Effect of Ethanol and Honge oil methyl ester (HOME) biodiesel blends on the Performance and emission characteristics of CI engine with and without Preheat

B M Dodamani[1], R B Baligar[2], S B Patil[3], S G Aladakatti[4], K P Talikeri[5]

Asst. Professor[1], Research Scholars[2,3,4,5]
Mechanical Engineering Department
Hirasugar Institute of Tech, Nidasoshi, Belagavi, Karnataka

Abstract- **As more and more fossil fuels are depleting day by day, it is very necessary to switch to alternative source of energy as a fuel for internal combustion engines. The internal combustion engines used in Propulsion, Transportation and marine applications, will leads to socio economical growth of any country. The emissions from the fossil fuels leads too many environmental problems like green houses effect, ozone depletion etc. This paper depicts the use of biodiesel as an alternative source of energy for an IC engine. The experimental investigation were carried out on single cylinder 4-stroke compression Ignition (CI) engine operating on Ethanol and Honge oil methyl ester (HOME) biodiesel and diesel blends, with and without preheat and studied the performance and emission characteristics. From the results obtained, it is observed that ethanol blend with biodiesel and up to 10%, will give superior results in concern with Brake thermal efficiency and emissions and for 5%, 15%, 20% ethanol with HOME shows inferior results in concern with Performance and emissions. NO_x emissions and smoke opacity were higher for pure biodiesels when compared to diesel operation. With reference to emissions, there will be an increased NO_x and Smoke emissions for pure biodiesel operation when compared with diesel operation and there will be a considerable reduction in NO_x and Smoke when blended with Ethanol up to 10% by volume. The experimental study were also be conducted with preheated ethanol up to 10% ethanol in a HOME blends and compare the results with pure diesel operation and found that up to 10% of ethanol will give us almost similar properties in terms of Performance and emission characteristics.**

Keywords: **Honge oil methyl ester (HOME), Biodiesel, Emission, Ethanol**

1. Introduction

Internal combustion engines the key devices for various applications directly or indirectly and also that attracts the concentration of researchers towards the innovation of alternative fuel for their operation for having the objective in mind that reduced emissions and improved efficiency. In that contrary many researchers worked on this area some of them are A.M. Liaquat et.al [1], studied to analyze engine performance and emissions characteristics for diesel engine using different blend fuels without any engine modification. They prepare four fuel sample, such as DF (100% diesel fuel), JB5 (5% Jatropha biodiesel and 95%DF0, JB 10(10% JB and 90% DF) and J5W5 (5% JB, 5% waste cooking oil and 90% DF), respectively were used in this study. They carried out engine performance test at 100% load keeping throttle 100% wide open with variable speed of 1500 to 2400 rpm at an interval of 100 rpm, and also carried out emission test at 2300 rpm at 100% and 80% throttle position. In this engine performance parameters have been measured are engine torque, brake power, and brake specific fuel consumption (BSFC).from this experiment they conclude that engine torque and brake power for blend fuels were decreased when compared to diesel fuels and also BSFC values for blend were higher than that of diesel fuel and reduction in HC , CO and CO_2 were found for JB5, JB10 and J5W5 when compared to DF at both engine operating conditions and also increased in NO_x emission for all blend fuels compared to DF mode

