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EFFECT OF ADDITIVES ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF DI DIESEL ENGINE USING HONNE OIL AS AN ALTERNATIVE FUEL AT DIFFERENT INJECTION PRESSURES

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Abstract - *In recent days, Biodiesel is so extensively considered as an alternative fuel in diesel engine which constitutes a major role in transportation. In this present work, experimental study was carried out using blends of Honne oil (B5, B10, B15, B20, B25, B30) and diesel in a single cylinder, 4-stroke water cooled DI diesel engine at various injection pressures 180,190,200 bars and experiments were also carried out for the best blend with additives. It was found that blend B20 (20%Honne oil by volume in diesel) has the thermal efficiency nearer to that of diesel. So the tests were carried out for pure diesel and blend of 20% Honne oil by volume in diesel engine at constant speed with varied loads at all the injection pressures. The Brake thermal efficiency of the blend B20 is less than the diesel at 180 bar, 190bar and higher than the diesel at 200 bar. The emissions UHC and CO_2 of the blend B20 and the diesel are below the BS-IV values at all the injection pressures. The CO emissions of the blend B20 are below the BS-IV value at all the loads and injection pressures and the CO emissions of diesel are below the BS-IV value at all the loads (except at the initial loads starting from zero to3Kgs) and at all the injection pressures. The NO_X emissions of the blend B20 and diesel are found to be higher than the BS-IV values. To reduce the CO emissions of diesel and NO_X emissions of diesel and blend B20, additives like Isobutanol and P-Phenylene diamine (PPD) are added in different proportions to the diesel and the blend B20 at all the injection pressures and experiments were conducted. The emissions were found below the BS-IV value and simultaneously the brake thermal efficiency was increased and Brake Specific Fuel Consumption was decreased.*

Key Words: Bio-diesel, Honne oil, Varying Injection Pressure, Performance and Emission characteristics, Additives, Isobutanol, P-phenylene diamine (PPD).

1. INTRODUCTION

Fuel additives have been one of the most prolific innovations of liquid engineering as well as material science giving natural fuel sources and additional properties which help us drive that little extra out of them. Fuel additives are compounds formulated to enhance the quality and efficiency of the fuels used in motor vehicles; researchers have developed a range of additives which give these fuels an added property which serves a pressing need from consumers by improving the performance of engine.

Additives have been developed to increase combustion rates, as anti-oxidants, to effect burn rates, to enable fuels to work under extreme temperatures, reduce harmful emissions and more.

1.1 CLASSIFICATION OF ADDITIVES

The types of additives include oxygenates, ethers, antioxidants, antiknock agents, metal deactivators, corrosion inhibitors and some that can't be categorized.

A.OXYGENATES:

These contain oxygen as a part of their chemical structure. They are used to reduce the Carbon monoxide emissions created when burning fuel. Oxygenates can be based on either alcohol or ethers.
Example: 1.Alcohol- methanol, ethanol, isopropyl alcohol, n-butanol, isobutanol.
2. Ethers-methyl tert-butyl ether, ethyl tertiary butyl ether, Diisopropyl ether, tertiary amyl methyl ether, tertiary hexyl methyl ether.

B. ANTIOXIDANTS:

Antioxidants are the molecules that inhibit the oxidation of other molecules and used as fuel additives when creating fuel blends. Oxidation reaction produce free radicals leading to chain reactions and antioxidants terminate the chain reaction by disrupting radical intermediates. Some antioxidants are used as a stabilizer in fuel to prevent oxidation.

Examples of some antioxidants used are:

i) Butylated Hydroxyl Toluene (BHT)
ii) 2, 4 Dimethyl-6-tert-butylphenol
iii) P-Phenylene diamine
iv) Ethylene diamine

C.ANTIKNOCK AGENTS:

An antiknock agent is a gasoline additive used to reduce engine knocking and increase the fuel's octane rating by raising the temperature and pressure at which auto-ignition occurs.

D.METAL DEACTIVATORS:

Metal deactivators or metal deactivating agents(MDA) are fuel additives and oil additives used to stabilize fluids by deactivating metal ions, mostly introduced by the action of naturally occurring acids in the fuel and acids generated in lubricants by oxidative processes with the metallic parts of the systems.

E.CORROSION INHIBITORS:

A corrosion inhibitor is a substance when added in a small concentration to an environment reduces the corrosion rate of a metal exposed to that environment. Inhibitors often play an important role in the oil extraction. Corrosion inhibitors are additives that prevent chemical attack on a metal surface. Some of the corrosion inhibitors are hexamine, phenylenediamine, dimethyl ethanolamine and their derivatives sometimes sulphite and ascorbic acid are also used.

