Investigation of Performance Parameters for Ethanol Diesel in CI Engine

Vijeth C
The National Institute of Engineering,
Mysore.
Narayana H
The National Institute of Engineering,
Mysore.

Sajan A B
The National Institute of Engineering,
Mysore.
Shamanth P
The National Institute of Engineering,
Mysore.

***Abstract*—Ethanol is an attractive alternative fuel because it is a renewable bio-based resource and it is oxygenated, thereby providing the potential to reduce particulate emissions in compression ignition engine. Ethanol combustion in an internal combustion engine yields many of the products of incomplete combustion; hence ethanol is blended with diesel. In this paper, the injection parameters are optimized for the E-diesel blends to obtain acceptable performance and emissions levels.**

In this study, the investigations was aimed to study the performance characteristics of a single cylinder four stroke diesel engine using ethanol blended in different ratios with diesel fuel and nozzles having different spray characteristics. The results are used to optimize the nozzle, injection timing and injection pressure. The results of engine test showed that the ethanol blend of 5-10% gives a compromising performance and low emissions. For nozzle E043269300 injection timing of 16.52º BTDC and injection pressure of 200 BAR gives better performance for 5% E-Diesel and for nozzle 105DLL110S1030 injection timing 9.62º BTDC and pressure of 200 BAR gives better performance for 10% E-Diesel. Further comparing both nozzles E043269300 with injection timing of 16.52º BTDC and injection pressure of 200 BAR using 5% E-Diesel gives acceptable performance.

Keywords— E-Diesel, performance, injection timing, injection pressure, nozzle configuration.

I. INTRODUCTION

In the context of higher crude oil price, depleting petroleum recourses and vehicular pollution search for renewable sources of energy and cleaner technologies has become significant. The agreement to reduce CO2emission has a great effect on automotive sector. Diesel engines provide important transportation power sources which are receiving additional attention due to their superior fuel economy and lower greenhouse gas emissions. However, diesel engines have the problem of emitting more amount of particulate matter (PM) due to its heterogeneous combustion. Diesel emission control is a function of combustion improvement, fuel formulation and after treatment devices [1].

In general, it has been recognized that the addition of oxygenated blend components to diesel fuel will result in lower particulate emissions under many operating conditions. Since ethanol (35% of oxygen content) is widely available oxygenate with long history of use in gasoline blends it has also been considered as a potential oxygenate with diesel fuel. The particulate matter reduction appeared to be related to the amount of oxygen content in the fuel blends [2, 3, 4]. Mixing up to 15 %(vol) of ethanol with diesel is the easiest method to use ethanol in diesel engines. But the ethanol solubility in diesel is one of difficulties of using ethanol in them. Ethanol has very low cetane number that reduces the cetane number of ethanol-diesel blend. Hence cetane improvers and co solvent are added.

With an increase of ethanol in diesel fuel, there will be a reduction in smoke and particulate matter, an increase in total hydrocarbon, CO and NOx could increase or decrease depending on the engine type and operating conditions [1]. Diesel oxidation catalysts installed on a vehicle’s exhaust system oxidizes CO, HCs and the soluble organic fraction of particulate matter in to carbon dioxide and water.

Based on this background, the purpose of this research is to compare the engine performance and exhaust temperature when diesel engine is fuelled with oxygenated bio fuel blends such as ethanol. The nozzle with different nozzle characteristic such as nozzle spray hole diameter, number of spray holes and spray configuration were used to find the effect of the nozzle characteristics on various E-Diesel blends. For the nozzle which resulted improved performance. Further, the injection timing and injection pressure were optimized.

II. ETHANOL RESOURCES IN INDIA

India is the second largest producer of sugarcane in the world [2]. Ethanol is mainly derived from sugarcane molasses which is by-product in the conversion of compromise on the food security front in India. On an average basis one ton of sugarcane yields 100 kgs of sugar and 11 litres of ethanol (On fermentation of 45kgs of molasses). While producing unrefined sugar in cottage industries appreciable amount of molasses are produced asby-product and mostly dumped as waste. These molasses can be utilized for bio ethanol production.

III. LITERATURE SURVEY

To study different parameters of blends we have researched and studied various renowned papers published by renowned authors in this field. Below are some of the papers referred during this study.