Madan mohan Avulupati et.al[2], stated that in recent times, searches for alternatives fuels has been intensified due to depleting fossils fuels and environmental impact. With the increase concern of the environment and more stringent regulation on exhaust emission, the reduction in engine emission is a major research objective for engine development. Ethanol is an attractive alternative fuels because it can renewable bio-based resource it has hydroxyl group, There by providing the potential to reduce particulate emission in compression ignition engines. Complete replacement of diesel with ethanol for CI engines is not a feasible solution due to difference in physical and chemical properties, which affects injection and combustion processes. He made the fuel preparation has fuel emission of various mixture proportion were prepared using magnetic stirrer at a temperature of 25°C.Diesel-ethanol blends formed macro emulsions, whereas all other mixture compositions seemed to formed micro emulsions. Experiments were performed using various fuels of different compositions. The distance between heating filaments and the droplet was maintained at about 2mm to ignite the droplets smoothly without contact. The time lapse between starting of heating element and ignition of droplet was observed to vary between 1 and 1.5 s based on the composition of fuels. Three types of droplet burning phenomena are observed, via smooth burning, puffing and explosion. After he conducted experiment he conclude that from above discussed data , it can be corroborated that diesel-biodiesel-ethanol blends used in his study have potential to undergo micro explosion at conditions encountered in diesel engines during injection and pre combustion phases. However, for precise understanding, studying micro explosion of diesel-biodiesel-ethanol blends at elevated pressure could be an interesting problem for future research's. Senthilkumar et.al,[3] worked on the prospects and opportunities of using various blends of methyl esters of palm oil as fuel in an engine with and without the affect of multi-functional fuel additives (MFA),Multi DM 32 are studied to arrive at an optimum blend of bio-diesel best suited for low emission and minimal power drop. He conducted on a four stroke, three cylinder and naturally aspirated D.I. Diesel engine with diesel and various blend percentage of 20%, 40%, 45%, and 50% under the 8 mode testing cycle. After conducting experiment the effect of biodiesel blending ratio on the combustion, exhaust emissions and performance was investigated at the base diesel fuel with blend ratio of B100 (pure palm bio-diesel),B50 (50% bio-diesel & 50% petro-diesel), B40, B45, B20 for engine speed of 1200, 1400, 1600, 1800 & 2000rpm.The blend ratio 40% palm bio-diesel (B40) exhibited an ideal balance between reduced emission and minimal power loss of around 5% when compared to 10% power loss occurring in pure bio-diesel (B 100), result shows that ,73% reduction in hydrocarbon emission, 46% reduction in carbon monoxide emission, and around 1% reduction in carbon dioxide emission characteristics. So experiment conclude that the blend ratio of 40% bio-diesel with MFA fuel additive creates reduced emission and minimal power drop due to effective combustion even when calorific value is comparatively lower due to its higher cetane number.

Mohd hafizil, et.al,[4] studied biodiesel (20%0-methanol(5%)-diesel (75%),biodiesel (20%)-methanol(10%)-diesel (70%), biodiesel (20%)-diesel (80%), and standard mineral diesel as a baseline fuel are tested in a multi-cylinder diesel engine. Those biodiesel-alcohol low proportion blends are investigated under the same operating conditions at 20%,40%,and 60% of engine loads to determine the engine performance and emission of the diesel engine. Overall, biodiesel-methanol-diesel blends shows higher brake specific fuel consumption than mineral diesel. As methanol proportions in blends increases, NO emissions increase, while CO emissions are reduced. Also, biodiesel-diesel blend with 5% of methanol is more effective than biodiesel blend with 20% for reducing CO emissions. This experimental work was conducted on a four cylinder, 4-cycle, indirect (IDI), water-cooled Mitsubishi 4D68 diesel engine, from this experiment come to know that biodiesel-methanol-diesel blends produce higher specific fuel consumption (BSFC) as compared to B20 mineral diesel at three different engine loads and also increases exhaust gas temperature at varying all engine loads and decreases NOx emissions and slight increase in CO emission. M.Storch et.al[5] studies on the influence of blending 20vol% ethanol to isooctane is investigated by simultaneous OH-chemiluminescence and soot radiation high-speed imaging. In this experiment for the measurements in the present work were performed in a modern single cylinder optical engine based on a series-production direct injection engine with four valves per cylinder and a variable valve train. From this study conclude that E20 showed OH-chemiluminescence and soot luminosity than isooctane, the investigation of bright combustion structures revealed higher intensities forE20 in comparison to isooctane. It was found that those structures also appear longer in the cycle for E20. This may be an important source for exhaust particulate a matter emission, and elevation in engine load increases combustion intensities and probability of diffusion controlled droplet combustion for both fuels .In further work particulate matter concentration is measured at the engine exhaust by laser induced incandescence. In addition the study is extended to other fuels (E85, pure ethanol).