F.OTHERS:

There are several other fuel additives that don't fall into the same categories as the above. Some of these are:-
1. Acetone- this is a vaporization additive. It is used together with methanol, to improve vaporization when the engine starts up.
2. Nitromethane - is used to up the engine power-commonly referred to as 'nitro'.
3. Ferrous picrate is used to improve combustion and increase mileage.
4. Ferox- this is a catalyst additive used to increase fuel efficiency, clean the engine, extend the life of the engine, lower emissions.

1.2 Injection Pressure Variation

To acquire high degree of fuel atomization in the injection system, high injection pressure is needed for the purpose of sufficient evaporation of fuel in very short time. From that the fuel particles acquire better spray penetration so that it can easily exploit the fuel air charge inside the cylinder. The desired amount of fuel should be measured by injection system of fuel, depending upon engine load and speed, and inject the fuel at desired rate in correct time. The appropriate shape and size of fuel particle obtained depends on the particular combustion chamber. Generally a supply pump withdraws the fuel from the fuel tank and carries it to the fuel injector via filter. In present experimental study the fuel injection pressure varied from 180 to 200bars.The injection pressure is varied by tightening or loosening the screw provided on the top of the injector. For the measurement of injection pressure on fuel injector system, a fuel injector pressure tester is used.

2. Experimental setup

The engine used for experimentation is Kirloskar make single cylinder, four stroke ,water cooled diesel engine coupled to eddy current dynamometer with all necessary instrumentation with computer interface .The specifications of the engine is shown in table 1.

Table -1: Engine Specifications

Make	Kirloskar
Type	Single cylinder, four stroke, water cooled
Capacity	5HP
Bore diameter	80mm
Stroke length	110mm
Connecting rod length	234mm
Orifice diameter	20mm
Compression Ratio	16.5:1

In present research experimental tests were carried out on 4-stroke single cylinder diesel engine using different proportions of Honne oil with diesel by varying loads at different rates and at different injection pressures usually 180,190,200bars and experiments were also carried out for the best blend with additives. The emission test was done by using AVL DIGAS-444 five gas analyser. To reduce the CO emissions of diesel and NO_X emissions of diesel and blend B20 that are above the BS-IV Values, additives like Isobutanol, P-Phenylene diamine are added to diesel and blend B20 at all the injection pressures.

Fig.1. AVL DIGAS-444 FIVE GAS ANALYSER

3. RESULTS AND DISCUSSIONS

3.1 PERFORMANCE PARAMETERS:

A.BRAKE THERMAL EFFICIENCY:

Fig.2 shows the variation of brake thermal efficiency with load for various blends .It is clearly seen in the figure that the brake thermal efficiency of the blends and diesel increases with increase of load .The brake thermal efficiency of all the blends is less than the diesel but the blend B20 is close to diesel at all the loads.

Fig.3 shows the variation of brake thermal efficiency with load at varied injection pressures like 180,190,200bars when diesel and the blend B20 are used. It can be seen in the figure that the brake thermal efficiency of the blend B20 and diesel increases with increase of load at all injection pressures. A higher brake thermal efficiency is obtained for the blend B20 at 200bar compared to diesel only at 60 and 80% of full load and also higher brake thermal efficiency is obtained for B20 blend at 210 bar compared to diesel at all the loads starting from 20% of full load but significant knocking is observed which lead to the termination of further experimentation.

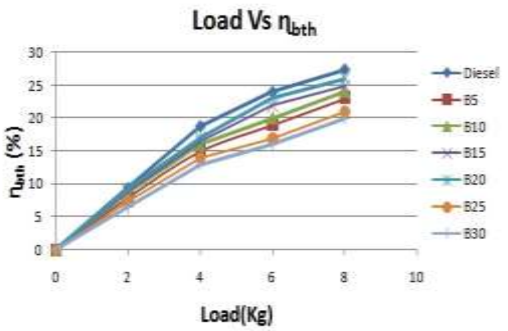

Fig.2 Comparision of Brake Thermal Efficiency for various blends

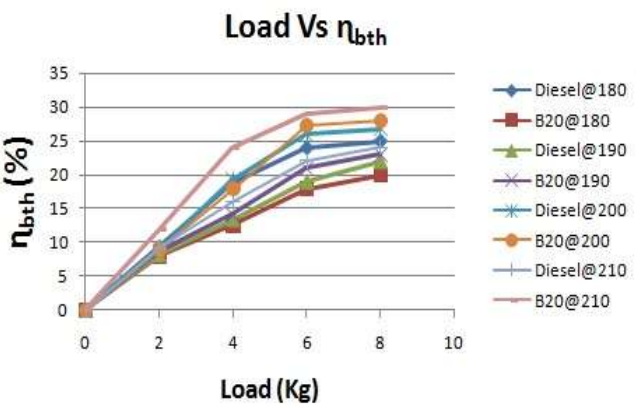

Fig.3 Comparision of brake thermal efficiency for different injection pressures

B.BRAKE SPECIFIC FUEL CONSUMPTION:

