EFFECT OF FUEL INJECTION PRESSURE ON DIESEL ENGINE PERFORMANCE AND EMISSION USING BLEND OF MAHUA OIL

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ABSTRACT : *In the present investigation, tests were conducted using a blend of Mahua oil and Diesel in a single cylinder, four stroke air cooled light duty direct injection diesel engine at different injection pressures as injection pressure is one of the main characteristics which effects the performance and emissions of a diesel engine. The injection pressure was increased from 150bar to 210bar (In steps of 30bar). Two test fuels were used during experiments including neat 100 % diesel fuel and a blend of 20% Mahua oil by volume in the diesel. The tests were carried out for the above proportion of Mahua oil and diesel. The performance tests were conducted at 1500 rpm with loading of 20,40,60,80, and 100 percent of maximum load.*

KEYWORDS – *Single Cylinder Diesel Engine, Mahua oil,Injection Pressure & Performance & Emission Test*

1. INTRODUCTION

Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Hence more stringent norms are imposed on exhaust emissions. Following the global energy crisis in the 1970s and the increasingly stringent emission norms, the search for alternative renewable fuels has intensified.

1.1 NEED FOR ALTERNATE FUELS:

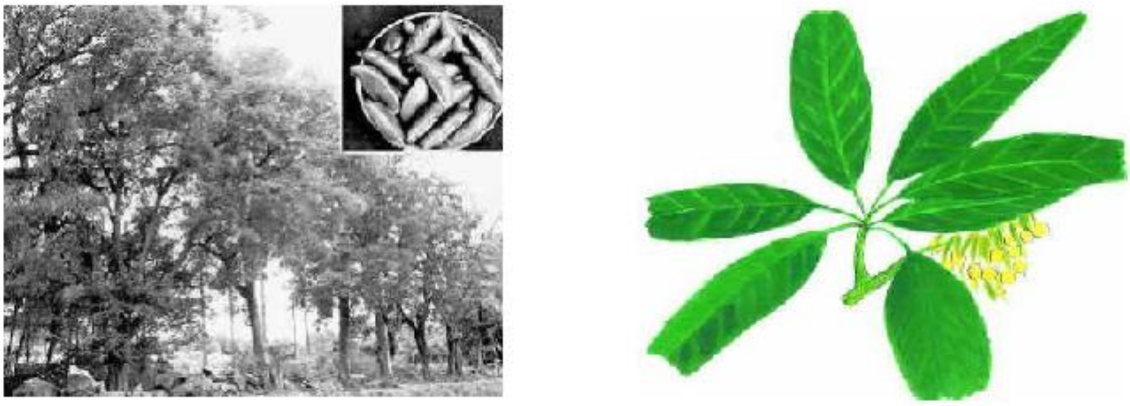
Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce. Although fuel economy of engines is greatly improved from the past and will probably continue to be improved, increases in number of automobiles alone dictate that there will be a great demand for fuel in the near future.

Another reason motivating the development of alternate fuels for the internal combustion engine is concern over the emission problems of gasoline engines. Combined with other air-polluting systems, the large number of automobiles is a major contributor to the air quality problem of the world. Quite a lot of improvements have been made in reducing emissions given off by an automobile engine. If a 35% improvement made over a period of years, it is to be noted that during the same time the number of automobiles in the world increases by 40% thereby nullifying the improvement. Lot of efforts has gone into achieving the net improvement. In cleaning up automobile exhaust. However, more improvements are needed to bring down the ever increasing air pollution due to automobile population.

A third reason for alternative fuel development is the fact that a large percentage of crude oil must be imported from other countries which control the larger oil fields.

1.2 MAHUA OIL:

Two species of the genus Madhuca Indica and Madhuca Longifolia are found in India. Mahua is known as *Illupai Maram* in Tamil and *Hippi* in Kannada, which can be successfully grown in the wastelands and dry lands. The seeds of the tree, popularly known as `Indian butter tree. The specific gravity of Mahua oil was 9.11% higher than that of diesel. The kinematic viscosity of Mahua oil was 15.23times more than that of diesel at temperature of 40^0c. The kinematic viscosity of Mahua oil reduced considerably with increase in temperature to 80c and by increasing the proportion of diesel in fuel blends.



Mahua oil tree plantations and seeds shown at the top right corner

Leaves and flowers of mahua oil tree

Figure 1.1

The seeds contain 30-40 per cent fatty oil called Mahua oil, which is edible and is also used in the manufacture of various products such as soap and glycerin. The oil cake is used as bio fertilizer, organic manure and as feed for fish and cattle. The leaves are used as fodder and as green manure. The flowers are used for extracting ethanol, which is used in making country liquor.

The tree is found in abundance in Thanjavur, Tiruchi and Perambalur regions of Tamil- Nadu and along the Cauvery River basin. About 30-40 percent of the tribal economy in north India such as in Bihar, Madhya Pradesh and Orissa is dependent on the Mahua seeds and flowers. The tree has a potential of enhancing rural income. Being an evergreen variety, it reaches a height of 45-60 feet, and is well adapted to varied weather conditions. With its wide spreading branches and circular crown the trees present a visually appealing structure. Though the tree starts bearing seeds from the seventh year of planting, commercial harvesting of seeds can be done only from the tenth year. Seed yield ranges from 20-200 kg per tree every year, depending on its growth and development. Being hardy and pest resistant, the tree requires little attention.