Ashraf Elfasakhany et.al[6] investigated the performance and exhaust emissions from spark ignition engine fueled with ethanol-methanol-gasoline blends. The test result obtained with the use of low contain rates of ethanol-methanol blends (3-10 vol%) in gasoline were compared to ethanol-gasoline blends, methanol, gasoline blends and pure gasoline test result. combustion and emission characteristic of ethanol methanol and gasoline and their blends were evaluated. Results showed that when the vehicle was fueled with ethanol -methanol-gasoline blends, the concentration of CO and UHC (unburnt hydrocarbon) emissions were significantly decreases, compared to the neat gasoline. Methanol-gasoline blends presented lowest emission of CO and UHC among all test fuel. In this experiment a spark ignition engine with a bore of 65.1mm and stroke of 44.5mm is used in this study. The engine is 1-cylinder, 4-stroke with a 7:1 compression ratio, air cooled, no catalytic converter unit and carburetor fuel system, in this study, engine performance and pollutant emission from different blended fuels in types (Ethanol-Methanol-Gasoline) and rates (3-10 vol% methanol and / or ethanol in gasoline) have been investigated experimentally. The test results indicated that ethanol-methanol-gasoline blends (EM) burn cleaner than both ethanol-gasoline blends and the need gasoline blends.

2. Properties of fuels

The properties of HOME and Diesel were determined and summarized in the table. The properties were measured in the Energy conversion laboratory of the college

2.1 Honge oil methyl ester (HOME)

Vegetable oils are produced from numerous oil seed crops. While all vegetable oils have high-energy content, most require some processing to assure safe use in internal combustion engines. Honge tree and seeds can be seen as shown fig.1. The extraction of oil from karanja seed was done by using different methods, i.e. mechanical expression, solvent extraction and cold percolation using n-hexane as solvent. As a diesel fuel substitute, Honge falls under the category of bio-diesel.

Fig 1. Honge tree and seeds

Biodiesel are naturally available fuels that can be replaced by fossil fuels to some extent. In this study Honge oil methyl ester is used as a fuel and the properties such as Density, Viscosity, Flashpoint, Fire point and Calorific value of the fuels were determined and the values are tabulated in table 1

Table 1 Properties of fuels used

Properties	Values	Instruments Used
Flash point	178 ^{0}C	Cleveland Apparatus
Fire point	185 ^{0}C	Cleveland Apparatus
Density	1078 kg/m^2	Redwood viscometer
Kinematic Viscosity	5.0 mm^2/s @ 50^0 C	Redwood viscometer
Calorific value	37600 KJ/Kg	Bomb calorimeter

It is found that the viscosity and density is comparatively higher for biodiesel than the diesel and also the calorific value is comparatively lesser than that of the diesel. The flash point and fire point is also higher for biodiesel than the diesel. The calorific value is found to be 37MJ for biodiesel using Bomb calorimeter in laboratory conditions. The effect of higher density and viscosity on the performance and emission characteristics was studies and tabulated. The effect of number of holes and injection pressure were studied on the performance and emission of diesel engine fuelled with this Honge oil methyl ester (HOME)

3. Experimental set up

Experiments were conducted on a Kirloskar TV1 type, four stroke, single cylinder, water-cooled diesel engine test rig fuelled with HOME. Figure4.1 shows the test rig used. In the study different blends of ethanol and HOME is used for different operating conditions like CR 17, CR 18 and blends like E5B95, E10B90, E15B85 and E20B80.