According to D.C. Rokopoulos et.al for ethanol diesel fuel blends, BSFC is a comparatively more than the diesel fuel reason being lower calorific value of ethanol compared to the 100% diesel fuel at same load.

De-Gang Li et.al claimed that reason is incomplete combustion due to the ignition delay of ethanol–diesel blend fuel. And increasing the ethanol proportion in the fuel blend increases the BSFC. The reason of higher fuel consumption is the low heating value per unit mass of ethanol which is considerably lower than that of the diesel fuel resulting in more consumption of ethanol blend. These results match those found by other authors.

According to M. Al. Hassan et.al blend containing 5% ethanol shows same engine power at that of neat diesel. As the percentage of ethanol increases the brake power decreases reason being low heating valve of biodiesel ethanol blends.

Tomas Mickevicius in his paper “Effect of ethanol on performance and durability of a diesel common rail high pressure fuel pump” stated that the use of the ethanol-diesel blend tested produced a negative effect on the durability of the high pressure fuel pump. The wear of plungers and barrels caused a decrease in fuel delivery up to 30% after 100h of operation. He suggested use of Teflon coating for both plunger and barrel.

Based on the above results Tarkan Sandalci et.al used a Teflon coated plunger and barrel in high pressure diesel pump. He found that the pump delivered at an efficiency of 95%, but there was no considerable improvement in performance of the four stroke diesel engine. These he suggest further experimentation on nozzle and timing for improvement in performance of the engine.

IV. EXPERIMENTAL SETUP

Fig. 1. Diesel engine test rig.

Main components of the lab are engine, fuel supply unit, loading unit including water rheostat, cooling system, temperature measuring devices, Tachometer, voltmeter, ammeter and Thermocouple with temperature indicator.

The engine as shown in Fig. 1 was a single cylinder four stroke, naturally aspirated direct injection and water cooled diesel engine. A thermocouple was introduced in the exhaust pipe to measure exhaust gas temperature. The specification of the engine is given in table 1. It is couple to a generator whose output is used in electrolysis process. This engine was used for evaluation of performance, combustion and emissions of E-Diesel blends.

TABLE I. ENGINE SPECIFICATIONS

Vertical Single cylinder diesel engine	
Make	Kirloskar.
Type	Four stroke.
Swept volume	553cc
Compression ratio	16:1
Rated power	3.75Kw @ 1500rpm
Loading	Direct current generator (water rheostat) Voltage 140V Max current 23 Amps

V. EXPERIMENTAL PROCEDURE

Fig. 2. Nozzles used.

The engine was operated at a constant speed of 1500rpm. Nine engine loads with valves of 0.0, 0.4, 0.8, 1.3, 1.7, 2.1, 2.5, 2.9 and 3.3kw were chosen for engine experiments. The first stage of experiment was performed with pure diesel at no load to full load (Baseline performance was established). The second stage of experiment was done using blends of E-Diesel (5% Ethanol, 10% Ethanol, and 15% Ethanol). Then same experiments were repeated for different nozzle having different injection characteristics. The nozzles which gave a better improvement of performance with considerable decrease in emission were selected for injection timing and injection pressure optimization.

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VI. Results and Discussions

A. *Performance Analysis:*

The following are the SFC versus BP curve for different nozzles.

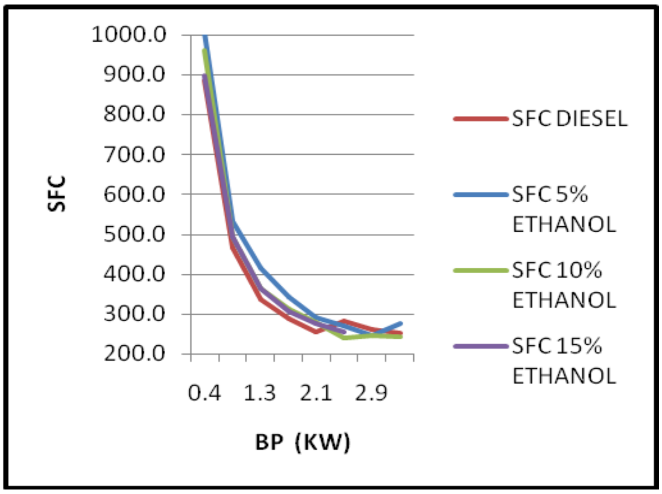

Fig. 3. SFC v/s BP for nozzle DLLA110S1030.

