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THE EXPERIMENTAL INVESTIGATION ON CI DIESEL ENGINE FOR OPTIMUM PARAMETERS OF NOZZLE

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ABSTRACT

The amount of fuel consumed in I.C engine is a crucial parameter which gives impact on performance and output. The efficiency of I.C engine is mainly depended on the amount of chemical fuel used and the energy absorbed from fuel by reducing hydrocarbon (HC) emissions. The spraying behavior of the fuel injector is much considered for reducing the fuel consumption. Fuel injection parameters play an important role in diesel engine performance for obtaining Proper combustion. The performance and emission characteristics of diesel engine depend on many parameters. The important parameters which influence the performance and emission of diesel engine are fuel injection pressure, fuel nozzle holes and its size.

An experimental study is performed on a light duty direct injection kirloskar diesel engine at 160 bar, 180 bar, 200 bar, 220 bar and 240 bar injection pressure to study its effect on performance and emission. Future emission will require substantial reductions of NOx and Smoke emissions from diesel engines.

The combustion and formation in a diesel engine is governed mainly by spray formation and mixing. Important parameters governing these are droplet size, distribution concentration and injection velocity. Smaller orifices are believed to give smaller droplet size, even with reduce injection pressure, which leads to better fuel atomization, faster evaporation and better mixing. From the conclusions the Mechanical efficiency of 4-hole nozzle is good at 200 and 220 barof injection pressures and for 5-hole nozzle at 180 bar of pressure the mechanical efficiency is good.

1.0 INTRODUCTION

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 inefficient combustion in the engine and causes the increase in NOx, CO emissions. Engine performancewill be decreased 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. Therefore, smoke is formed at exhaust of engine.

The geometry of the nozzle in an injector plays a vital role in controlling diesel spray atomization and combustion. In order to bring fuel droplet size small, the nozzle-hole size is required to be reduced to produce smaller droplets. By decreasing the nozzle-hole size, the spray tip penetration is reduced due to the low spray momentum. High injection pressures with small nozzles are common in the modern diesel engine as they reduce injection duration and improve combustion efficiency.

So many computational simulations are performed to study the effect of reduced nozzle-hole size and nozzle tip-hole configuration on the combustion characteristics of a high speed direct injection diesel engine. In this work the effects of fuel injection pressure and fuel nozzle holes are experimentally studied on performance and emission characteristics of single cylinder light duty direct injection diesel engine.

Because diesel engines are the primary source of power for the light, medium and heavy duty applications and as such there can be no replacement for it in agriculture and transportation sectors. The advantages of diesel engines are high fuel efficiency, reliability and durability.

2.0 LITERTAURE REVIEW

Effect of injector nozzle holes on diesel engine performance by Semin, In his paper by modeling software called GT-POWER presented the simulation results are shown in every cases, such as case 1 is on 500 rpm, case 2 is on1000 rpm, case 3 is on 1500 rpm, case 4 is on 2000 rpm, case 5 is on 2500 rpm, case 6 is on 3000 rpm, case 7 is on 3500 rpm and case 8 on 4000 rpm. Numerous studies have suggested that decreasing the injector nozzle orifice diameter is an effective method on increasing fuel air mixing during injection (Baik, 2001). Smaller nozzle holes have found to be the most efficient at fuel/air mixing primarily because the fuel rich core of the jet is smaller. In addition, decreasing the nozzle hole orifice diameter would reduce the length of the potential core region.The optimal nozzle design would be one that provided the maximum number of liquid fuel burn in combustion process and minimum number of liquid fuel unburned

The simulation result on engine performance effect of injector fuel nozzle holes number and Geometries in indicated power, indicated torque and indicated specific fuel consumption (ISFC) of engine are shown. The injector fuel nozzle holes orifice diameter And injector nozzle holes numbers effect on indicated power, indicated torque and ISFC performance of direct-injection diesel engine is shown from the simulation model running output. An aerodynamic interaction and turbulence seem to have competing effects on spray breakup as the fuel nozzle holes orifice diameter decreases. The fuel drop size decreases if the fuel nozzle holes orifice diameter is decreases with a decreasing quantitative effect for a given set of jet conditions.

For excessively small nozzle size, the improvements in mixing related to decreased plume size may be negated by a reduction in radial penetration (Baumgarter, 2006). This behavior is undesirable because it restricts penetration to the chamber extremities where a large portion of the air mass resides. Furthermore, it hampers air entrainment from the head side of the plume because the exposed surface area of the plume is reduced. It has been suggested that a nozzle containing many small holes would provide better mixing than a nozzle consisting of a single large hole

Experimental study of the Effect of Fuel Injector nozzle holes on Direct Injection Diesel Engine by Rohit Sharma, in this paper they mainly concentrated on the NOχemissions and effects on brake thermal efficiency and brake specific fuel consumption on engine performance.