Fig 2 Biodiesel blends with Ethanol

Performance and emissions characteristics were studied on each blend. The optimized blend combination was preheated to 35, 45, and 55^o C and again noted the performance and emission characteristics so that the optimized combination of blends with and without preheated were suggested. The variation of Brake thermal efficiency with reference to performance characteristics and CO, CO2, HC and NOx were studied with reference to emission characteristics

Fig 3. Experimental set up

The specification of the test rig used in the study is mentioned in the table 2

Table 2 Specifications of the Engine

Sl. No	Parameters	Specification
1	Type of engine	Kirloskar make Single cylinder four stroke direct injection diesel engine
2	Nozzle opening pressure	200 to 205 bar
3	Rated power	5.2 kW (7 HP) @1500 RPM
4	Cylinder diameter (Bore)	87.5 mm
5	Stroke length	110 mm
6	Compression ratio	17.5 : 1
7	Displacement volume	660cc
8	Arrangement of valves	Over head
9	Combustion chamber	Open chamber (Direct injection)
10	Cooling type	Water cooled
11	Loading	Eddy current dynamometer

4. Results and Discussions

4.1 Variation of Carbon Monoxide with Load

From graph 4 it is observed that as load increases brake thermal efficiency increases gradually. And all preheated ethanol-biodiesel blends compared with E10B90 blend in above graph. From graph it shows that B90E10 T45^{0}C blend leads to improved brake thermal efficiency compared to all blends because after 10% of ethanol used in Biodiesel separation takes place due to this separation there is a improper mixing of ethanol and biodiesel blends taking place so that leads to inferior combustion so that the brake thermal efficiency of the engine is going to be reduces.

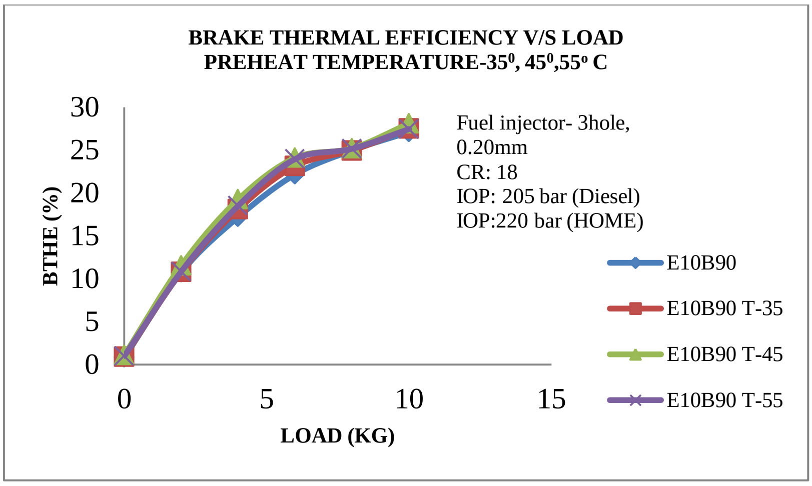

Fig 4: Variation of Carbon Monoxide with Load

4.2 Variation of Carbon Monoxide with Load

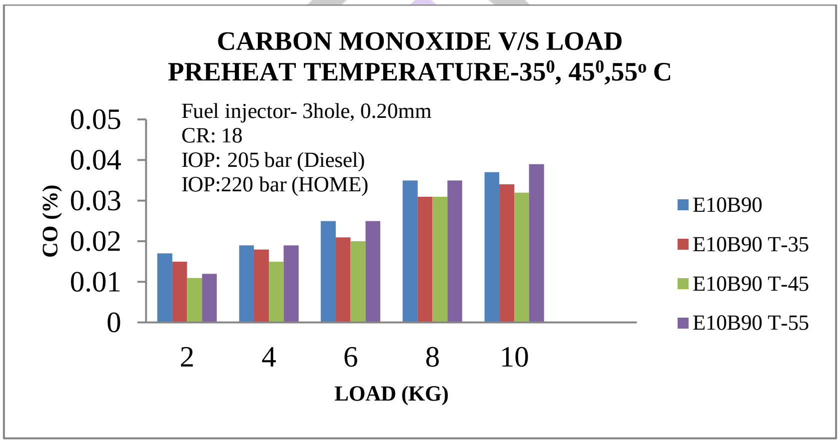

Fig 5: Variation of Carbon Monoxide with Load

From the graph 4.2 it is observed that emission of CO and CO_2 for B90E10 T-45^{0}C less compared to other preheated blends because of more oxygen content in biodiesel which leads efficient combustion of biodiesel. So that E10B90 blend is more emission compared to all preheated blends. Variation of CO_2 with load is shown in fig 5.13