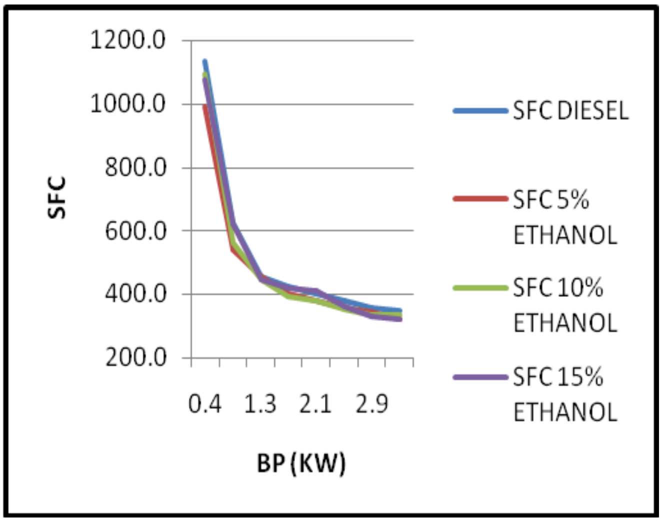

Fig. 4. SFC v/s BP for nozzle DLL150S405.

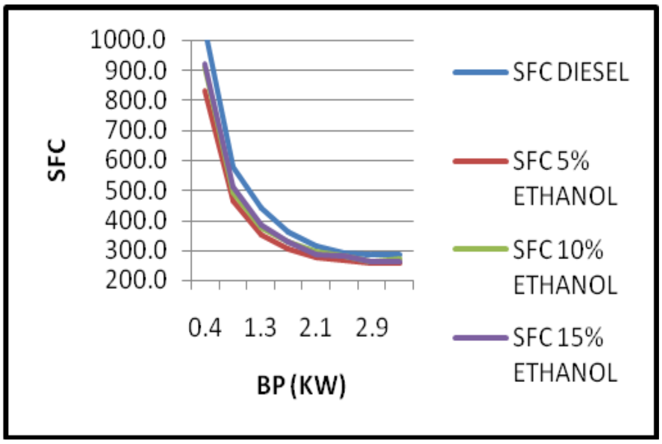

Fig. 5. SFC v/s BP for nozzle E043269300.

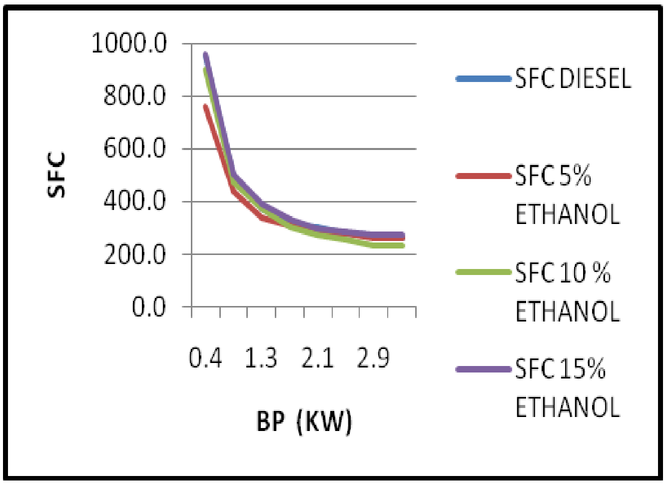

Fig. 6. SFC v/s BP for nozzle DLL110S1030.

Fig. 3, 4, 5 and 6 shows specific fuel consumption versus brake power for E-Diesel blends. It is from graphs that as the load increases, the SFC decreases. The specific fuel consumption of Ethanol blends is lower than that of diesel. These behaviors are reasonable because the oxygenated blends have low calorific valve compared to that of diesel fuel. The improvement in energy consumption is due to better combustion on account of oxygen enrichment.

B. *Exhaust Temperature Analysis:*

Fig. 7, 8, 9 and 10 shows exhaust gas temperature versus brake power for the ethanol-diesel blend fuels for various loads. It is observed that for all E-diesel blends, the temperature is slightly lower than for pure diesel operation. This due to the latent heat of evaporation of the ethanol blends compared with that for the diesel fuel. By the reduction in the exhaust gas temperature we can say that there is an improvement in combustion process because of the use of emission levels.