Effect onBrake Thermal Efficiency (BTE)

The Effect of nozzle hole geometry for NH1 (3 hole nozzle) and NH2 (5 hole nozzle) on brake thermal efficiency is shown. It is found that, nozzle-hole geometry has significant influences on droplet size (spray) penetration. At Injection pressure say 220 bar, it is noticed that, rise in thermal efficiency with increase in nozzle hole size. This is due to increase in nozzle hole size responsible to rise in air fuel mixing, fuel vaporization and improved combustion and heat release rate.

Effect on Brake Specific Fuel consumption (BSFC)

Theexperiments are aimed to arrive at an optimum nozzle size and fuel injection pressure that would give better fuel economy, The values of BSFC are lower for an IP of 220 bar compared to IP of 200 bar and 240 bar. Further increase in the IP beyond 220 bars is resulted in higher values. This could be due to the fact that with increase in injection pressure, not only the fuel droplet size decreases but also increases the momentum of the droplets. Therefore, too high increase in pressures would have developed even small droplets but with increase in momentum the droplets could have got impinged on the cylinder inner wall and to develop same power, the fuel consumption should have increased. Thus, at the prevailing conditions, an IP of 220 bars yielded lower BSFC

Effect on Nitrogen Oxides (NOx) emission

At any nozzle-hole operation with increase in IP, NOx emission is found to be increasing due to faster combustion and higher temperatures reached in the cycle. However, at IP 240 bar at 60%, 80% or full load for NH1, the NOx emissions reduced for due to lower combustion phase and incomplete combustion caused by poor atomization, sprays characteristics and increased ignition delay at this pressure

Experimental Study on Effects of Nozzle-Hole Geometry on Achieving Low Diesel Engine Emissions by PRASHANTH K. KARRAIn this study, three injectors with different nozzle geometries are tested in a multicylinder turbocharged diesel engine. Effects of nozzle geometry are investigated together with the use of high injection pressure, exhaust gas recirculation, and various injection timings. The fuel consumption, gaseous emissions, and soot emissions are measured. The use of a convergent nozzle allowed higher injection pressures to be used due to reduced cavitation. Emissions results showed that the convergent nozzle produced higher soot emissions than the straight-hole nozzle.

The possible reason is that the lack of cavitation in the convergent nozzle may have a negative effect on liquid atomization. The cylinder pressure measurements also indicated a slow combustion when the convergent nozzle is used. Effects of the convergent nozzle on NOx emissions and fuel consumption are not significant. The ten-hole injectors also allowed higher injection pressures to be used, as compared with the baseline six-hole injectors. The small nozzles in the ten-hole injector can produce small fuel drops for better atomization and mixing to reduce soot emissions. By using more nozzle holes, better air utilization can also contribute to the reduction in NOx and soot emissions.

3.0 EXPERIMENTAL SETUP

The experimental setup consists of single cylinder four stroke water cooled diesel engine coupled to eddy current dynamometer with the help of flexible rubber coupling and is mounted on a centrally balanced base frame made of mild steel channels .the setup has standalone fully powder coated panel box consisting of air box, fuel tank, and manometer, Fuel measuring unit, digital indicators and transmitters for measuring various parameters. It is also provided with necessary sensors and transmitters for combustion pressure and crank angle measurements. All these signals are interfaced to computer through signal conditioner and signal converter

To evaluate the performance and emission and combustion parameters of the compression ignition engine at different prerequisite conditions the complete setup is arranged in the IC engines laboratory of mechanical engineering, JNTUCEH.

KIRLOSKAR DIESEL ENGINE

A single cylinder four stroke, naturally aspirated, direct injection and water cooled diesel engine with a displacement volume of 562cc, compression ratio of 16.5:1, and speed 1500 rpm is used for conducting experiments. Engine is directly coupled with and eddy current dynamometer that permits engine motoring either fully or partially.

The engine and the dynamometer are interfaced to a control panel which is connected to computer. The computer software supplied for the test rig is used for recording the test parameters such as fuel rate, temperatures, air flow rate, load, brake power etc. from these parameters the engine performance characteristics such as brake thermal efficiency, brake specific fuel consumption volumetric efficiency and mechanical efficiency are calibrated.

The calorific value and the density of the fuel under test are given as input to the computersoftware.