Fig.4 shows the variation of Brake Specific Fuel Consumption with load for the blend B20 and diesel at injection pressures like 180,190,200bars. It can be seen in the figure that the BSFC of blend B20 and diesel decreases up to a load of 6Kg and thereafter increases at all the injection pressures. The BSFC of the blend B20 is higher than the diesel at injection pressures 180,190bar and less than the diesel at 200bar. From the graph it is clearly seen that the blend B20 at 200bar has lowest BSFC value at all the loads and injection pressures.

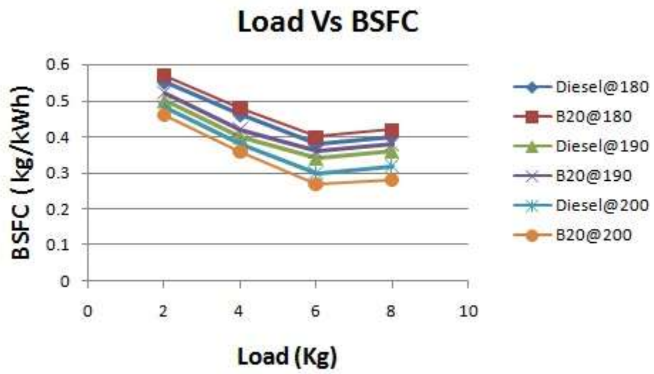

Fig.4 Comparision of Brake Specific Fuel Consumption

3.2 EMISSION PARAMETERS:

i) CARBON MONOXIDE (CO) EMISSIONS:

The variation of CO emissions with load at different injection pressures for pure diesel and blend B20 is shown in Fig.5.The CO emissions of the blend B20 and diesel decreases with increase of load at all the injection pressures. The CO emission of diesel is higher than the BS-IV value from zero to 2.6Kgs of load at 180bar, zero to 3.7Kgs of load at 190bar, zero to 3Kgs of load at 200bar and lower than the BS-IV value beyond a load of 2.6Kgs, 3.7Kgs, 3Kgs of load at 180,190,200bar .The CO emissions of the blend B20 is less than the BS-IV value at all the loads and injection pressures. It can be seen clearly from the graph that the blend B20 has lowest CO emissions at all the loads and at an injection pressure of 200bar.

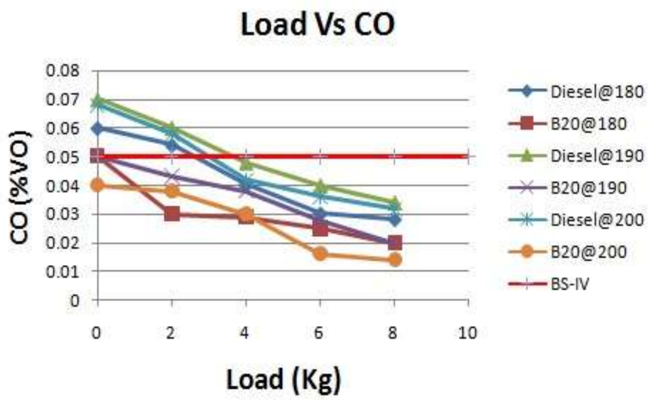

Fig.5 Comparision of CO emissions

ii) CARBON MONOXIDE (CO) EMISSIONS OF DIESEL WITH AND WITHOUT ADDITIVES AT AN INJECTION PRESSURE OF 180bar:

The variation of CO emissions with load at an injection pressure of 180 bar for pure diesel with and without additives is shown in fig.6.The CO emissions of pure diesel with and without additives decreases with increase of load at an injection pressure of 180bar.The CO emission of the diesel without additives is higher than the BS-IV value from zero to 2.6Kgs of load and lower than the BS-IV value beyond a load of 2.6Kgs at an injection pressure of 180bar.The CO emissions of the diesel with additives are below the BS-IV value at all the loads and at an injection pressure of 180bar.It is clearly seen from the graph that diesel with additive Isobutanol of 600ppm concentration has lowest CO emissions at all the loads and at an injection pressure of 180bar.