4.3 Variation of Carbon Dioxide with Load

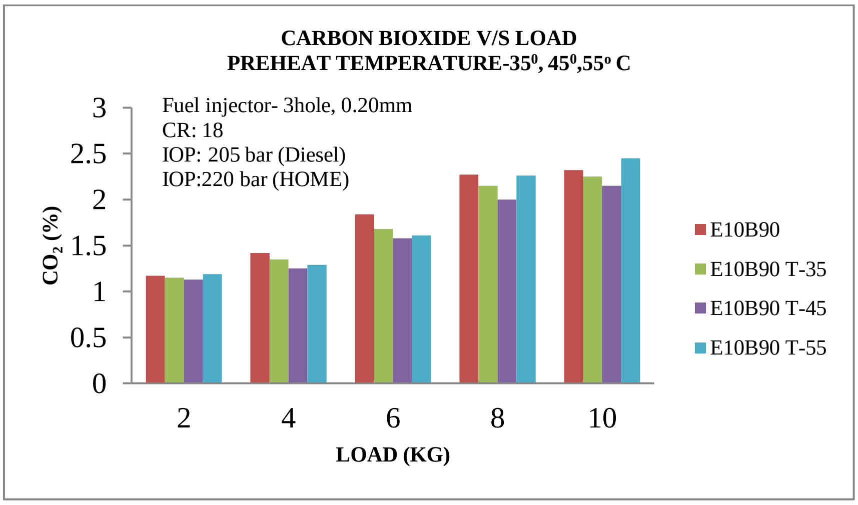

Fig 6: Variation of Carbon Dioxide with Load

4.4 Variation of Hydrocarbon with Load

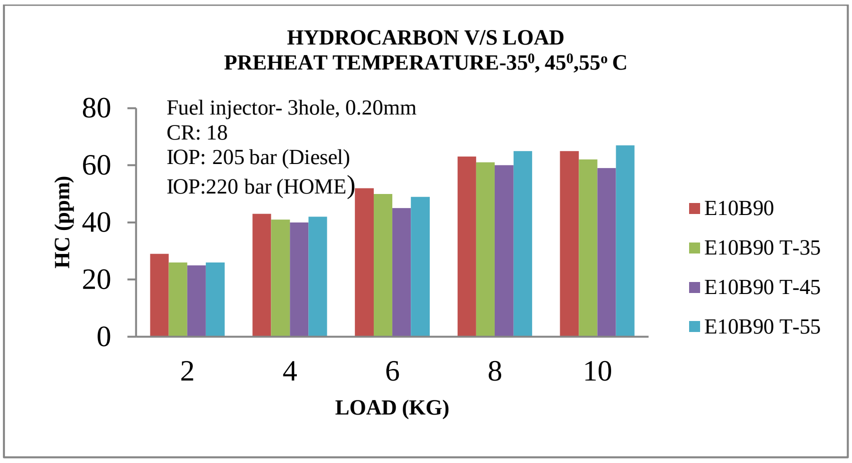

Fig 7: Variation of hydrocarbon with Load.

From the graph it shows that emission of HC of preheated blends is lesser than without preheated blend because viscosity of biodiesel decreases by heating it. And E10B90 T450C is less emission of HC compared to other blends.