Table specifications of the test engine

Engine power	:	5.2 KW
Engine max speed	:	1500 rpm
Cylinder bore	:	87.5 mm
Stroke length	:	110 mm
Connecting rod length	:	234 mm
Compression ratio	:	17.5:1
Stroke type	:	Four
No. of cylinders	:	One
Speed type	:	Constant

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Cooling type	:	Water
Dynamometer type	:	Eddy current

Dynamometer (loading unit)

It consists of stator in which numbers of electromagnets are fitted and rotor disc coupled to output shaft of the engine. When rotor rotates in stator eddy currents are produced due to magnetic flux setup by passage of field current in the electromagnets. Eddy currents oppose the rotor motion thus loading the engine. This type of dynamometer needs cooling arrangement as eddy currents dissipates heat. Moment arm measure torque, regulating the current in electromagnets controls the load.

To prevent overheating of the dynamometer a water supply pressurized to minimum indicated in specification is connected to a flanged inlet on the bed plate. Water passes from the inlet to the casing via a flexible connection; permitting movement of the casing. Water passes through loss (Grooved) plates in the casing positioned either side of the rotor and absorbs the heat generated.

4.0 RESULTS

Experimental investigation performed on kirloskar diesel engine using 3-hole nozzle

The experiments are performed on KIRLOSKAR diesel engine using high speed diesel, the engine performance test is performed at 180 bar injection pressure. The injection pressure is set by adjusting the spring tension using screw on the fuel injector. If the screw is rotated clockwise the fuel injection pressureincreases and if the screw is rotated anti–clockwise the fuel injection pressure decreases. The fuel injector nozzle is standard nozzle having 3 holes with 0.28 mm hole diameter, and it is made with hardened steel with composition of Nickel, Chromium and Steel.

The engine started manually by rotating the crank shaft using the lever after starting, engine left running ideally on no load condition for some time. Load is imposed on engine using the eddy current dynamometer. Load increased from 0 to 14kg, by increasing 2kg each time in 7 steps. Rpm is recorded for each load, manometers reading, time taken for 10 ml fuel consumption, and air flow readings are taken for each load conditions. Rota meter is adjusted according to the required water flow.

During the performance test at each load the exhaust gas emissions are also taken using gas analyzer, the exhaust gas pipe have a valve connection into the pipe, by inserting the analyzer into the valve and holding for 2 min, after that the readings are taken. The CO, CO_2, NO_x, O_2 and HC proportions of exhaust gas are measured by exhaust gas analyzer.

At full load, after the readings are taken the load is gradually decreased to no load condition and the engine is stopped using the lever which stops the passage of fresh