The following are the Exhaust temperature versus BP curves for different nozzles.

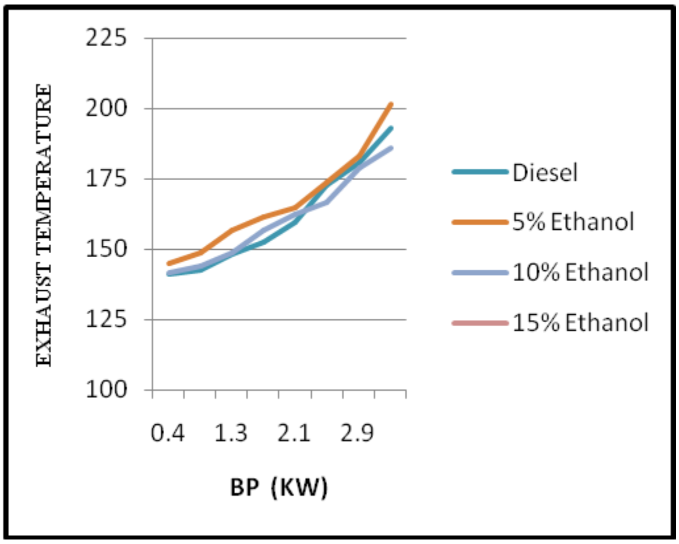

Fig. 7. . Exhaust temperature v/s BP for nozzle DLLA110S1030.

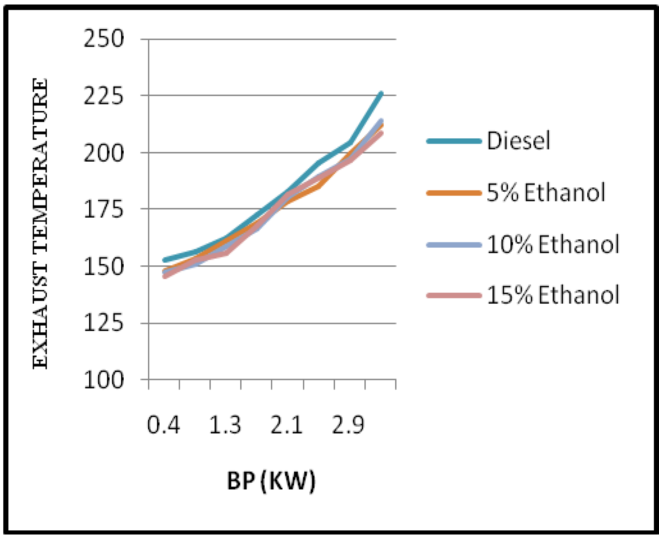

Fig. 8. Exhaust Temperature v/s BP for nozzle DLL150S405.

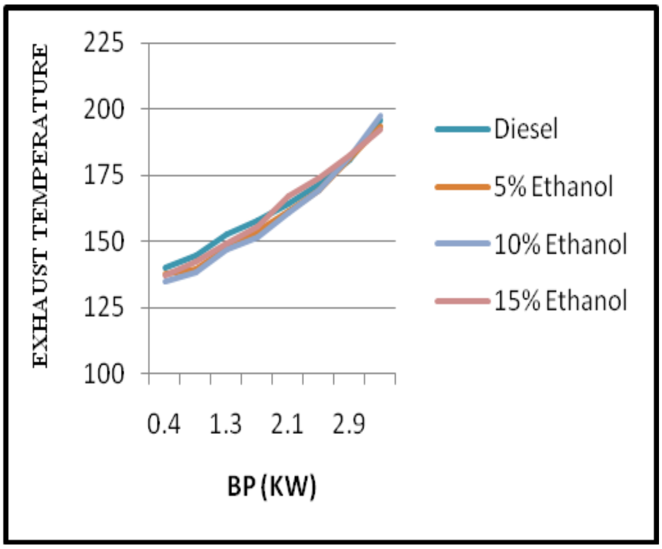

Fig. 9. Exhaust temperature v/s BP for nozzle E043269300.

