Optimization of Inlet and Exhaust Manifold on a Single Cylinder Diesel Engine to Enhance the Combustion

V. V. Naga Deepthi, K. Govinda Rajulu

Abstract— In the internal combustion Diesel engines the most important subsystem is Intake manifold and Exhaust manifold. In the intake manifold which supplies fresh air –fuel mixture in to the cylinders where combustion takes place at high temperature and high pressure. After exhaust gases scavenged through valves from the cylinders, these gases past exhaust manifold an outlet, through which the gases flow into exhaust pipes from there to the emission control equipment of engine which consists of catalytic and thermal converters. The development of swirl can be enhanced by re-designing of inlet port of an Engine. There is further development in the swirl due to combustion process to another maximum part way in to the power stroke. Swirl can promotes the combustion process in a better way and causes efficiency increase. Better mixing of air – fuel there is a little bit changing the inlet and exhaust valve. Valve stem diameter is 9.5mm, Inlet valve diameter is 36mm, Exhaust Valve diameter is 28mm by varying the pitch 1.0mm to 2mm and thread depth of cut as 4mm and three thread per inch from this arrangement to investigate the performance by enhancing the swirl of air flow to get betterment in the performance and decrease in emissions in a (DI) direct injection diesel engine with single cylinder when compared with normal engine.

Keywords: : Diesel Engine, Inlet Manifold, Exhaust Manifold, Swirl motion.

1. LITERATURE REVIEW

In this system the diameter and position of exhaust valves are modified to control the chances of knock in SI and CI engines. Due to small dimensions of the exhaust valve, dilution of charge reduces with comparison to size of the inlet valve. This is due to the high temperature occurred near the exhaust valve with comparison to that of surrounding temperature near to the inlet valve. With increase in the size of exhaust, valve there is a possibility of increase in knock as charge entering into chamber will have higher tendency of combustion over exhaust valve surface. On the other hand with the decrease in the size of exhaust valve, causes higher tendency in the dilution of the charge as there is less space for the exhaust gases to leave the chamber. In order to minimize the problems, engine modifications should be done. Normally in IC engines, the exhaust and inlet valves are placed vertically in the combustion chamber. Now place the exhaust valve perpendicular to the cylindrical axis and increase the valve size, then there will be less tendency for dilution which also causes increase in knocking as the valve is placed along the horizontal axis.

As the outlet valve is positioned in-line with horizontal axis, the external surface of outlet valve will be in contact with water cooling system of the combustion chamber. Thus in the water cooling system the coolant will release the heat at the external surface of the outlet valve and transfers heat from the seat surface of the outlet valve. As the surface area is perpendicular to the direction of the heat flow the rate of heat transfer will be more. When the piston moves from BDC to TDC, burnt gases leaves through the exhaust valve. Due to the low density, with high temperature, the burnt gases escape easily in the combustion chamber. By the process of scavenging we can remove the unburnt gases from the cylinder. Changing the valve seat materials, increases the rate of heat transfer. As the heat transfer rate increases, density increases without affecting the performance of the engine. As the size of the exhaust valve is increased, the amount of air moving through exhaust per stroke increases. Increased velocity is used for the turbocharger for the improvement of the overall efficiency.

In I.C engines, the different components perform different functions such as thermal loadings, stresses and different forces. The main components of the diesel engine are inlet and exhaust valves. The air enters into the combustion chamber, through inlet valve and the valve mechanism is controlled by means of the exhaust gases. Due to high temperature and high pressure, both the valves are subjected to thermal loading. This paper mainly focuses on the failures in thermal loading, wear, corrosion, erosion, fatigue, engine performance which is caused by inlet and exhaust valves.

In I.C engines the C.I engines plays major role in power generation, propulsion and energies. This paper aims in the improvement of the engine performance by changing the inlet manifold and reducing the fuel consumption and in reducing emissions. The present automobiles should follow some rules for creating the good environment. The parameters considered are combustion ratio, injection pressure of the fuel, compression ratio, designing of the combustion chamber and intake temperatures. This work

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mainly focuses on the inlet manifold orientation of different types affecting the engine performance and its parameters. The major problem is the mixture of air and fuel which is not homogeneous. The movement of air in the cylinder is the major cause for the distribution and atomization of the fuel inducted into the combustion chamber. Based on the literature survey, it is infer that the varying of flow field structure of in-cylinder, will affects the characteristics of the engine such as performance and emissions.

2. INTRODUCTION

Growing of energy sources, leads to development in the energy conversion machines and systems. Researchers have put their efforts to enhance the performance of engine by minimizing exhaust emissions and fuel. As a most energy efficient conversion machine, the diesel engine is used for many applications. The major factor is motion of air in the cylinder which causes better fuel-air mixing in engines which effects performance of engine and emissions. Swirl motion of air is based on the design of the inlet and exhaust manifolds, configuration of the combustion chamber. Initially the pattern of intake air flow is set up by the intake process then in compression process modifications can be done. During the intake system, in diesel engine, by changing the shape of the bowl, we can manage intensity of turbulence and mixing of air-fuel. The variation of shape leads to change in flow inside the engine. Variation in shape of intake arrangement, piston cavity shape , etc., makes to a change in the flow inside the engine.