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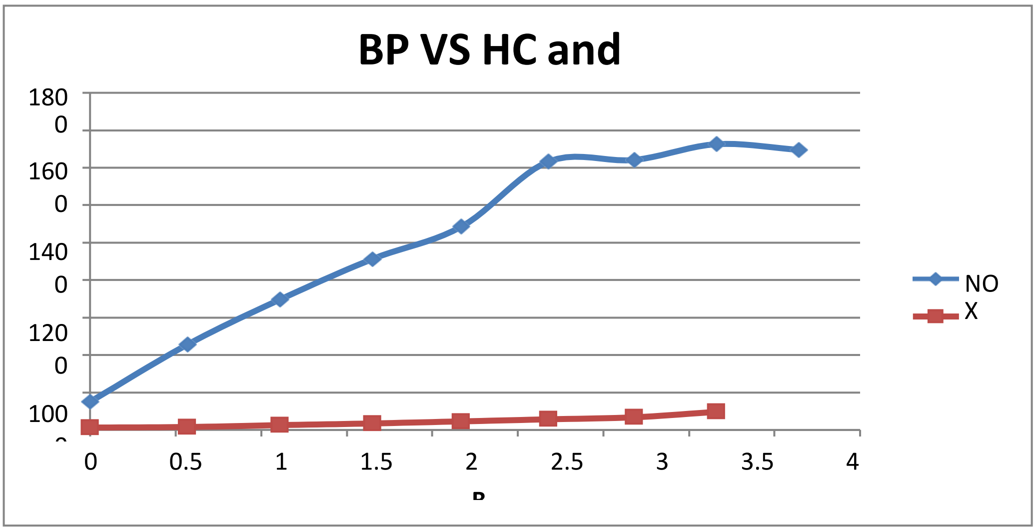
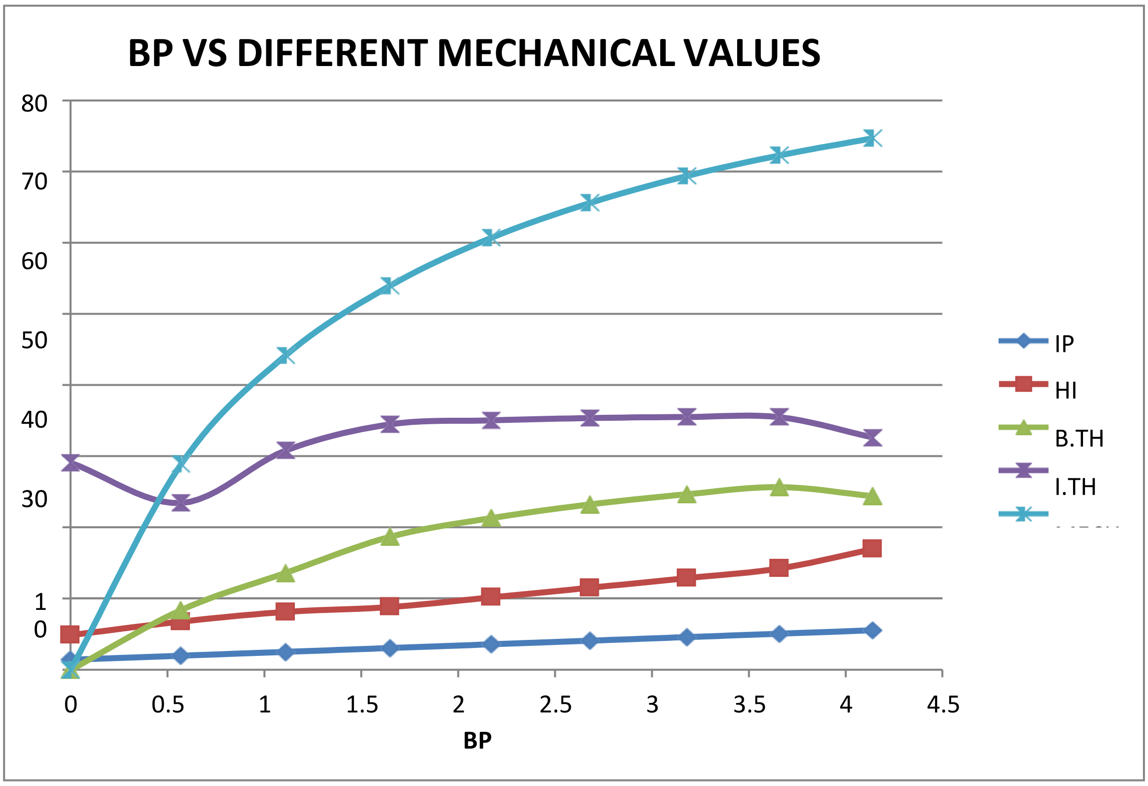
air into combustionchamber

These graphs are drawn BP as abscissa and indicated power, heat input, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency as ordinate.





