Performance and Emission Analysis of Four Stroke Diesel Engine by Varying its Fuel Injection Nozzle Holes on a VCR Engine

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Abstract:- **Variable Compression Ratio Engine test rig is used to determine the effect of Compression Ratio on the performance and emission of the diesel engine. Fuel injection plays an important role in diesel engine performance for proper combustion. The performance and emission characteristics of diesel engine depends on many parameters. An experimental study was conducted on a light duty DI diesel engine at three and five hole fuel injection to study its performance and emission by using conventional diesel fuel on the single cylinder four stroke engine, where the engine works at different engine loads at various compression ratio 14,15,16. Future emission regulation will require substantial reduction of NO_x and CO_2 emission from diesel engines. At compression ratio 15 emission of both three and five nozzle holes was found to be same. Important parameters governing these are droplet size, distribution concentration and injection velocity. Smaller orifices are believed to give smaller droplet size, with increase injection nozzle hole, which leads to better fuel atomization, faster evaporation and better mixing. The performance and emission characteristics of the diesel engine were presented evidently that they were found better with three hole nozzle by means of varying compression ratio for the light duty engine.**

Keywords: Fuel Injector, Nozzle Holes, Performance and Emission Characteristics ofCI Engine, VCR.

1. INTRODUCTION

The four stroke direct injection diesel engines are the primary source for the light, medium and heavy duty applications which is widely used in agriculture and transportation sectors. Diesel engines provides high fuel efficiency, reliability and durability. The term Compression ratio is introduced to obtain performance and emission characteristic of a diesel engines. In the diesel engine the minimum compression ratio that can be used is governed by the ease of engine cold starting ability. For the high speed direct injection engines compression ratio of around 16:1 is used. The turbo charged heavy duty engines employ compression ratio in the range of 13 to 14:1. Cold starting requirements prevents further reduction in the compression ratio. Use of compression ratio results in a shorter ignition delay period. A shorter delay would results in less over mixing of fuel and air and hence, lower hydro carbon emission. Further the higher combustion temperatures obtained at a higher compression ratios tends to increase oxidation of the unburned hydro carbon. At a low compression ratio, a longer delay increases the fraction of fuel burned during the premixed phases resulting in higher peak pressures and temperatures which causes an increase in NO_x formation. On the other hand, increase in compression ratio due to higher combustion temperature which tends to increase formation of NO_x. If the ignition delay is too long, the combustion may begin in the expansion stroke reducing combustion pressure and temperature.For obtaining low particulate and NO_x emissions simultaneously, an optimum compression ratio is to be used. The compression ratio depends on fuel injector. 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 produced smaller droplets [1]. In this work the effect of fuel compression ratio and fuel nozzle holes are experimentally studied on performance and emission characteristics of single cylinder light duty direct injection diesel engines.

2. EXPERIMENTAL SETUP AND PROCEDURE

An experimental rig is developed to undertake the thermal performance evaluation and emission characteristics evaluation of a variable compression ratio compression ignition engine fuelled with diesel oil. The experimental test rig is suitably developed to conduct various test runs under different working conditions to evaluate the thermal performance and emission constituents of a diesel run engine in comparison with that three hole and five hole injector nozzle of an engine. The experimental test rig consists of a variable compression ratio compression ignition engine, eddy current dynamometer as loading system, fuel supply system for diesel oil supply, water cooling system, lubrication system and various sensors and instruments integrated with computerized data acquisition system for online measurement of load, air and fuel flow rate, instantaneous cylinder pressure, injection pressure, position of crank angle, exhaust emissions. Table 1 gives the technical specifications of different components used in the test rig. The setup enables the evaluation of thermal performance and emission constituents of the VCR engine Commercially available lab view based engine. Performance analysis software package-En evaluation. The exhaust emission of the engine are analyzed using an exhaust gas analyzer. The constituents of the exhaust gas measured are CO (% and ppm), CO_2(%), O_2(%), HC(ppm), NO_x(ppm) and SO_2(ppm).