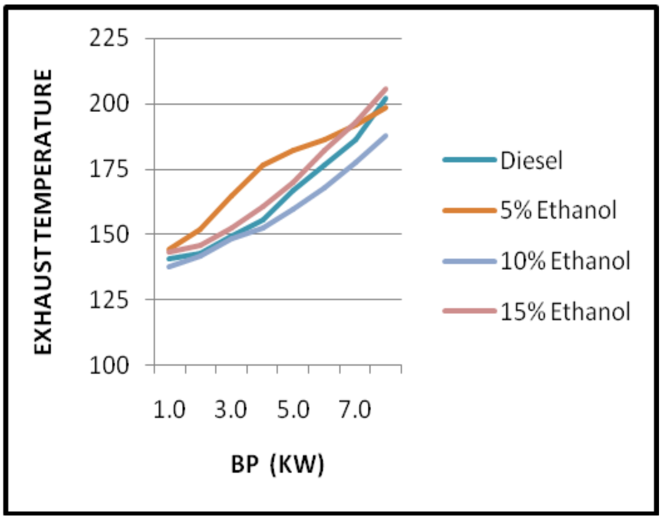

Fig. 10. Exhaust temperature v/s BP for nozzle DLL110S1030.

C. Injection Timing Optimization:

Injection timing optimization is needed as there must be a sufficient time in engine for ethanol to mix and burn. Ethanol having lower calorific valve burns first releasing oxygen. This aids the combustion of diesel.

Following figures for 5% Ethanol-diesel blend:

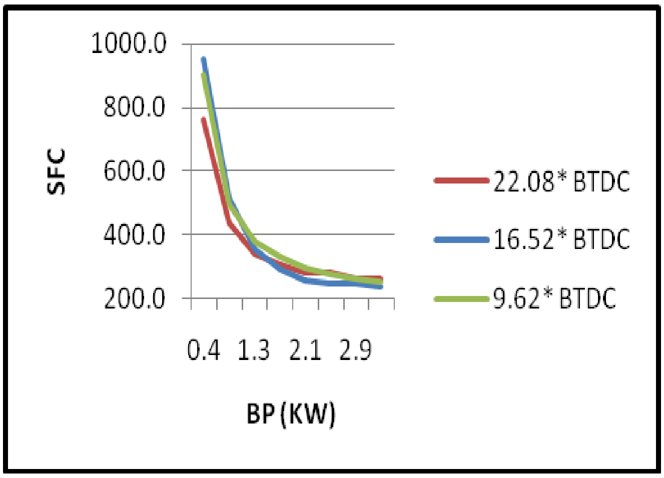

Fig. 11. SFC v/s BP for different injection timing.

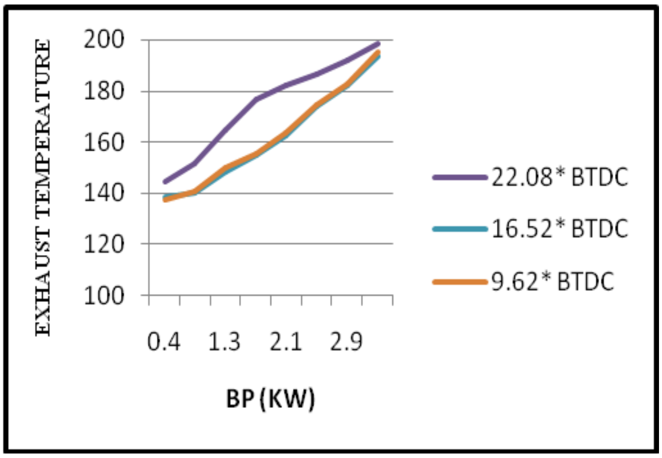

Fig. 12. Exhaust temperature v/s BP for injection timing.

Following figures for 10% Ethanol-diesel blend:

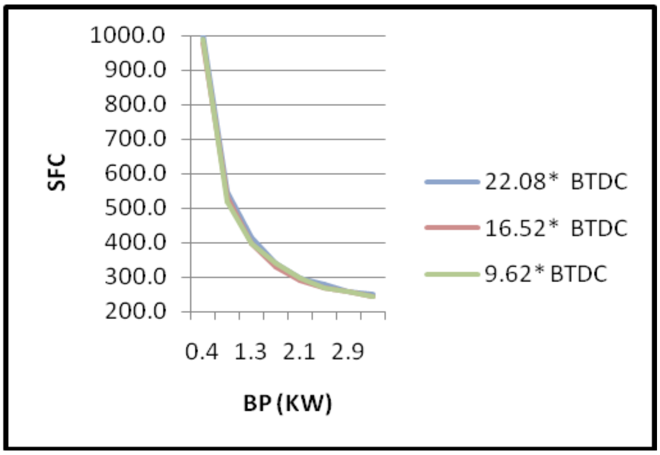

Fig. 13. SFC v/s BP for different injection timing.