In this graph **bp** as abscisa and **co, co2, o2**, emissions as ordinate

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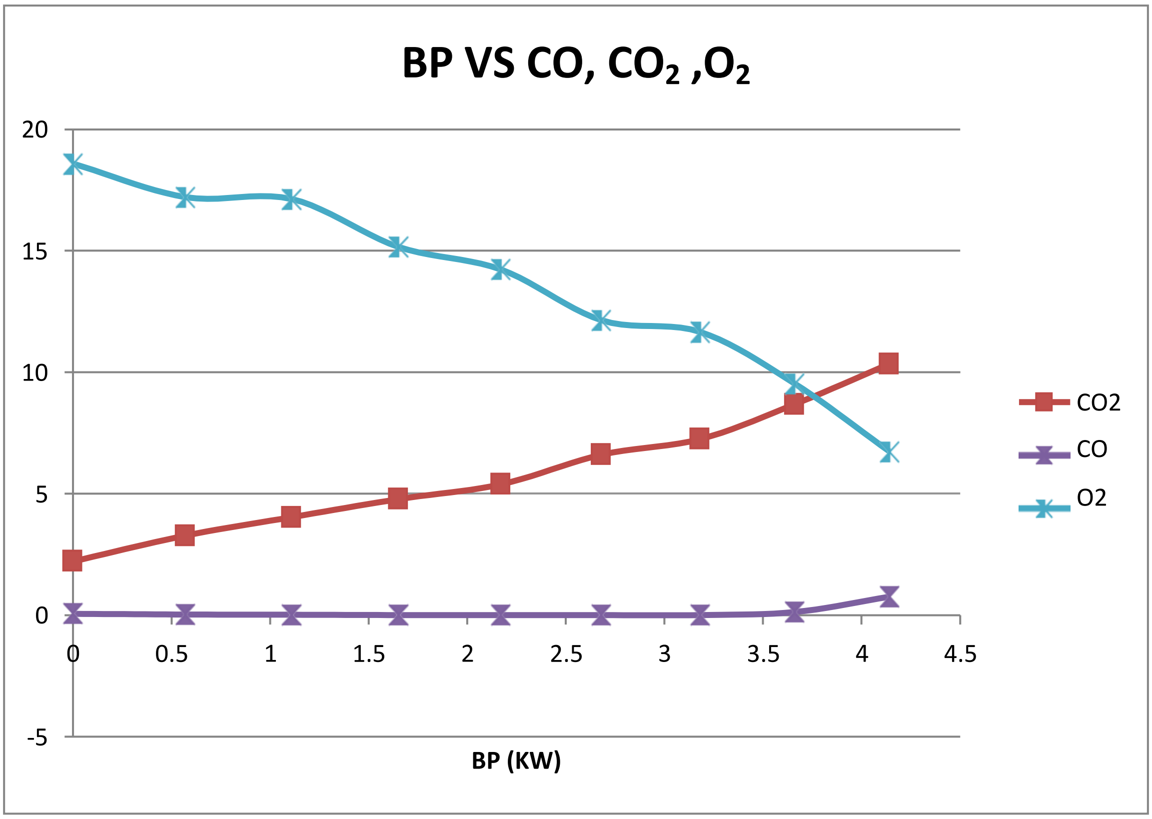

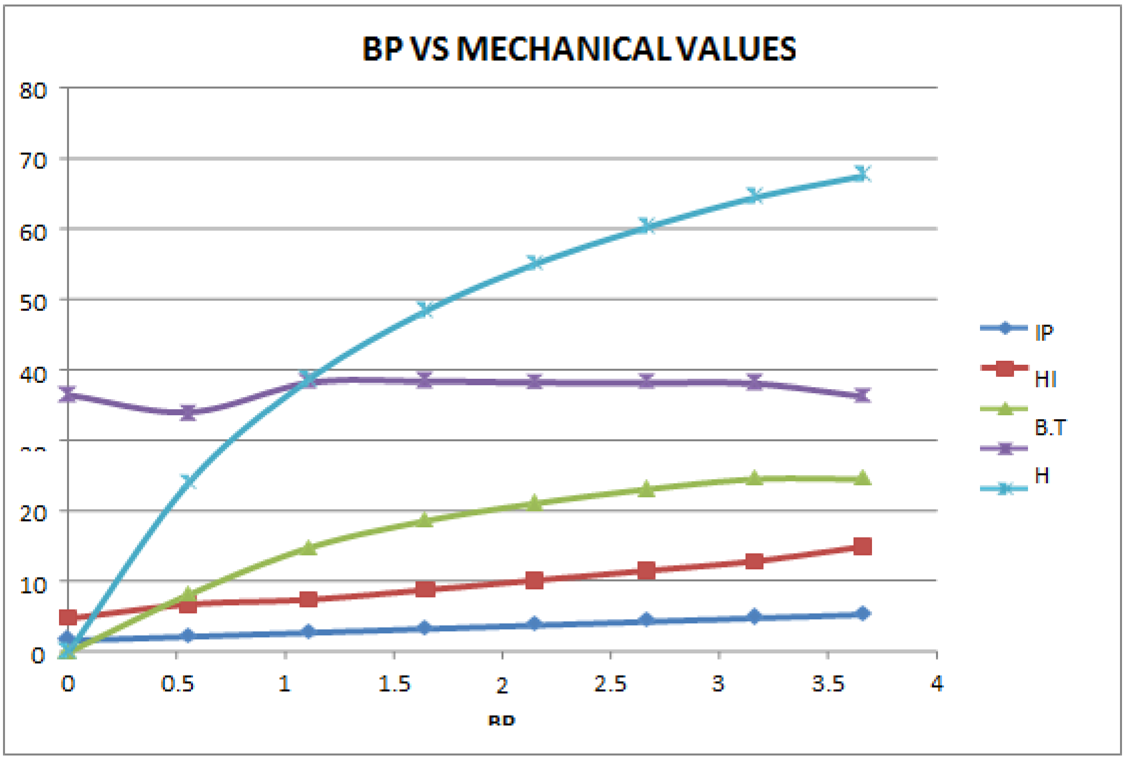

In this graph **bp** as abscisa and **hcandno$_X$** emissions as ordinate

The experiments are performed on KIRLOSKAR diesel engine using high speed diesel, the engine performance test is performed at 180, 200, 220, and 240 bar injection pressures. The injection pressure is set by adjusting the spring tension using screw on the fuel injector. If the screw rotated clockwise the fuel injection pressure increases and ifit is rotated anti–clockwisethe fuel injection pressure decreases. The fuel injector nozzle is standard nozzle having 4 holes with 0.26 mm hole-diameter, and it is made with hardened steel with composition of Nickel, Chromium and Steel.