TABLE 1: TECHNICAL SPECIFICATIONS OF EXPERIMENTAL TEST RIG

Type	Single cylinder, Four stroke, Water cooled, Diesel
Number of cylinder	one
Rated power	3.5 Kw at 1500 rpm
Bore and stroke	87.5mm and 110mm
Combustion principle	Compression ignition
Cubic capacity	0.661 liters
Compression ratio	17.5:1 (modified to work at 14, 15 ,16)
software	Engine soft LVI engine
Rota meter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH

COMMERCIAL SOFTWARE – ENGINESOFTLV

Lab view based engine performance anal is used for the on line performance evaluations. Engine soft LV can serve most of the engine testing application needs including monitoring, reporting, data entry, data logging. Software evaluates power, efficiencies, fuel consumption and heat release. It is configurable as per engine setup. Various graphs are obtained at different operating conditions. While online testing of an engine is in RUN mode necessary signals are scanned, stored and presented in the form of graphs. Stored data file is accessed to view the data graphical and tabular formats. Fig. 1 represents the emission characteristics using AVL DIGAS 444, five gas analyzer.

FIG. 1: EMISSION CHARACTERISTICS ON AVL DIGAS 444

3.RESULTS AND DISCUSSION

EFFECT ON BRAKE THERMAL EFFICIENCY (BTE)

Effect of nozzle hole geometry for three and five hole nozzle on brake thermal efficiency is shown in Fig. 2 and Fig. 3 respectively. It was found that compression ratio influences the brake thermal efficiency. From Fig. 2 and Fig. 3 at corresponding compression ratio 14 it was noticed that there is rise in thermal efficiency with increase in nozzle hole. This rise is due to increase in nozzle hole was responsible to rise in air fuel mixing, fuel vaporization, improved combustions and while applying various load the compression ratio is decreased.

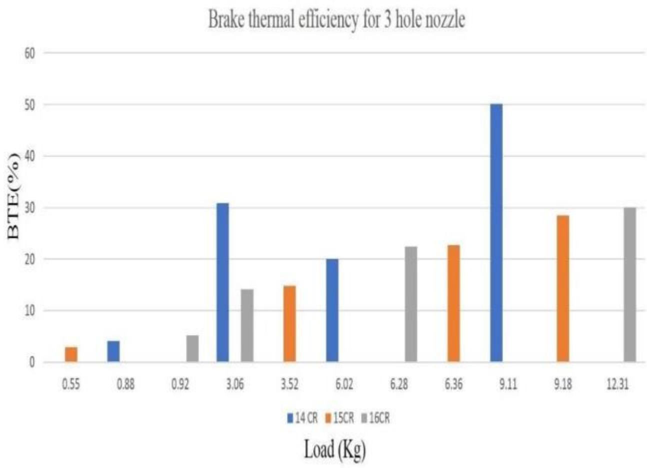
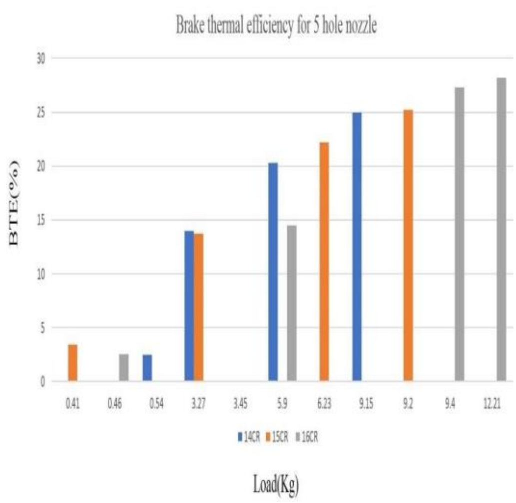


FIG. 2: BTE(%) VS LOAD (KG) FOR THREE HOLE NOZZLE

EFFECT ON INDICATED THERMAL EFFICIENCY (ITE)

Effect on nozzle hoe geometry for three and five hole nozzle on indicated thermal efficiency is shown in Fig. 4 and Fig. 5 respectively. It was noticed that rise in thermal efficiency with increase in nozzle hole. From the Fig. 4 and Fig. 5 at corresponding compression ratio 14 say increase with decrease in three hole nozzle and compression ratio 16 say decrease with increase in five hole nozzle.