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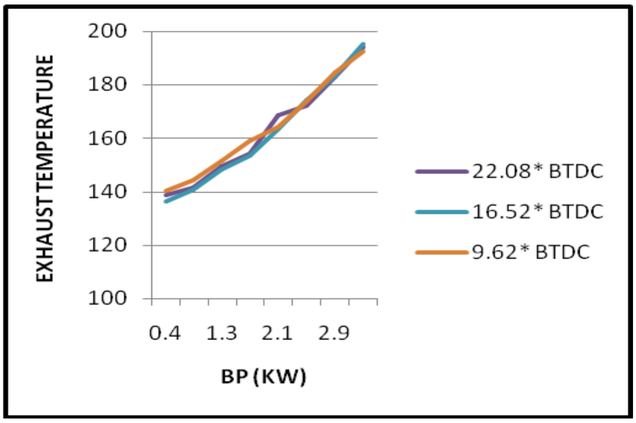

Fig. 14. Exhaust temperature v/s BP for injection timing.

Hence we observe that 5% ethanol diesel blend; injection timing 16.52º BTDC gives better performance than 9.62º BTDC. For 10% ethanol diesel blend, injection timing 22.08º BTDC gives better performance than 16.52º BTDC and 9.62º BTDC.

D. Injection Pressure Optimization:

The following graphs show SFC v/s BP for different injection pressure. For both 5% ethanol – diesel blend and 10% ethanol blend, it is observed that injection pressure 200 Bar could be preferred over 220 Bar and 180 Bar

Following figures for 5% Ethanol-diesel blend:

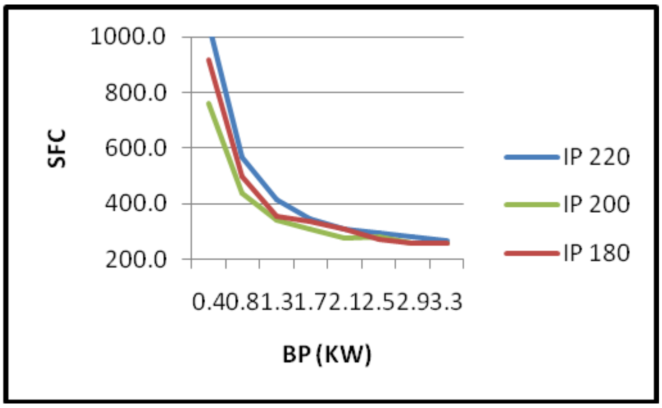

Fig. 15. SFC v/s BP for different injection pressure.

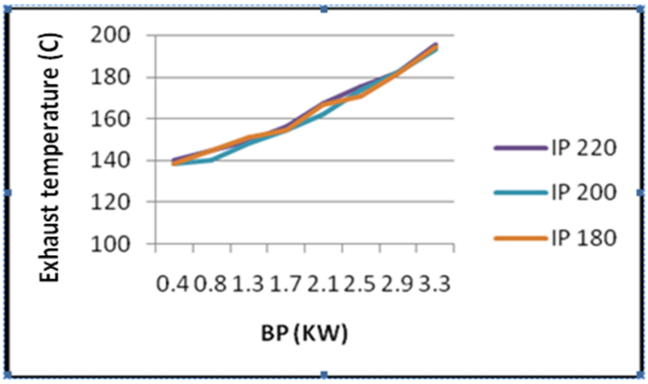

Fig. 16. Exhaust temperature v/s BP for injection pressure.