4.5Variation of Nitrous Oxide with Load

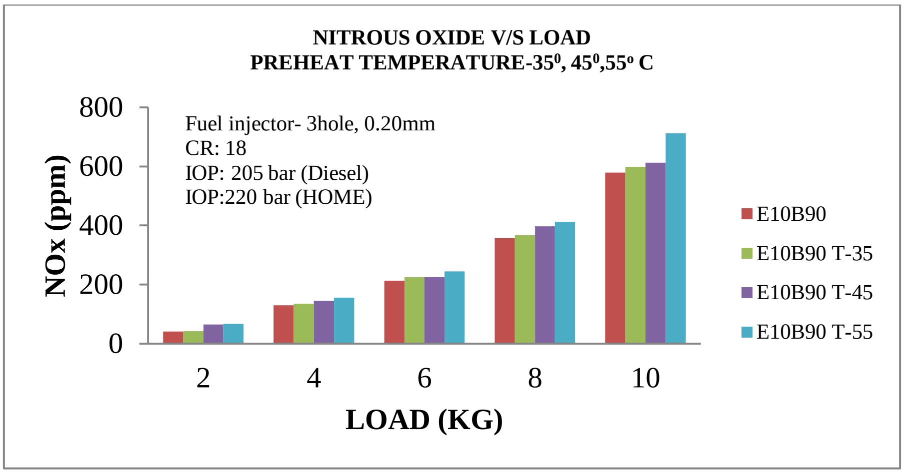

Fig 8: Variation of emissions of Nitrogen oxide with Load.

From the graph 4.5 it shows that emission of NOx of E10B90 T-45^{0}C is less compared toall preheated blends. E10B90 blend is less emission of NOx compared to preheated blends because of due to heating higher temperature in combustion chamber. And E10b90 t-55^{0}c is more emission of NOx compared to other blends.

Optimized Blend comparison with Diesel

4.6 Variation of Brake Thermal Efficiency with Load

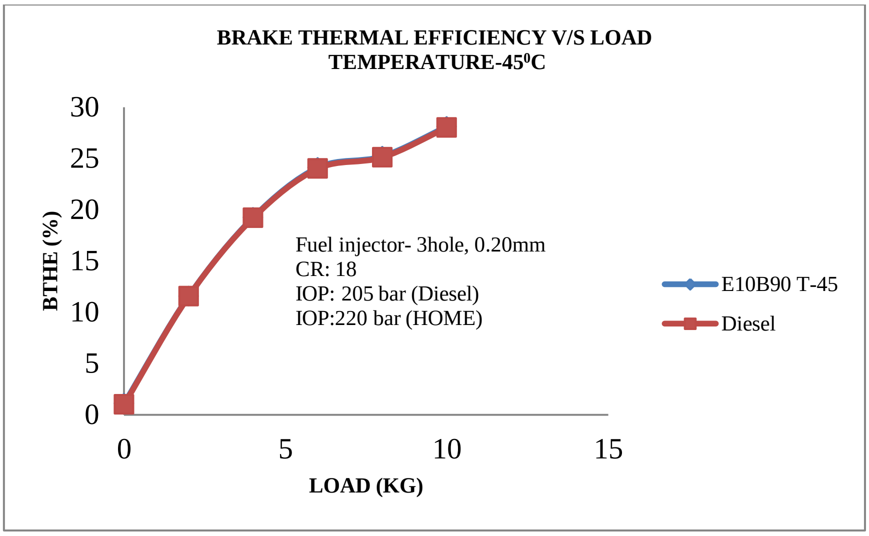

Fig 9: Variation of Brake Thermal Efficiency with Load.

From graph 4.6 it shows that brake thermal efficiency of optimised blend and diesel increases with increases of load gradually. And E10B90 T-45^{0}C is comparatively more brake thermal efficiency than diesel because of proper combustion in E10B90 T-45^{0}C blend compared diesel