The engine started manually by rotating the crank shaft using the lever after starting, engine left running ideally on no load condition for some time. Load is imposed on engine using the eddy current dynamometer. Load increased from 0 to 14kg, by increasing 2kg each time in 7 steps. Rpm is recorded for each load, manometers reading, time taken for 10 ml fuel consumption, and air flow readings are taken for each load conditions. Rota meter is adjusted according to the required water flow.

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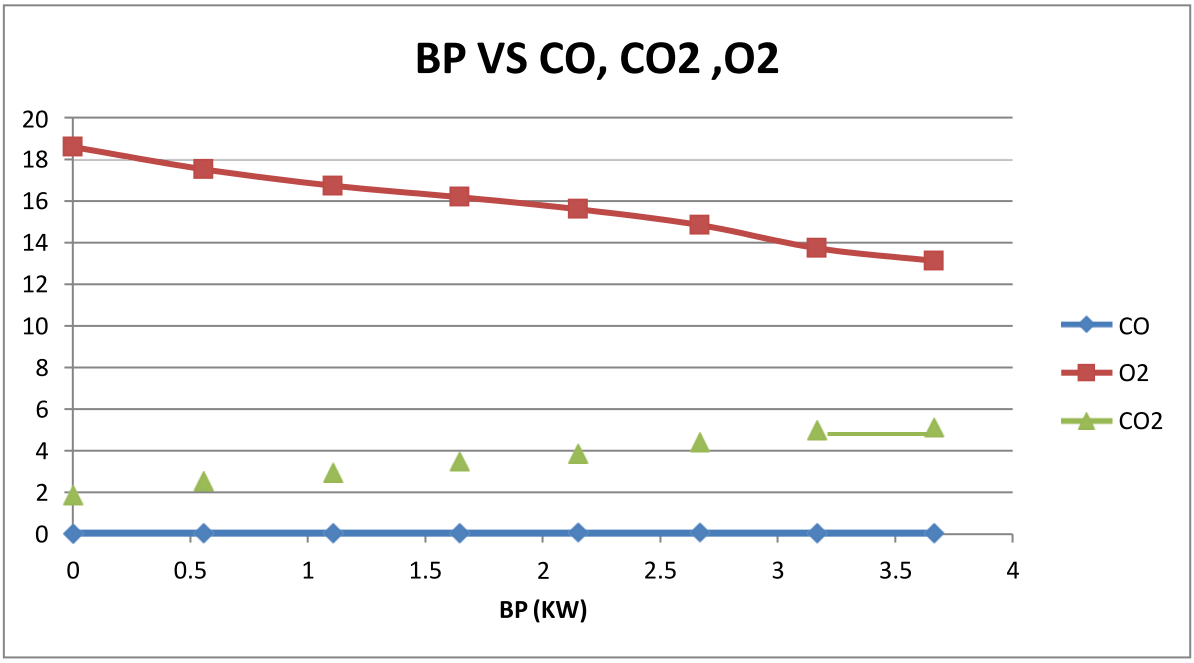
At full load, after the readings are taken the load is gradually decreased to no load condition and the engine is stopped using the lever which stops the passage of fresh air into combustionchamber.

These graphs are drawn BP as abscissa and indicated power, heat input, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency as ordinate