Mahua oil is obtained from the seeds of Madhuca Indica, a deciduous tree which can grow in semi-arid, tropical and sub-tropical areas. It grows even on rocky, sandy, dry shallow soils and tolerates water logging conditions.Mahua oil was procured from an oil mill. The oil was filtered to remove the impurities. Diesel fuel was used as baseline fuel. The properties of Mahua oil used in the present investigation are presented in Table 1. The viscosity was determined at different temperatures using redwood viscometer to find the effect of temperature on the viscosity of Mahua oil. The viscosity of Mahua oil was found to be 9 times higher than that of diesel fuel. The high viscosity of Mahua oil may be due to its larger molecular weight compared to diesel. The flash point of Mahua oil was higher than diesel and hence it is safer to store.

1.3 EFFECT ON INJECTION PRESSURE ON CI ENGINE:

The diesel engine is a type of internal combustion engine; more specifically, it is a compression ignition engine, in which the fuel ignited solely by the high temperature created by compression of the air-fuel mixture. The engine operates using the diesel cycle. The diesel engine is more efficient than the petrol engine, since the spark-ignition engine consumes more fuel than the compression-ignition engine. The used of diesel engines have extended in the last years to vehicles area due to their high efficiency also by economic fuel cost. In present diesel engines, fuel injection systems have designed to obtain higher injection pressure. So, it is aimed to decrease the exhaust emissions by increasing efficiency of diesel engines. When fuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period during the combustion will increase. This situation leads to increase pressure. Engine performance will be decrease since combustion process goes to a bad condition. When injection pressure increased of fuel particle diameters will become small. Since formation of mixing of fuel to air becomes better during ignition period, engine performance will be increase. If injection pressure is too higher, ignition delay period becomes shorter. Possibilities of homogeneous mixing decrease and combustion efficiency falls down. The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization in order to enable sufficient evaporation in a very short time and to achieve sufficient spray penetration in order to utilize the full air charge. The fuel injection system must be able to meter the desired amount of fuel, depending on engine speed and load, and to inject that fuel at the correct time and with the desired rate. Further on, depending on the particular combustion chamber, the appropriate spray shape and structure must be produced. Usually, a supply pump draws the fuel from the fuel tank and carries its through a filter to the high-pressure injection pump.

Dependent on the area of application and engine size, pressures between 100 and 200 MPa generated. The high pressures injection pump carries the fuel through high-pressure pipes to the injection nozzles in the cylinder head. Excess fuel transported back into the fuel tank. The functionality of the so-called unit pump system is practically identical to that of the unit injector system and offers the same advantages and disadvantages. However, the pump and nozzle not combined into one unit. The camshaft driven a high pressure pump and thus directly coupled with the engine speed. The injection nozzle is located inside also-called nozzle holder in the cylinder head and connected via a high-pressure pipe with the pump. An advantage of this system is that the pump and nozzle not installed at the same place. This reduces the size of the components that have integrated into the cylinder head and simplifies the assembly of the injection system.

Effects of injection pressure on engine performance have investigated on a unit pump system direct injection diesel engine. The diesel engine performance and fuel consumption have been measured at constant speed with varying loads by changing the fuel injection pressure. In the investigation is the effect of injection pressure are conducted using Mahua oil diesel blend ratio (20:80) which is called as B-20 is used at the different fuel injection pressures (150 to 210 bar).

When fuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period during the combustion will increase. This situation leads to inefficient combustion in the engine and causes the increase in NOx, CO emissions. When the injection pressure is increased fuel particle diameters will become small. The mixing of fuel and air becomes better during ignition delay period which causes low CO emission. But, if the injection pressure is too high ignition delay become shorter. So, possibilities of homogeneous mixing decrease and combustion efficiency falls down.

Table 1.1 Properties of Mahua oil:

Properties	Diesel	Mahua oil
Kinematic viscosity at 40 ^{0}C (cSt)	4.59	5.47
Density at 15 ^{0}C (kg/m^3)	850	876
Flash point (^{0}C)	52	150
Calorific value (kJ/kg)	42000	39900
Sp.Gravity	0.85	0.876
Ash (% by mass)	0.01	0.14

II EXPERIMENTAL SETUP & PROCEDURE

2.1 Introduction

The details of the experimental set up are presented in this chapter the alternations made to the instrumentation are also described .The experimental setup is fabricated to fulfill the objective of the present work. The various components of the experimental set up including modification are presented in this chapter.

2.2 Experimental set up

The experimental set up consists of engine, an alternator, top load system, fuel tank along with immersion heater, exhaust gas measuring digital device and manometer.

Engine:

The engine which is supplied by M/s. Alimgar Company the engine is single cylinder vertical type four strokes, Air-coo1ed, compression ignition engine. The engine is self governed type whose specifications are given in Appendix 1.is used in the present work.

2.3 Reasons for selecting the engine

The above engine is one of the extensively used engines in industrial sector in India. This engine can with stand the peak pressures encountered because of its original high compression ratio. Further, the necessary modifications on the cylinder head and piston crown can be easily carried out in this type of engine. Hence this engine is selected for the present project work.

Dynamometer

The engine is coupled to a generated type electrical dynamometer which is provided for loading the engine.

