-UTO blends compared to the pure diesel. This is due to the complete oxidation of carbon, which is evident from decrease in CO emissions when diesel-UTO blends are used. Fig. 7 shows the plot of HC emissions against varying loads for different Diesel-UTO blends and the pure diesel.

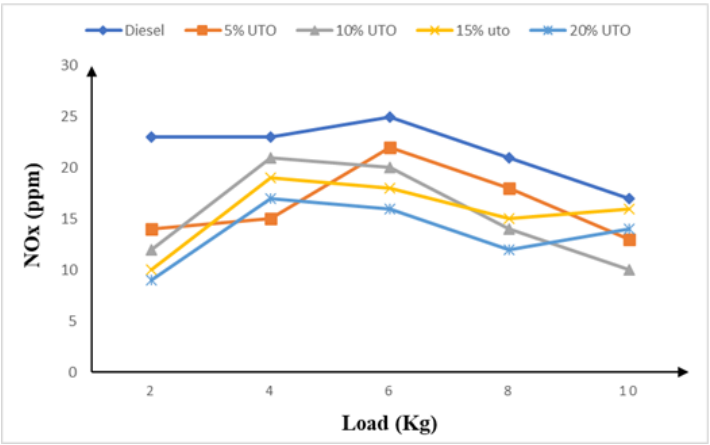

Fig. 8 Plot of NOx emissions against varying loads for different Diesel-UTO blends and the pure diesel

From the obtained results, an average NOx emission for sample-1 (Pure diesel) is found to be 21.80 ppm, for sample-2 (95% diesel + 5% UTO) it is 16.40 ppm, for sample-3 (90% diesel + 10% UTO) it is 15.40 ppm, for sample-4 (85% diesel + 15% UTO) it is 15.60 ppm and for sample-5 (80% diesel + 20% UTO) it is 13.60 ppm. Hence it is clear that there is a significant decrease in the NO_x emissions when the engine is operated with diesel-UTO blends compared to the pure diesel. The NO_x emissions are found decreasing as the percentage of UTO is increasing in the fuel sample. Fig. 8 shows the plot of NO_x emissions against varying loads for different Diesel-UTO blends and the pure diesel.

4. Conclusions

In the present work, the experimentations are carried out to study the Performance and emission characteristics of four stroke indirect injection (IDI) diesel engine with Diesel-UTO blends and comparing the results with that of the pure diesel.

From the results obtained from the performance tests, the following conclusions were made

1. At lower loads, it is found that the BP of the diesel-UTO blends is almost same as that of the pure diesel. But at higher loads, there is a slight decrease in the BP in the case of diesel-UTO blends compared to the pure diesel.
2. The BSFC of the engine decreases with load. At lower loads, it is found that the BSFC of the diesel-UTO blends is almost same as that of the pure diesel. But at higher loads, there is a slight decrease in the BSFC in the case of diesel-UTO blends compared to the pure diesel.
3. At lower loads, it is found that the Brake thermal efficiency of the diesel-UTO blends is almost same as that of the pure diesel. But at higher loads, there is a slight increase in the Brake thermal efficiency in the case of diesel-UTO blends compared to the pure diesel.

From the results obtained from the emission tests, the following conclusions were made

1. A slight reduction in the CO emissions is observed when the engine is operated with diesel-UTO blends compared to the pure diesel.
2. There is no much variation in the HC emissions is observed when the engine is operated with diesel-UTO blends compared to the pure diesel.
3. A slight increase in the CO_2 emissions is observed when the engine is operated with diesel-UTO blends compared to the pure diesel. This is due to the complete oxidation of carbon, which is evident from decrease in CO emissions when diesel-UTO blends are used.
4. A significant decrease in the NO_x emissions is observed when the engine is operated with diesel-UTO blends compared to the pure diesel. The NO_x emissions are found decreasing as the percentage of UTO is increasing in the fuel sample.

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