FIG. 3: BTE(%) VS LOAD(KG) FOR FIVE HOLE NOZZLE



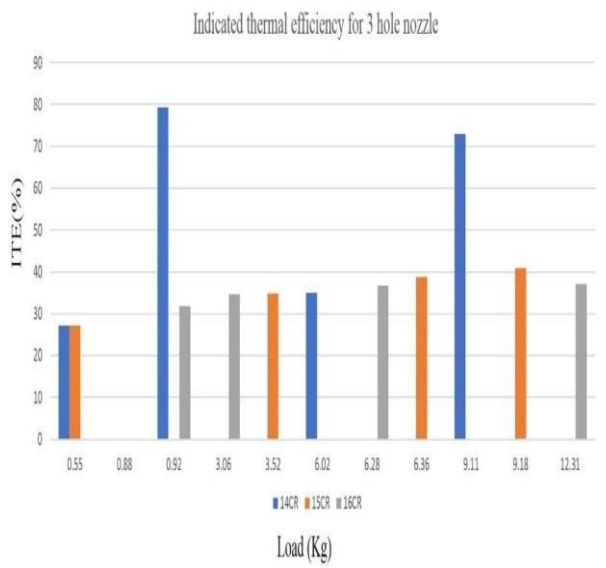


FIG. 4: ITE(%) VS LOAD (KG) FOR THREE HOLE NOZZLE

EFFECT ON MECHANICAL EFFICIENCY (MECH EFF)

Effect on nozzle hoe geometry for three and five hole nozzle on mechanical efficiency is shown in Fig. 6 and Fig. 7 respectively. It was found that nozzle hole geometry has rise in mechanical efficiency with decrease and increases in three hole fuel injector at compression ratio 14 and at compression ratio 16 there is decrease with increase in a five hole injector**.**

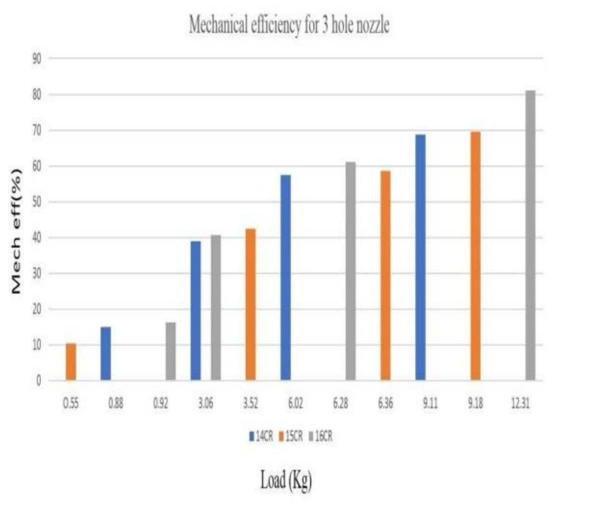


FIG. 5: MECHANICAL EFFICIENCY VS LOAD FOR FIVE HOLE NOZZLE

EMISSION CHARACTERISTICS

EMISSION CHARACTERISTICS FOR THREE HOLE NOZZLE

Compression Ratio	CO (%)	HC (PPM)	CO_2 (%)	O_2 (%)	NO_x (PPM)
CR 14	0.166	139	6.54	11.61	22
CR 15	0.145	123	6.43	11.67	22
CR 16	0.144	98	2.57	17.06	16

EMISSION CHARACTERISTICS FOR FIVE HOLE NOZZLE

Compression Ratio	CO (%)	HC (PPM)	CO_2 (%)	O_2 (%)	NO_x (PPM)
CR 14	0.338	181	2.74	16.98	15
CR 15	0.299	160	6.75	11.36	22
CR 16	0.185	141	6.68	11.49	23

CONCLUSION

The brake thermal efficiency for three hole and five nozzle at maximum load was found increased at compression ratio 14 and 16. The indicated thermal efficiency for three hole nozzle at compression ratio 14 is increase with decrease and five hole nozzle at compression ratio 16 is decrease with increase. Mechanical efficiency for three hole nozzle at compression ratio 14 decrease with increase and five hole nozzle at compression ratio 16 was noticed decreases with increase. At present scenario environmental protection is more important than fuel economy. So decrease in emission is the primary concern which required moderate injection nozzle hole for a light duty diesel engine hence we can conclude that three hole nozzle is better than five hole nozzle.

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