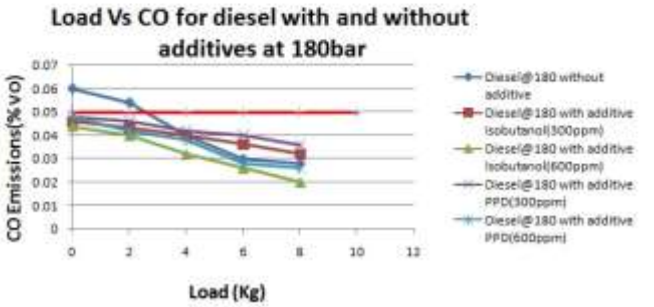

Fig.6 Comparision of CO emissions of diesel with and without additives at an injection pressure of 180bar

iii) CARBON MONOXIDE (CO) EMISSIONS OF DIESEL WITH AND WITHOUT ADDITIVES AT AN INJECTION PRESSURE OF 190bar:

The variation of CO emissions with load at an injection pressure of 190 bar for pure diesel with and without additives is shown in fig.7.The CO emissions of pure diesel with and without additives decreases with increase of load at an injection pressure of 190bar.The CO emission of the diesel without additives is higher than the BS-IV value from zero to 3.7Kgs of load and lower than the BS-IV value beyond a load of 3.7Kgs at an injection pressure of 190bar.The CO emissions of the diesel with additives are below the BS-IV value at all the loads and at an injection pressure of 190bar.It is clearly seen from the graph that diesel with additive Isobutanol of 600ppm concentration has lowest CO emissions at all the loads and at an injection pressure of 190bar.

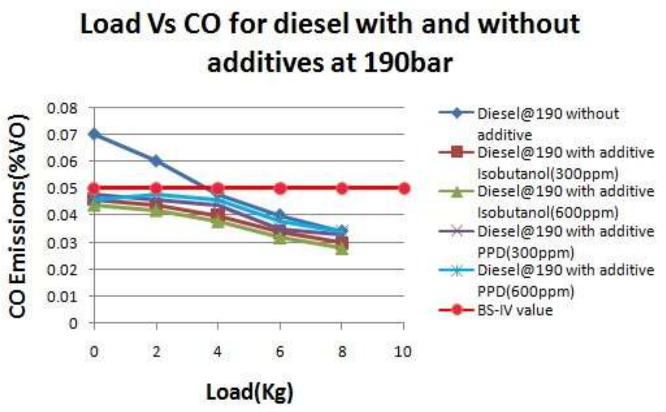

Fig.7 Comparision of CO emissions of diesel with and without additives at an injection pressure of 190bar

iv) CARBON MONOXIDE (CO) EMISSIONS OF DIESEL WITH AND WITHOUT ADDITIVES AT AN INJECTION PRESSURE OF 200bar:

The variation of CO emissions with load at an injection pressure of 200 bar for pure diesel with and without additives is shown in fig.8.The CO emissions of pure diesel with and without additives decreases with increase of load at an injection pressure of 200bar.The CO emission of the diesel without additives is higher than the BS-IV value from zero to 3Kgs of load and lower than the BS-IV value beyond a load of 3Kgs at an injection pressure of 200bar.The CO emissions of the diesel with additives are below the BS-IV value at all the loads and at an injection pressure of 200bar.It is clearly seen from the graph that diesel with additive Isobutanol of 600ppm concentration has lowest CO emissions at all the loads and at an injection pressure of 200bar.

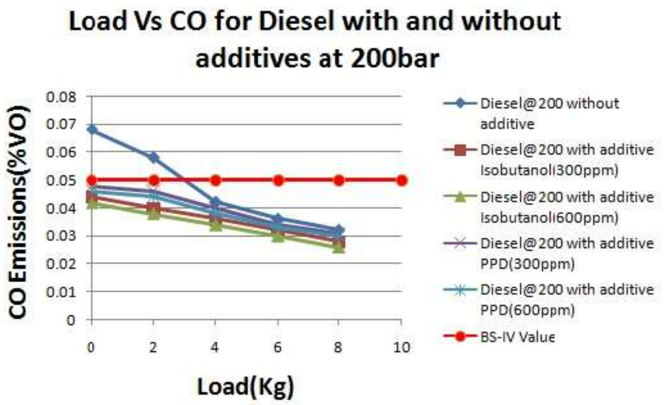

Fig.8 Comparision of CO emissions of diesel with and without additives at an injection pressure of 200bar

v) CARBON MONOXIDE (CO) EMISSIONS OF BLEND B20 WITH AND WITHOUT ADDITIVES AT AN INJECTION PRESSURE OF 200bar:

The variation of CO emissions with load for the blend B20 without additive and with additives at an injection pressure of 200bar is shown in fig.9.The CO emissions of the blend B20 without additive and with additives decreases with increase of load at an injection pressure of 200bar.The CO emissions of the blend B20 with and without additives are below the BS-IV Value at all the loads and at an injection pressure of 200bar.It can be seen clearly from the graph that the blend B20 with additive Isobutanol of 600ppm concentration has lowest CO emissions at all the loads and at an injection pressure of 200bar.