IN THIS GRAPH **BP** AS ABSCISA AND **CO, CO2, O2**, EMISSIONS AS ORDINATE



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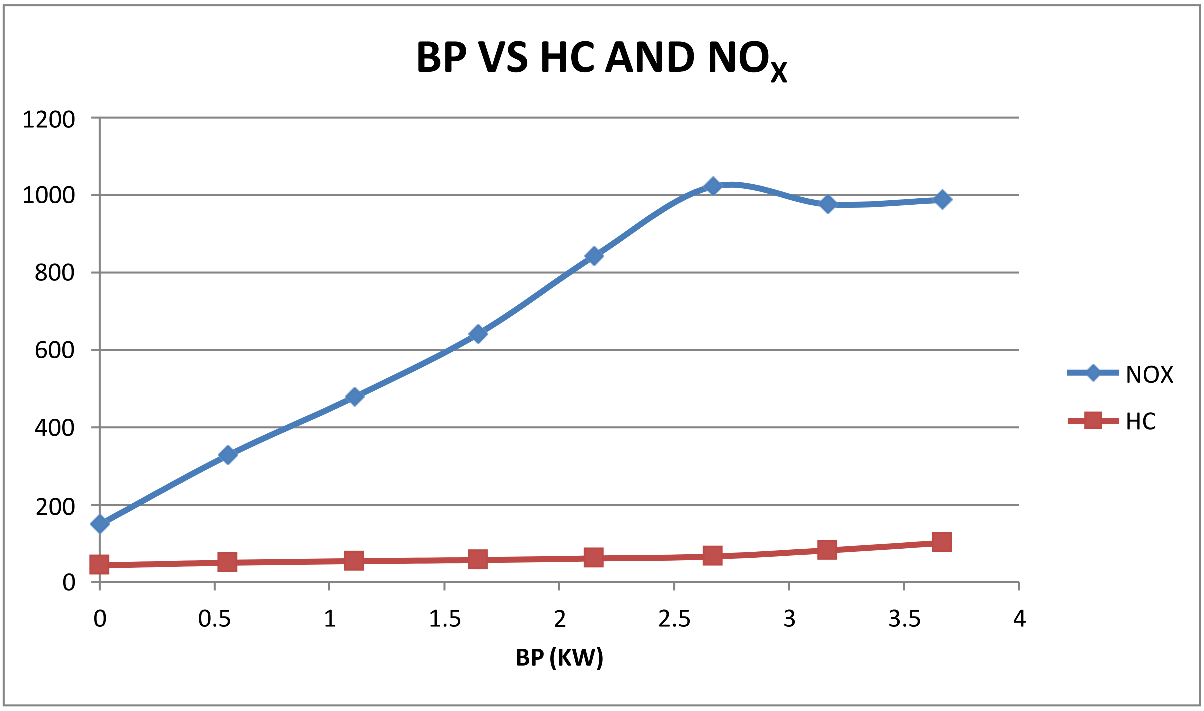