Fuel injection pump

The pump is driven by consuming some part of the power produced by the engine; it will provide the required pressure to the injector. The pump is BOSCH fuel injection pump.

Fuel injector (BOSCH)

A cross sectional view of a typical BOSCH fuel injector

The injector assembly consists of

i. A needed valve

ii. A compression spring

iii. A nozzle

iv. An injector body

U-tube manometer

The one of end of the U-tube manometer is connected to the orifice of the air tank and the other end is exposed to the atmosphere, the manometer liquid used is water.

Digital thermometer

It consists of a temperature sensing element connected to the electronic digital display which is operated by battery

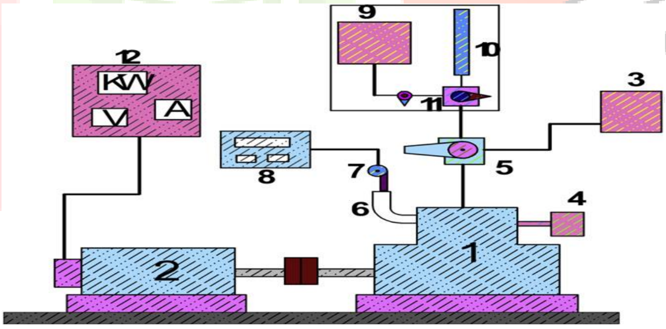


Figure 2.1

2.4 Experimental Procedure

Before starting the engine, the fuel injector is separated from the fuel system. it is clamped on the fuel injection pressure tested and operates the tester pump. Observe the pressure reading from the dial. At which the injector starts spraying. In order to achieve the required pressure by adjusting the screw provided at the top of the injector .This procedure is repeated for obtaining the various required pressures.

As first said, diesel alone is allowed to run the engine for about 30 min, so that it gets warmed up and steady running conditions are attained. Before starting the engine, the lubricating oil level in the engine is checked and it is also ensured that all moving and rotating parts are lubricated.

The various steps involved in the setting of the experiments are explained below

1. The Experiments were carried out after installation of the engine
2. The injection pressure is set at 150 bar for the entire test.

3. Precautions were taken, before starting the experiment.
4. Always the engine was started with no load condition
5. The engine was started at no load condition and allowed to work for at least 10 minutes to stabilize.
6. The readings such as fuel consumption, spring balance reading, cooling water flow rate, manometer reading etc., were taken as per the observation table.
7. The load on the engine was increased by 20% of full Load using the engine controls and the readings were taken as shown in the tables.
8. Step 3 was repeated for different loads from no load to full load by varying injector pressures (such as 180 bar and 210 bar).
9. After completion of test, the load on the engine was completely relieved and then the engine was stopped.
10. The results were calculated as follows.

The above experiment is repeated for various loads on the engine. The experimental procedure is similar as foresaid. While starting the engine, the fuel tank is filled in required fuel proportions up to its capacity. The engine is allowed to run for 20 min, for steady state conditions, before load is performed.

Finally, the engine is run by Mahua oil diesel blend at various injection pressures the corresponding observations are noted.

The test is carried on the Alamgir Engine for the following fuel blends:

1. 100% Diesel
2. 20% Mahua Oil + 80% Diesel

III CALCULATIONS AND GRAPHS

3.1 Calculations

The parameters that are determined at different loads are as fallows

1. Brake Power, B.P $= \frac{VI\cos\phi}{\eta_{tran} \times \eta_{gen} \times 1000}$ kw

Where,

V	=	Voltage, volts
A	=	Current, amperes
Cos Ø	=	Power factor = 1
η_{tran}	=	Transmission Efficiency = 0.98
η_{gen}	=	Generator Efficiency = 0.9

2. T.F.C $= \frac{20 \times 0.85 \times 3600}{t \times 1000}$ Kg/h

Where,

T.F.C	=	Total Fuel Consumption, Kg/h
Specific gravity of diesel	=	0.85
t	=	Time taken for 20 c.c fuel, seconds

3. Brake Specific Fuel Consumption, BSFC $= \frac{T.F.C}{B.P}$ Kg/kwh

4. Heat Input = T.F.C X C.V kW

Where,

C.V = Calorific Value of Fuel, kJ/kg k

5. Frictional Power, F.P = kW (from graph by William's line method)

6. Indicated Power = B.P + F.P Kw

7. Mechanical efficiency, η_{mech} = $\frac{B.P}{I.P}$ x 100 %

8. Brake thermal efficiency = $\frac{B.P}{\text{Heat Input}}$ x 100 %

9. Indicated thermal efficiency = $\frac{I.P}{\text{Heat Input}}$ x 100 %

10. Brake Mean Effective Pressure, bmep = $\frac{B.P \times 60}{L \times A \times n \times k}$

Where

L = length of the stroke, m n = speed of the engine = 1500/2

A = Area of the cylinder, m^2 k = no. of cylinders

$$\text{Bmep} = \frac{3.1188 \times 60}{0.116 \times \frac{\pi}{4} \times (0.102)^2 \times \frac{1500}{2} \times 1}$$

11. Indicated Mean Effective Pressure, Imep = $\frac{I.P \times 60}{L \times A \times n \times k}$

$$\text{Imep} = \frac{4.6688 \times 60}{0.116 \times \frac{\pi}{4} \times (0.102)^2 \times \frac{1500}{2} \times 1}$$