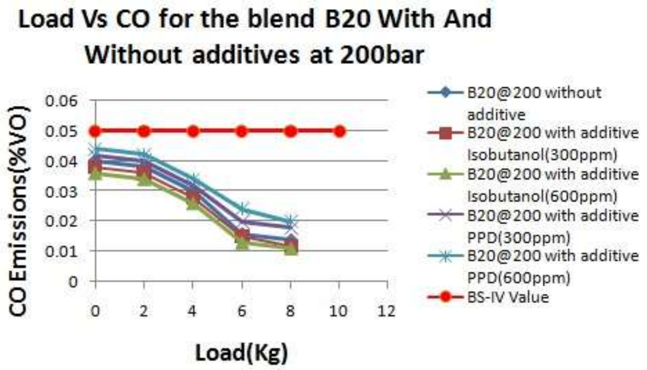

Fig.9 Comparision of CO emissions of blend B20 with and without additives at an injection pressure of 200bar

vi) OXIDES OF NITROGEN (NO_X) EMISSIONS:

Fig.10 shows NO_X variation with increasing load at all pressures for B20 blend and diesel. It can be seen clearly in the figure that the NO_X emissions are increased with increasing load for all the injection pressures. It can be observed from the figure that the NO_X emissions for pure diesel will be beyond the BS-IV value after a load of 3.8 Kg at 180bar, 4.2 Kg at 190bar, 4.9 Kg at 200 bar and the NO_X emissions for the blend B20 will be beyond BS-IV value after a load of 3.8 Kg at 180bar, 5.8 Kg at 190bar, 6.7 Kg at 200bar.From the graph it is clearly seen that the blend B20 at 200bar has lowest NO_X emissions.

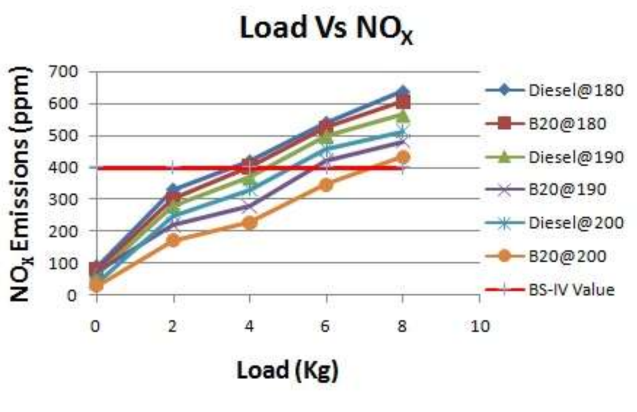

Fig.10 Comparision of NO_X Emissions

vii) OXIDES OF NITROGEN (NO_X) EMISSIONS FOR PURE DIESEL WITH AND WITHOUT ADDITIVES AT 180bar:

The variation of NO_X Emissions with load for pure diesel without additive and with additives at an injection pressure of 180bar is shown in fig.11.The NO_X emissions of pure diesel with and without additives increases with increase of load at an injection pressure of 180bar.The NO_X emissions of diesel without additive and with additive Isobutanol of 300ppm,600ppm concentration are below BS-IV value from zero to 3.8Kgs of load, zero to 3Kgs of load, zero to2.4Kgs of load at 180bar and these emissions are beyond the BS-IV value after a load of 3.8, 3, 2.4Kgs at 180bar.The NO_X emissions of the diesel with additive PPD of 300,600ppm concentration are below BS-IV value from zero to3.8Kgs, zero to 4.2Kgs of load and these emissions are beyond the BS-IV value after a load of 3.8Kgs, 4.2Kgs at 180bar.

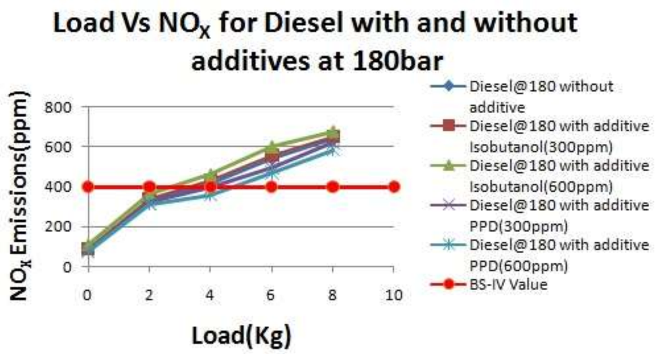

Fig.11 Comparision of NO_X Emissions of diesel with and without additives at an injection pressure of 180bar