Following figures for 10% Ethanol-diesel blend:

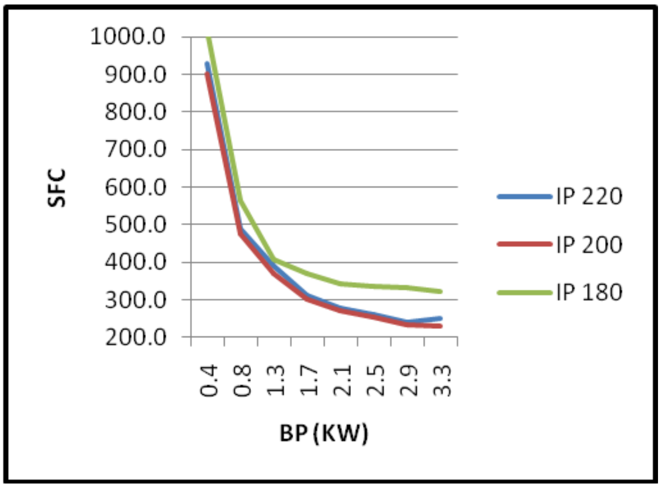

Fig. 17. SFC v/s BP for different injection pressure.

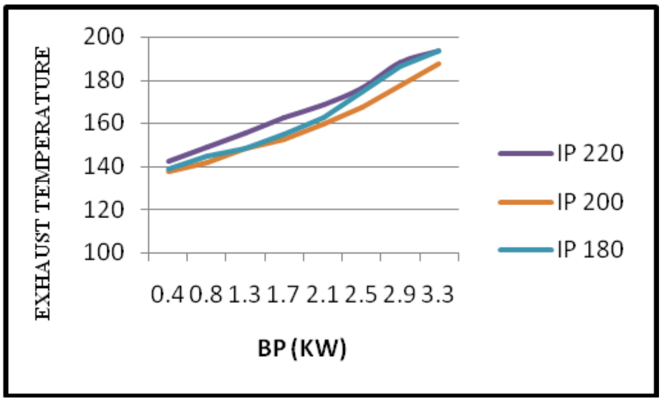

Fig. 18. Exhaust temperature v/s BP for injection pressure.

E. Economic analysis

As 10% Ethanol-diesel blend gave better performance than other blends. its economic feasibility was compared against diesel.The above graph compares cost of running diesel for 100hrs against cost of running 10%E-diesel (Diesel cost: INR 57.5/litre nd Ethanol cost: INR 100/litre).

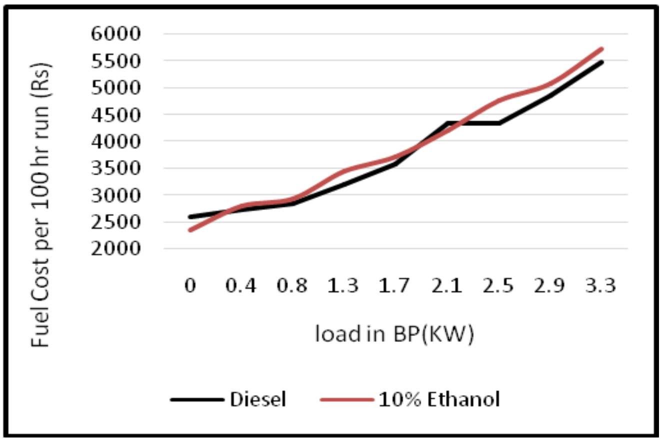

Fig. 19. Fuel cost v/s load for diesel & 10% E-diesel blend.

Considering the rise in petroleum prices, various nations are in economic difficulties by importing this input, or face supply problems. In this context, the demand for alternative energy sources has attracted worldwide attention to the production of agricultural raw materials, namely those with feasibility for manufacturing ethanol. On comparing the above tables, the economic feasibility of E-diesel can be compromised over its low emissions.

VI. CONCLUSION

For 5% Ethanol-diesel blend:

1. Nozzle **E043269300**gave optimal results**.**
2. For same nozzle optimum injection timing is 16.52º BTDC.
3. Injection pressure of 200Bar is found optimal for same nozzle operating at injection timing of 16.52º BTDC.

For 10% Ethanol-diesel blend:

1. Nozzle **105-DLL110S1030**showed optimal results.
2. For same nozzle optimum injection timing is 22.08 º BTDC.
3. Injection pressure of 200Bar is found optimal for same nozzle operating at injection timing of 22.08º BTDC.

A. Future work:

Injection parameters have to be further optimized, to study the long term effect of ethanol on combustion, emission levels and durability on engine. As ethanol has low viscosity than that of diesel, injection pipe and injection pump have to be optimized for improved performance

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