11. Volumetric efficiency, η_{vol} = $\frac{\text{Actual volume flow rate of air}}{\text{The rate at which volume is displaced}}$ x 100 %

$$\eta_{vol} = \frac{\text{Area of inlet pipe} \times \text{Velocity of air}}{\begin{bmatrix}\text{Area of}\\ \text{the cylinder}\end{bmatrix} \times \begin{bmatrix}\text{Length of}\\ \text{the stroke}\end{bmatrix} \times \begin{bmatrix}\text{Revolutions}\\ \text{per second}\end{bmatrix}} \times 100\%$$

3.2 Graphs

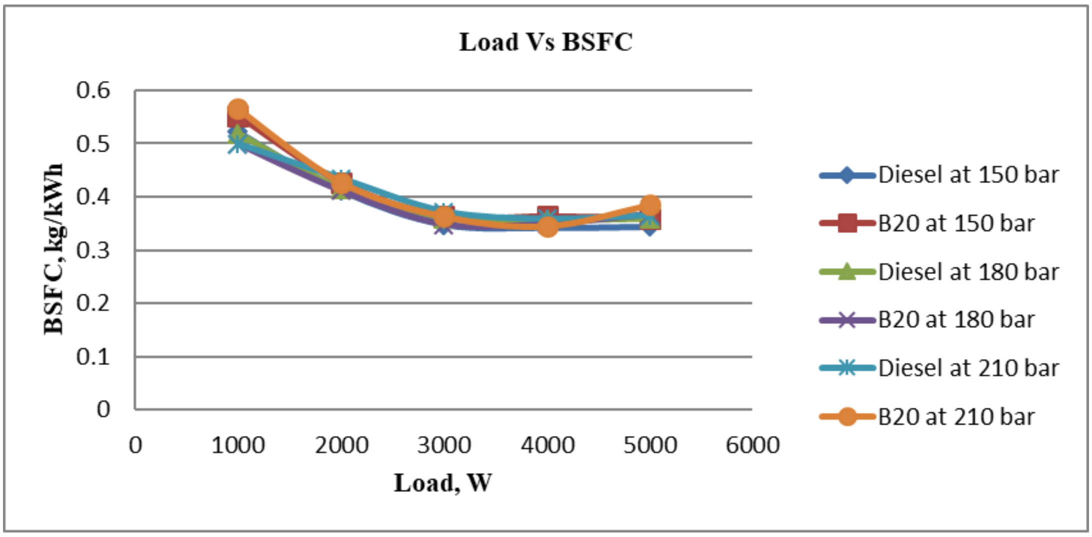


Fig. 3.1 Load Vs Brake Specific Fuel Consumption

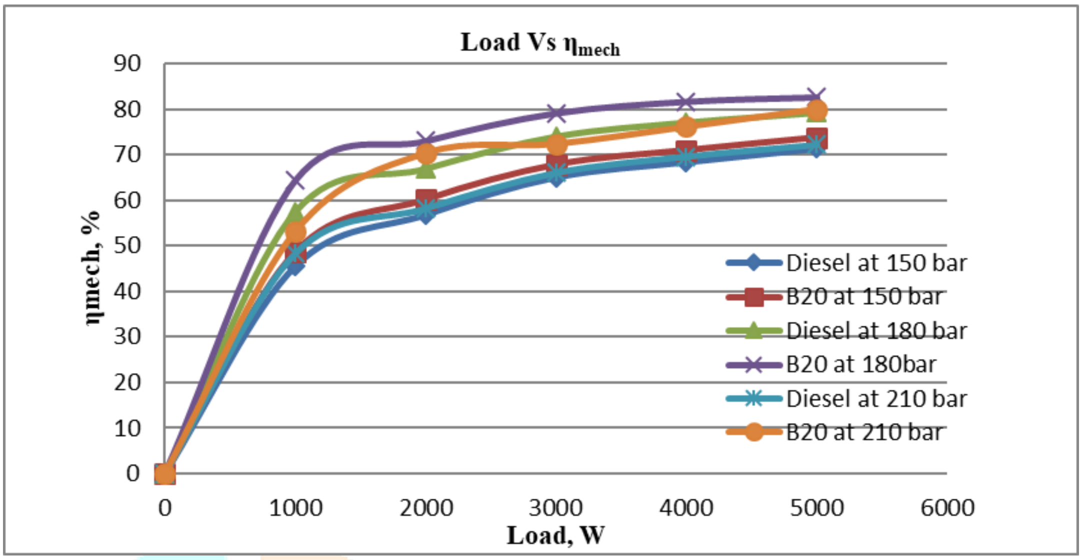