Viii) OXIDES OF NITROGEN (NO_X) EMISSIONS FOR THE BLEND B20 WITH AND WITHOUT ADDITIVES AT 180bar:

The variation of NO_X Emissions with load for the blend B20 without additive and with additives at an injection pressure of 180bar is shown in fig.12.The NO_X emissions of the blend B20 with and without additives increases with increase of load at an injection pressure of 180bar.The NO_X emissions of the blend B20 without additive and with additive Isobutanol of 300ppm,600ppm concentration are below BS-IV value from zero to 3.8Kgs of load, zero to 2.8Kgs of load, zero to 3.4Kgs of load at 180bar and these emissions are beyond the BS-IV value after a load of 3.8, 2.8, 3.4Kgs at 180bar.The NO_X emissions of the blend B20 with additive PPD of 300,600ppm concentration are below BS-IV value from zero to 4.1Kgs, zero to 4.3Kgs of load and these emissions are beyond the BS-IV value after a load of 4.1Kgs, 4.3Kgs at 180bar.

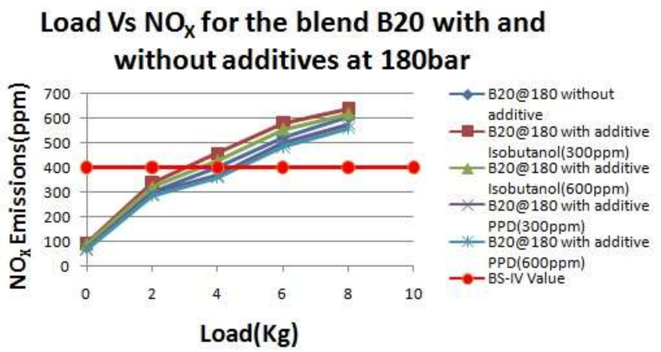

Fig.12 Comparision of NO_X Emissions of the blend B20 with and without additives at an injection pressure of 180bar

ix) OXIDES OF NITROGEN (NO_X) EMISSIONS FOR DIESEL WITH AND WITHOUT ADDITIVES AT 190bar:

The variation of NO_X Emissions with load for pure diesel without additive and with additives at an injection pressure of 190bar is shown in fig.13.The NO_X emissions of pure diesel with and without additives increases with increase of load at an injection pressure of 190bar.The NO_X emissions of diesel without additive and with additive Isobutanol of 300ppm,600ppm concentration are below BS-IV value from zero to 4.2Kgs of load, zero to 4Kgs of load, zero to 4.1Kgs of load at 190bar and these emissions are beyond the BS-IV value after a load of 4.2, 4, 4.1Kgs at 190bar.The NO_X emissions of the diesel with additive PPD of 300,600ppm concentration are below BS-IV value from zero to 4.4Kgs, zero to 4.6Kgs of load and these emissions are beyond the BS-IV value after a load of 4.4Kgs, 4.6Kgs at 190bar.

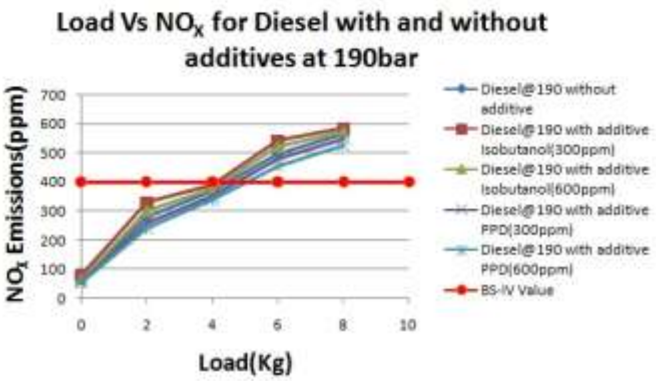

Fig.13 Comparision of NO_X Emissions of diesel with and without additives at an injection pressure of 190bar

x) OXIDES OF NITROGEN (NO_X) EMISSIONS FOR THE BLEND B20 WITH AND WITHOUT ADDITIVES AT 190bar:

The variation of NO_X Emissions with load for the blend B20 without additive and with additives at an injection pressure of 190bar is shown in fig.14.The NO_X emissions of the blend B20 with and without additives increases with increase of load at an injection pressure of 190bar.The NO_X emissions of the blend B20 without additive and with additive Isobutanol of 300ppm,600ppm concentration are below BS-IV value from zero to 5.8Kgs of load, zero to 5Kgs of load, zero to 5.4Kgs of load at 190bar and these emissions are beyond the BS-IV value after a load of 5.8, 5, 5.4Kgs at 190bar.The NO_X emissions of the blend B20 with additive PPD of 300,600ppm concentration are below BS-IV value from zero to 5.9Kgs, zero to 6.1Kgs of load and these emissions are beyond the BS-IV value after a load of 5.9Kgs, 6.1Kgs at 190bar.