4.7 Variation of Carbon Monoxide with Load

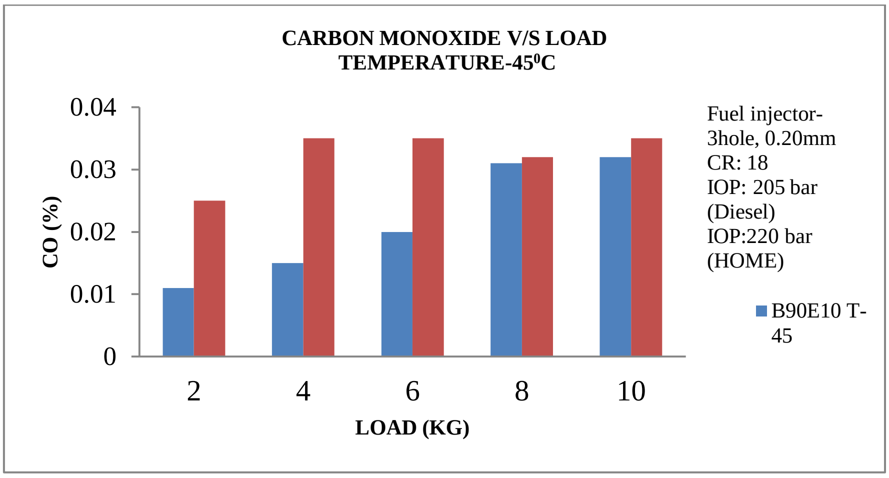

Fig 10: Variation of Carbon Monoxide with Load.

From graph 4.7 and 4.8 it shows that B90E10 T-45^{0}C is lesser emission of CO and CO_2 than diesel because of more oxygen in biodiesel compared to diesel due than more emission in CO and CO_2 in diesel. The graph of emissions of CO_2 shown in fig 5.18 below.

4.8 Variation of emissions of Carbon Dioxide with Load.

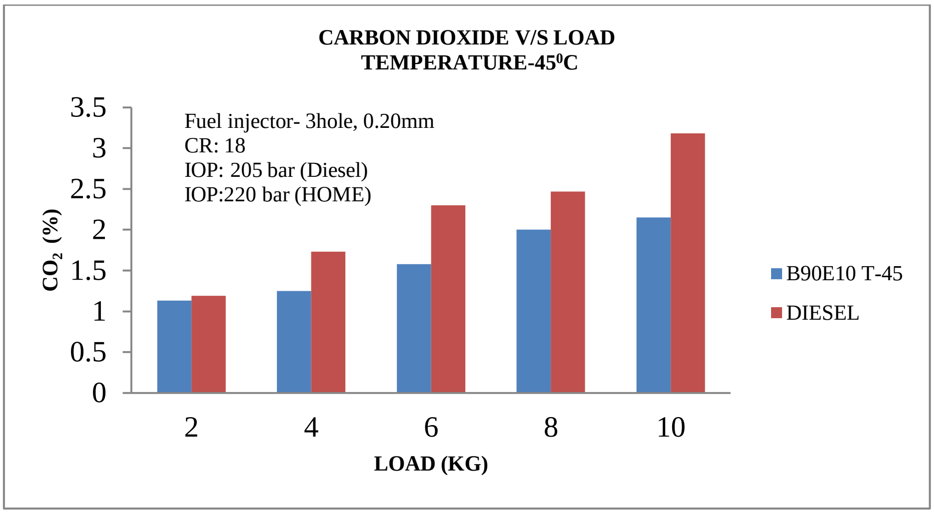

Fig 11: Variation of Carbon Dioxide with Load.

4.9 Variation of Hydrocarbon with Load

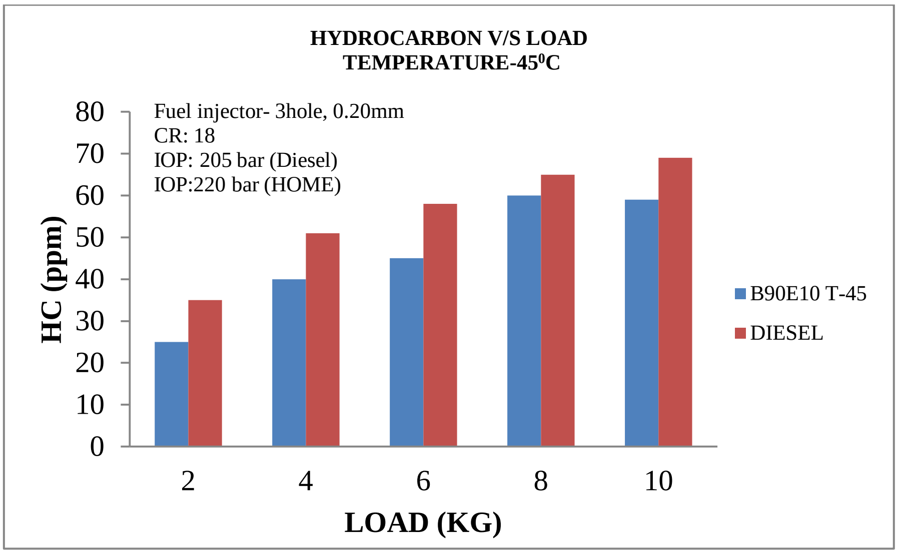

Fig 12: Variation of Hydrocarbon with Load.