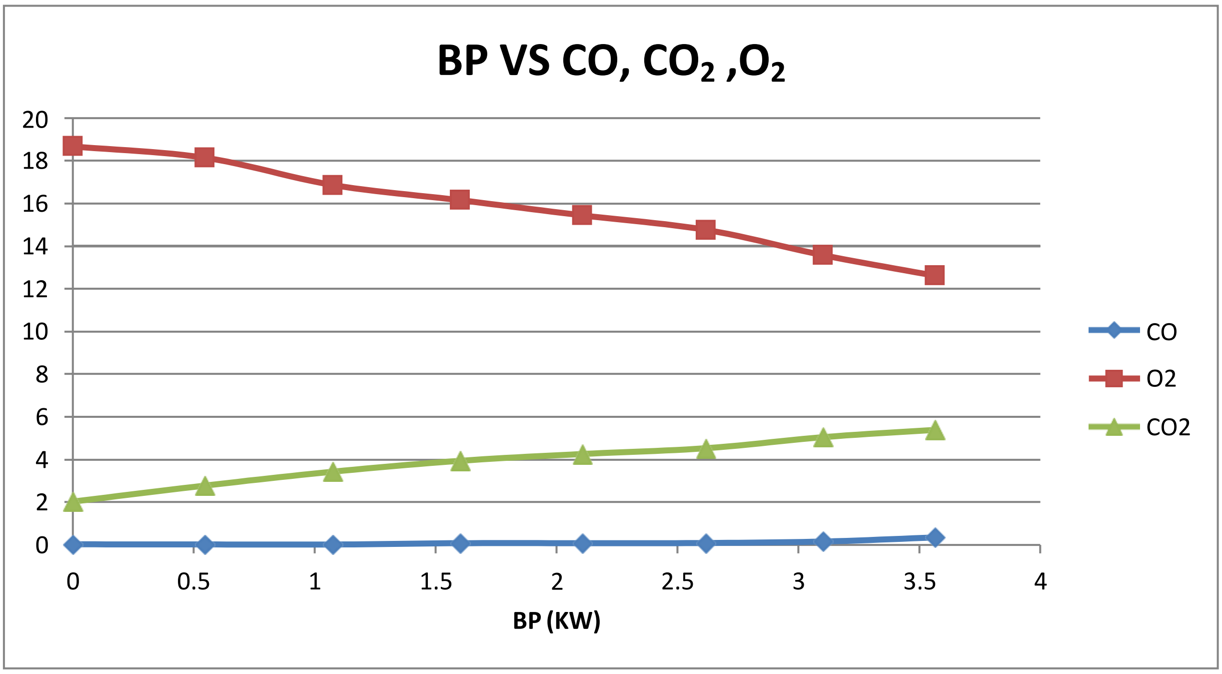

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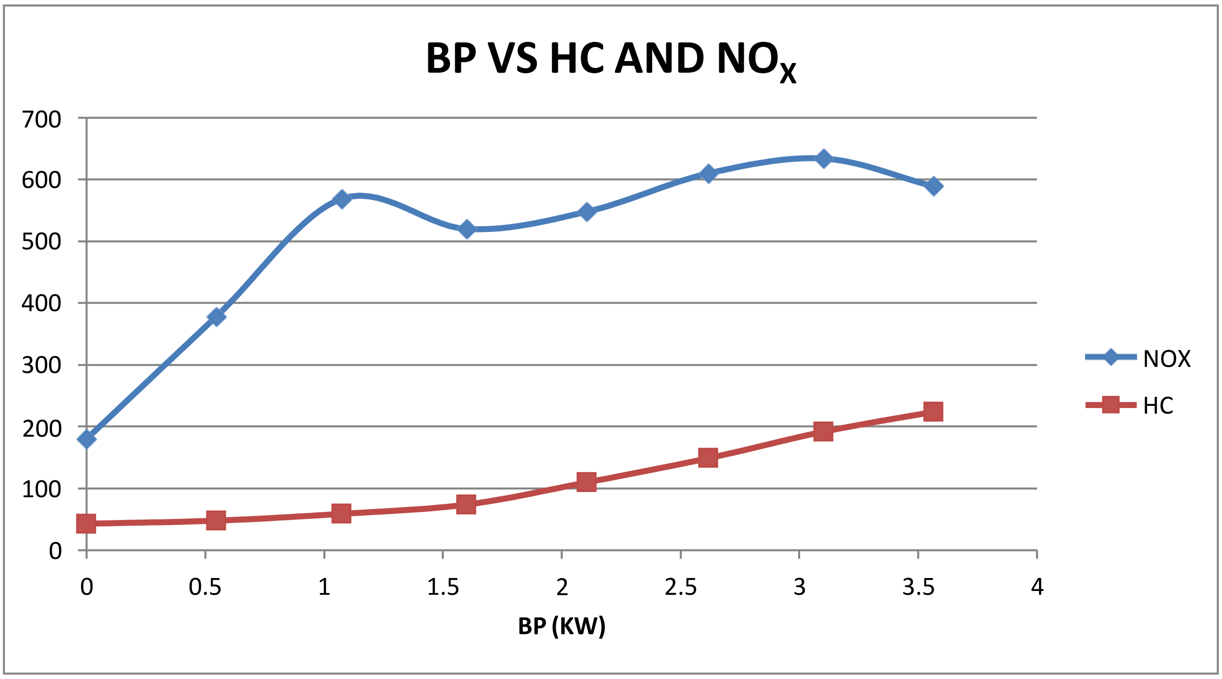

5.0 CONCLUSION

The experiments have been carried out on kirloskar diesel engine with different nozzles and the following conclusions are drawn.

- At 180, 200, 220 and 240 bar of fuel injection pressures, the mechanical efficiency is high for 5-hole nozzle compared to 3 and 4-hole nozzles. This is due to power loss in the mechanical components of the engine and it directly effect the mechanical efficiency.
- Brake specific fuel consumption is high for 5-hole nozzle at 180, 200, 220, and 240 bar fuel injection pressures, when compared to 3 and 4-hole nozzles. Because more mass of fuel is injected into combustion chamber
- Indicated and brake Thermal efficiency is high for 4-hole nozzle when compared to 5 hole nozzle at 200, 220, 240 bar fuel injection pressures. Because of proper combustion in the combustion chamber for corresponding pressures.
- At 180 and 200 bar of fuel injection pressure NO$_x$, HC and CO emissions are less for 5-hole nozzle compared to 3 and 4-hole nozzles, because of high specific fuel consumption and incomplete combustion.
- At 220 bar pressure for 4-hole nozzle HC emissions are high at no load compared to HC emissions of 5-hole nozzle at

full load, because of idling engine release high emissions than engine is at load condition.

- At 240 bar fuel injection pressure for 5-hole nozzle CO emissions are increased from part load to full load and for 4-hole nozzle emissions increased from no load to part load, due to in complete combustion.

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