Fig. 3.2 Load Vs Mechanical efficiency

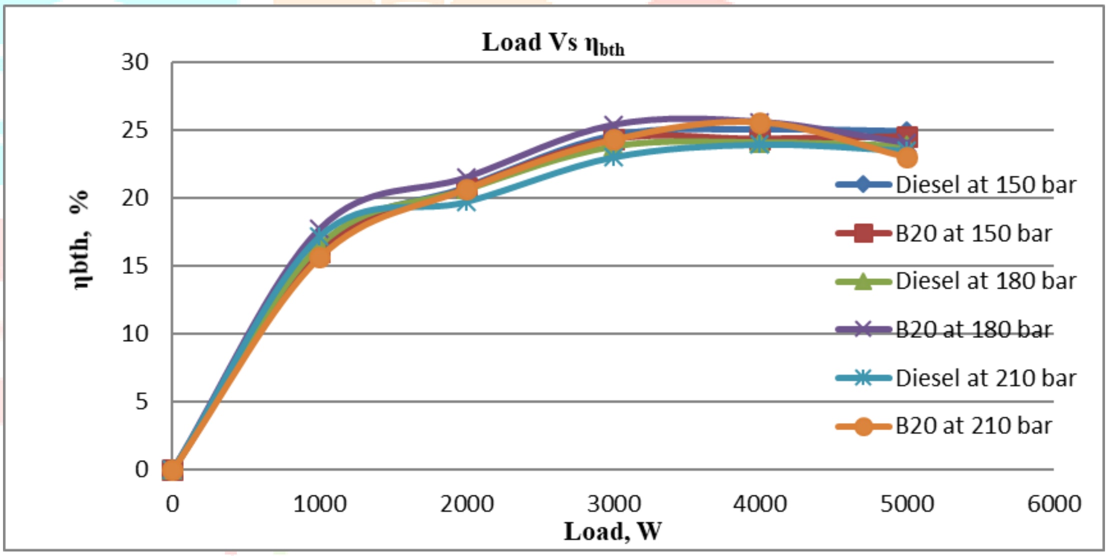


Fig. 3.3 Load Vs Brake Thermal Efficiency

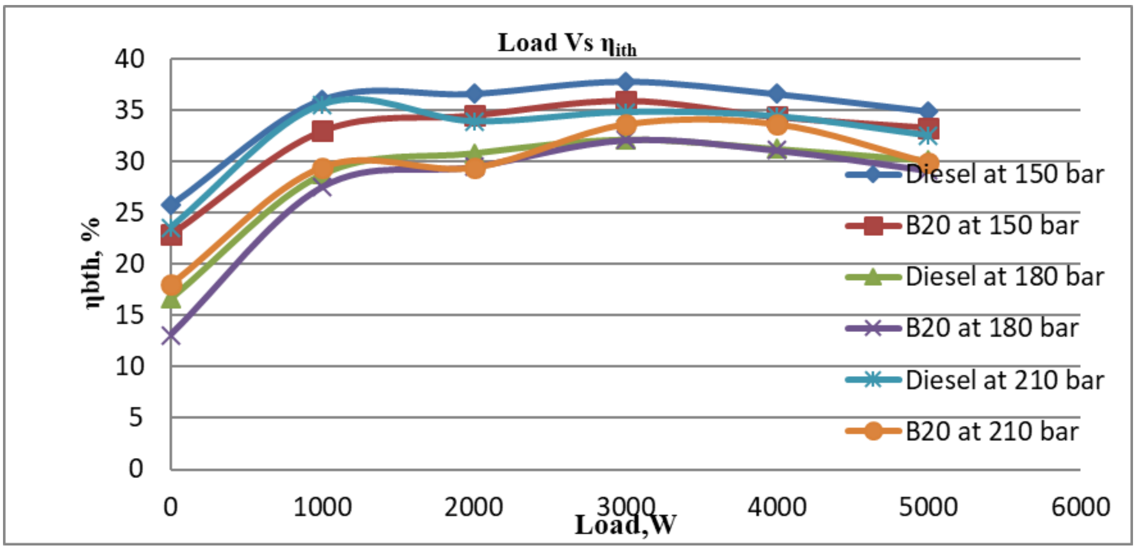


Fig. 3.4 Load Vs Thermal Efficiency

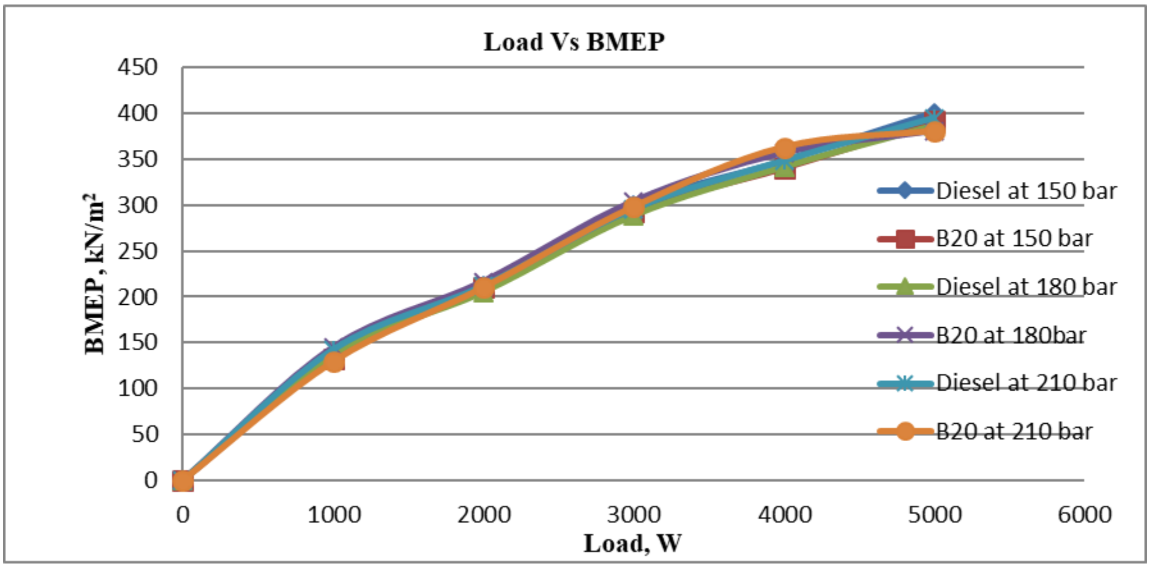


Fig. 3.5 Load Vs Brake Mean Effective Pressure

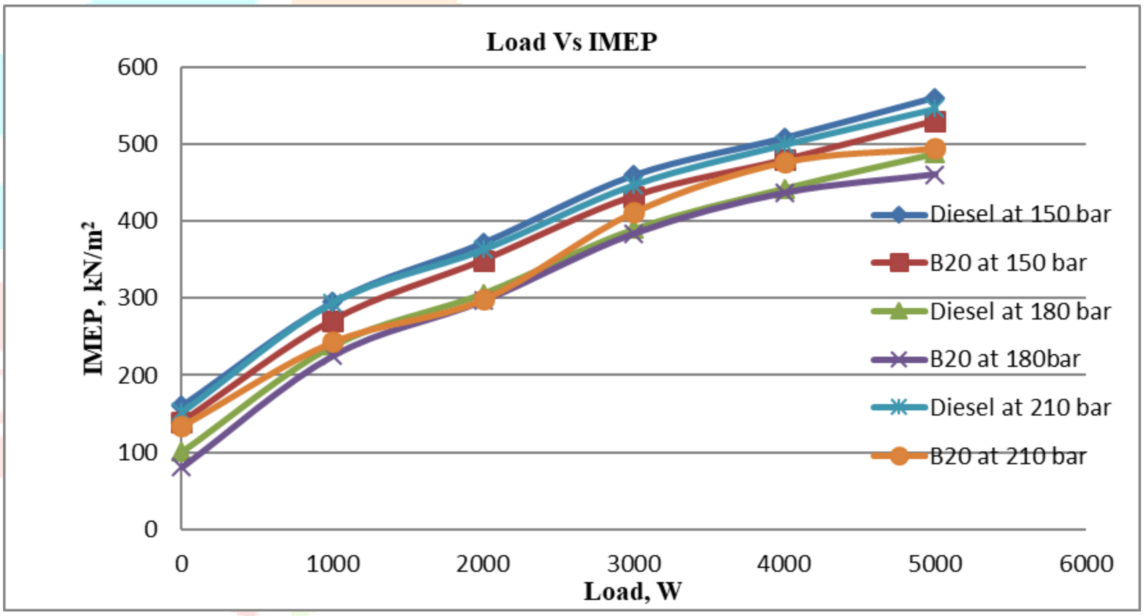


Fig. 3.6 Load Vs Indicated Mean Effective Pressure

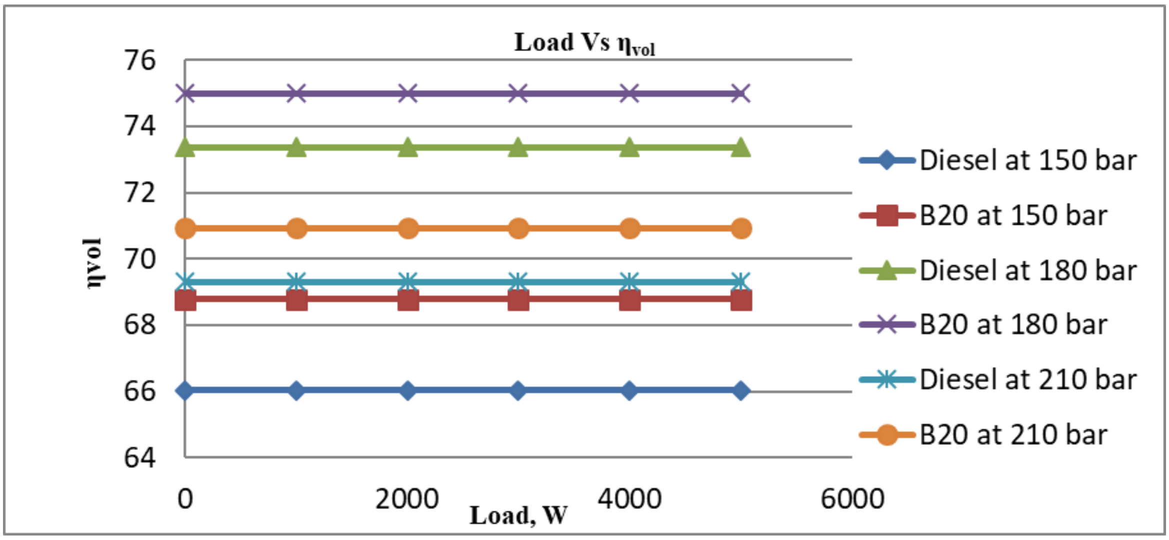


Fig. 3.7 Load Vs Volumetric Efficiency

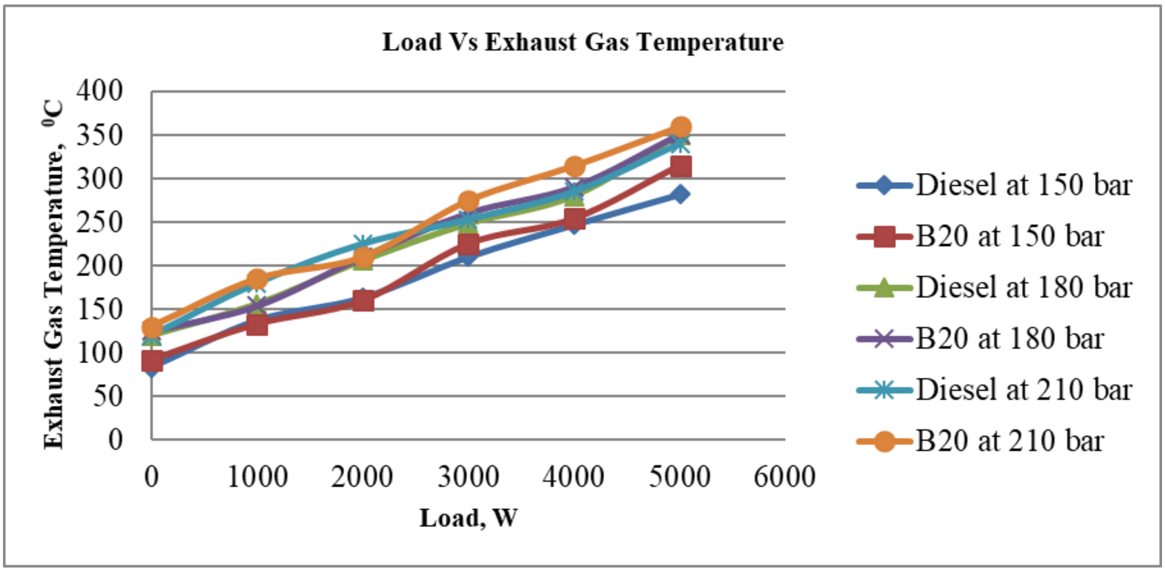


Fig. 3.8 Load Vs Exhaust Gas Temperature