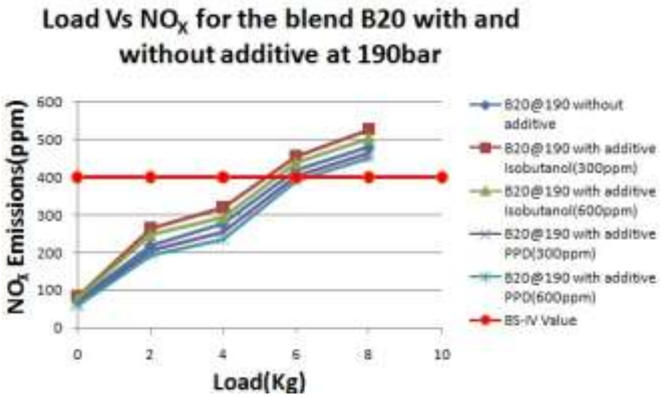

Fig.14 Comparision of NO_X Emissions of the blend B20 with and without additives at an injection pressure of 190bar

xi) OXIDES OF NITROGEN (NO_X) EMISSIONS FOR DIESEL WITH AND WITHOUT ADDITIVES AT 200bar:

The variation of NO_X Emissions with load for pure diesel without additive and with additives at an injection pressure of 200bar is shown in fig.15.The NO_X emissions of pure diesel with and without additives increases with increase of load at an injection pressure of 200bar.The NO_X emissions of diesel without additive and with additive Isobutanol of 300ppm,600ppm concentration are below BS-IV value from zero to 4.9Kgs of load, zero to 4.1Kgs of load, zero to 4.4Kgs of load at 200bar and these emissions are beyond the BS-IV value after a load of 4.9, 4.1, 4.4Kgs at 200bar.The NO_X emissions of the diesel with additive PPD of 300,600ppm concentration are below BS-IV value from zero to 5.2Kgs, zero to 5.7Kgs of load and these emissions are beyond the BS-IV value after a load of 5.2Kgs, 5.7Kgs at 200bar.

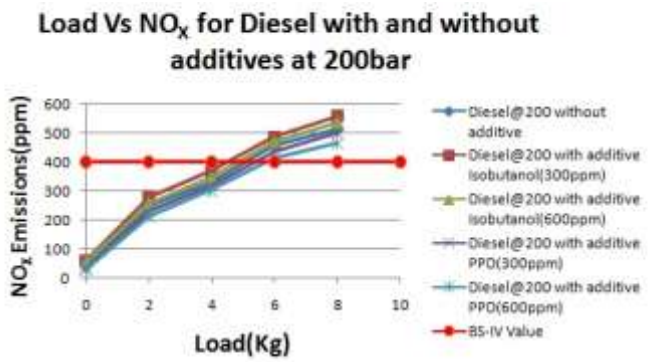

Fig.15 Comparision of NO_X Emissions of diesel with and without additives at an injection pressure of 200bar

xii) OXIDES OF NITROGEN (NO_X) EMISSIONS FOR THE BLEND B20 WITH AND WITHOUT ADDITIVES AT 200bar:

The variation of NO_X Emissions with load for the blend B20 without additive and with additives at an injection pressure of 200bar is shown in fig.16.The NO_X emissions of the blend B20 with and without additives increases with increase of load at an injection pressure of 200bar.The NO_X emissions of the blend B20 without additive are below BS-IV value from zero to 6.7Kgs of load at 200bar and beyond the BS-IV value after a load of 6.7Kgs at 200bar.The NO_X emissions of the blend B20 with additives Isobutanol and PPD are below the BS-IV value at all the loads and at an injection pressure of 200bar.It can be seen clearly from the graph that the blend B20 with additive PPD of 600ppm concentration has lowest NO_X emissions at all the loads and at an injection pressure of 200bar.