From graph 4.9 shows that emission of HC of B90E10 T-45^{0}C is lesser than diesel because of more oxygen content in biodiesel compared to diesel .And due to increase in temperature of biodiesel viscosity decreases therefore emission of HC more compare to diesel.

4.10 Variation of Nitrous Oxides with Load

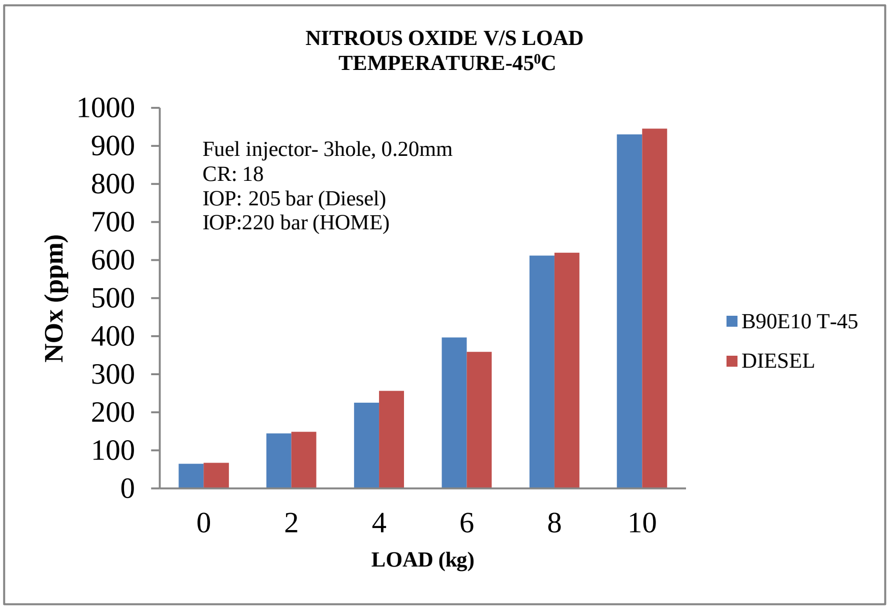

Fig 13: Variation of Nitrogen Oxides with Load.

From graph 4.10 it shows that emission of nitrous oxide inB90E10 T-45^{0}C is lesser than diesel because proper ethanol blend with biodiesel and preheating ethanol acts as boosting for combustion process therefore emission of nitrous oxide less compare to diesel.

Conclusion

The variable compression ratio diesel engine designed to run on bio-fuel has been tested with pure diesel and blend of ethanol-Honge biodiesel.

- The viscosity and density of the biodiesel is comparatively higher than the diesel and also the calorific value of the biodiesel is less that is 37600 KJ/Kg
- The study has been carried out on different compression to suggest the optimized compression ratio for the E5B95, E10B90, E15B85 and E20B80 blends.
- From the exhaustive study it is observed that the blend E10B90 gives good results than the other this is because of separation of ethanol with biodiesel.
- Increasing the proportion of ethanol in a biodiesel more than 10% by volume leads to separation of ethanol and biodiesel in turn it will affect the overall performance of the engine.
- The optimized blend E10B90 is preheated with different level of temperatures like 35^o, 45^o and 55^o C in order to analyse the results in terms of its performance and emissions
- Preheating up to 45^o C of charge gives considerable results in terms of brake thermal efficiency but it is observed that there will be a gradual increase in NO_x due to higher temperature within the combustion chamber.
- For a blend E10B90 shows lesser CO, CO_2, HC and NO_x compared to other blends like E5B95, E15B85 and E20B80

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