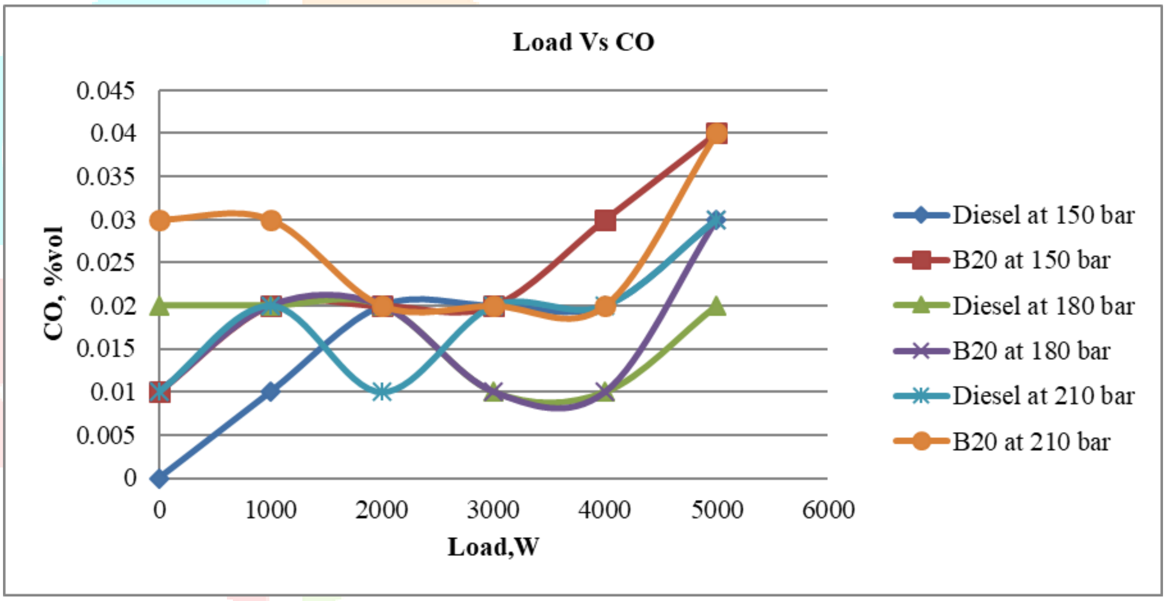


Fig. 3.9 Load Vs Carbon monoxide

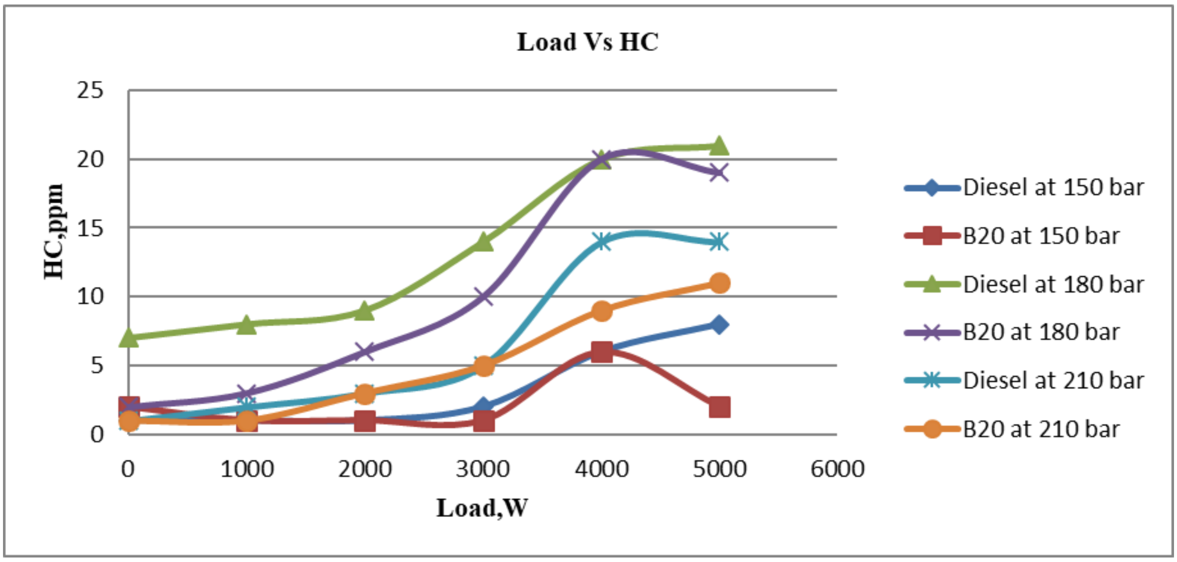


Fig. 3.10 Load Vs Hydro carbons

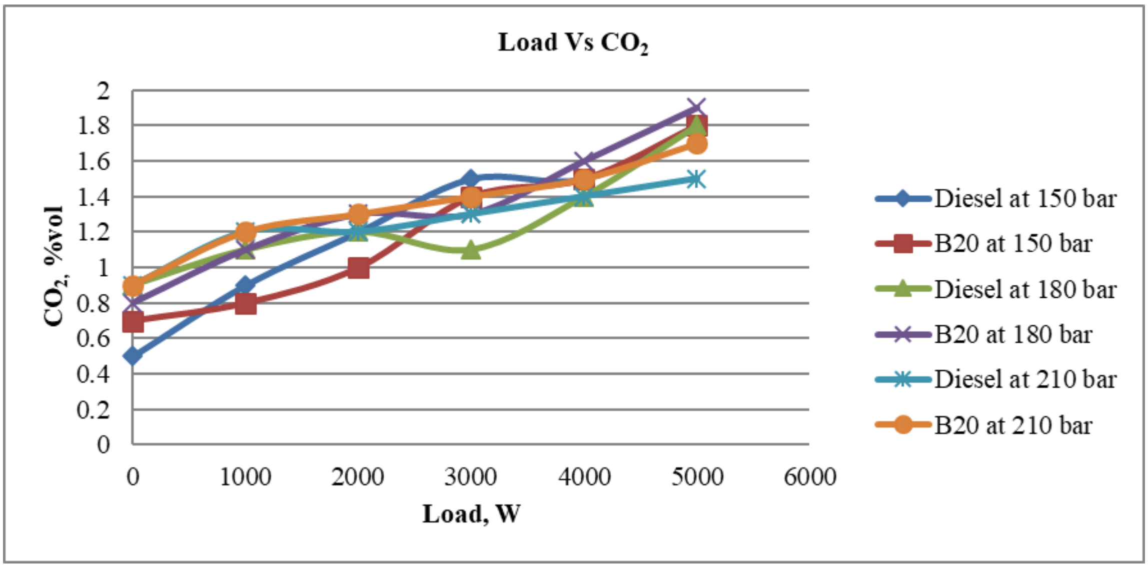


Fig. 3.11 Load Vs Carbon dioxide

IV. CONCLUSION

The engine was made to run on diesel fuel mode, and Mahua oil –diesel mode. The experiments were conducted at 3 different fuel injection pressures of 150 bar, 180 bar and 210 bar. The performance and emission of the engine at full load were investigated. The following results were obtained.

- Brake specific fuel consumption for Mahua oil-diesel blend ishigher than the BSFCat 210 bar.(0.345 kg/kWhr at 150 bar, 0.367 kg/kWhr at 180 bar, 0.384 kg/kWhrand 0 kg/kW at 210 bar.)
- The brake thermal efficiency of the engine for Mahua oil- Diesel blend of is high compared to diesel mode at 180 bar and 210 bar.
- The exhaust gas temperature of diesel fuel mode is less compared to Mahua oil-diesel mode at fuel injection pressures of 150 and 180 bar.
- CO emission of Mahua oil-diesel mode is higher compared to that of diesel fuel mode at all fuel injection pressures.
- CO_2 emission increased up to the fuel injection pressure of 180 bar for Mahua oil- diesel mode and then decreased slightly at 210 bar injection pressure.
- CO emission decreased with increase in fuel injection pressure from 180 bar to 210 bar for fossil diesel mode of operation.
- HC emission of Mahua oil-Diesel fuel operation is less than the diesel fuel mode at all fuel injection pressures.

From the above analysis the main conclusion is Mahua oil blends are suitable substitute for diesel at high injection pressure(value), whichproduces lesser emission and better performance then diesel.

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