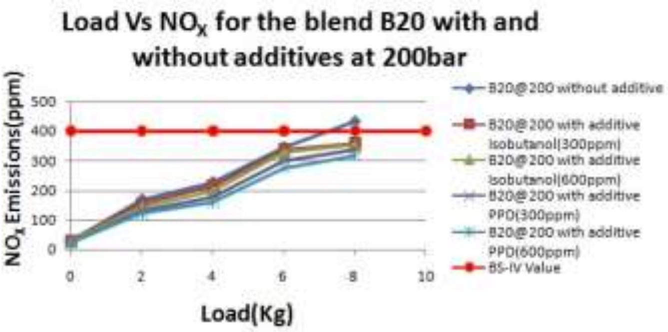

Fig.16 Comparision of NO_X Emissions of the blend B20 with and without additives at an injection pressure of 200

I. COMPARISION OF BRAKE THERMAL EFFICIENCY OF THE BLEND B20 WITH AND WITHOUT ADDITIVES AT 200 bar:

The variation of Brake thermal efficiency with load for the blend B20 without additive and with additives at an injection pressure of 200bar is as shown in the Fig.17.The brake thermal efficiency of the blend B20 with and without additives increases with increasing load at 200bar.It is clear that the brake thermal efficiency is increased simultaneously with the addition of additives. From the graph, the blend B20 with additive P-Phenylene diamine (PPD) of 600ppm concentration has highest brake thermal efficiency at 200bar.

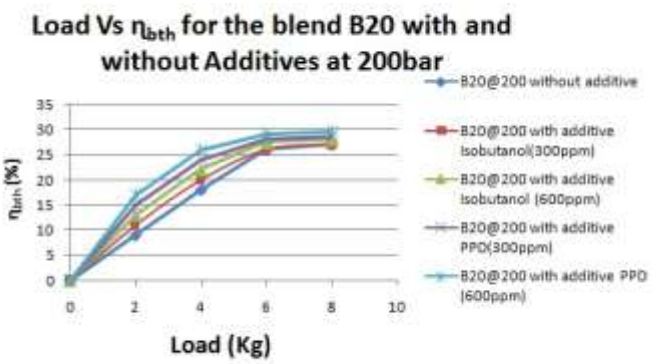

Fig.17 Comparision of Brake thermal efficiency of the blend B20 with and without additives at 200bar

II. COMPARISION OF BRAKE SPECIFIC FUEL CONSUMPTION OF THE BLEND B20 WITH AND WITHOUT ADDITIVES AT 200bar:

Fig.18 shows the variation of Brake Specific Fuel Consumption with load for the Blend B20 without additive and with additives at an injection pressure of 200bar.It can be seen in the figure that the BSFC of blend B20 without additive and with additives decreases up to a load of 6Kg and thereafter increases at an injection pressure 200bar.From the graph it is clearly seen that the blend B20 with additive PPD of 600ppm concentration has lowest BSFC at all the loads and at an injection pressure of 200bar.

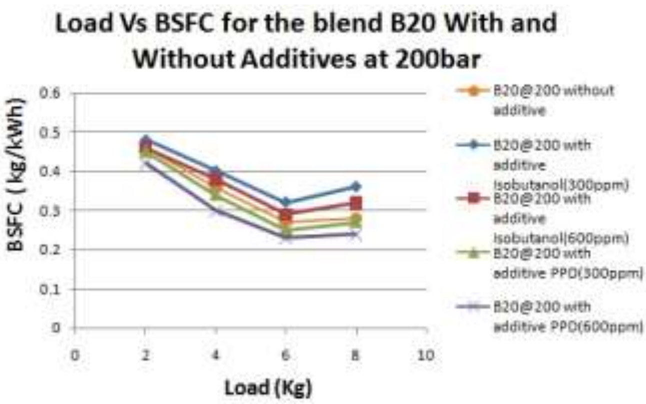

Fig.18 Comparision of Brake Specific Fuel Consumption of the blend B20 with and without additives at 200bar

4. CONCLUSIONS

From the experimental study following conclusions were drawn:

1) The blend B20 with additive Isobutanol of 600ppm concentration has lowest CO emissions at all the loads and at an injection pressure of 200bar.

2) The NO_X emissions of the blend B20 are lower than the diesel at all the loads and injection pressures.

3) The NO_X emissions of the blend B20 with additives are lower than the NO_X emissions of the blend B20 without additives at 200bar.

4) The blend B20 with additive PPD of 600ppm concentration has lowest NO_X emissions at all the loads and at an injection pressure of 200bar.

5) The brake thermal efficiency of biodiesel is very close to diesel at 200bar. However at 60 and 80% load brake thermal efficiency is higher for biodiesel than diesel at 200bar.

6) Blend B20 has the highest brake thermal efficiency at 200bar with additive PPD of 600ppm concentration.

7) The Brake Specific Fuel consumption is high for Honne oil blend and diesel mode. As the injection pressure increased the BSFC is decreased.

8) The blend B20 with additive PPD of 600ppm concentration has lowest BSFC at all the loads and at an injection pressure of 200bar.

Based on the experimental investigation it is clear that the engine emissions were decreased and performance was increased with the addition of additives.

ACKNOWLEDGEMENT:

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