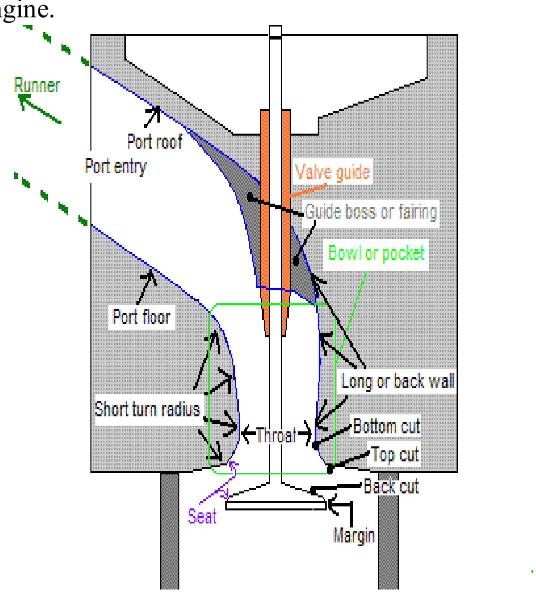

Fig 1: Valve elements of the body of Inlet and Exhaust

The output shaft of the engine is connected with Eddy Dynamometer with a stator over which many number of electromagnets are fitted with a rotor manufactured from of steel or copper. The rotation of rotor produces current in the stator because, the field current developed in the electromagnets due to passage of field current. This dynamometer requires some cooling requirements because eddy currents will dissipate heat during its production. As in the other common type of dynamometers the torque will be measured from moment arm and load can be regulated by controlling the power in electromagnets.

3. TECHNICAL SPECIFICATIONS OF THE ENGINE

Table1: Specifications of Engine

1.Name of engine type	Four Stroke Single cylinder Diesel engines
2. Engine capacity	5 kW (kilo Watt)
3. Fuel capacity	10 cc (Cubic Centimeters)
4. Speed	1500 rpm (revolutions per minute)
5. Current (volts)	230 V (Volts) single phase generator
6. Loading unit	Eddy Current Dynamometer
7.Diameter of the bore	0.095m
8: Length of the cylinder and bore	0.110m &0.080m

4. PROCEDURE

The manner adopted during this work is changing the size of the recess and valve stem diameter is 9.5 mm, Inlet valve diameter is 36mm , Exhaust Valve diameter is 28mmand taking the pitch 1.0mm to 2mm and thread depth of cut as 4mm and 3thread per inch. from this arrangement to research the performance by enhancing the air swirl to attain betterment in engine performance and emissions in a very direct injection (DI) single cylinder internal-combustion engine and compared with the standard diesel engine. The dimensions of an recess valve is more than valve, as a result of recess air (or) fuel air mixture has less pressure as compared to exhaust gas. Once the ability stroke the exhaust gas within the engine cylinder has additional pressure and temperature and gases are ready to leave in to the combustion chamber. The ability of the engine is measured by the Eddy current dynamometer that's not to mention engine and engine exhaust emissions area unit measured by gas analyzer at completely different load. This analysis work presents how to increase the swirl motion and turbulence within the recess valve and ICE performance and their emission characteristics.

Fig2: Intake and Exhaust valve Pitch diameter 1mm,1.5mm, 0.2mm

5. RESULTS AND DISCUSSION

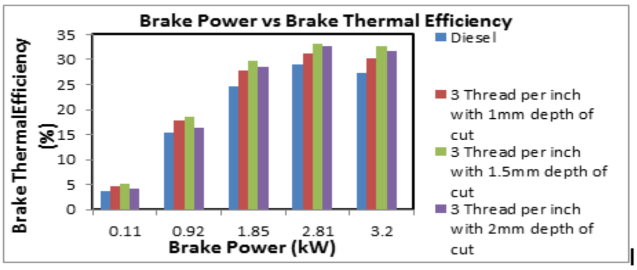

Fig 3: Variation of Brake Power Vs Brake Thermal Efficiency

The contrast of BTHE (brake thermal efficiency) along with power in different variations are represented in Figure 3, for usual engine at 3/4 load it is 28.94%. It was observed that, variations in inlet as well as exhaust valve diameters with 1mm,1.5mm,and 2mm depth of cut for 3 threads per inch give thermal efficiencies of 31.25%, 33.12% and 32.67%, at 3/4 load. Figure is showing that the BTHE (brake thermal efficiency) is increasing with respect to brake power for various configurations. It also noticed that there is a gain of 14.4% provided three threads per inch with 1.5mm depth of cut is contrasted with normal engine. This might be because of the upgraded air whirl in the ignition chamber which brought about better blending of fuel and air and just as complete burning of the charge in the ignition chamber.

Brake Specific Fuel Consumption:

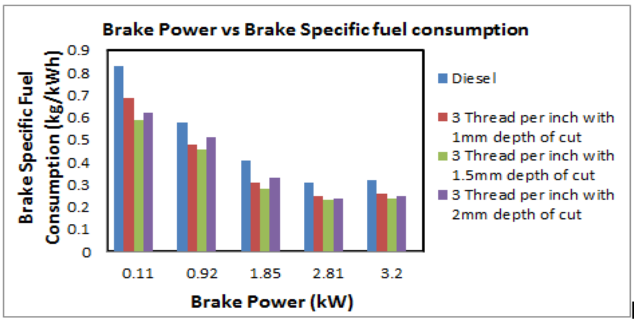

Fig 4: Variation of Brake Power Vs Brake Specific Fuel Consumption

The varieties of BSFC(brake specific fuel consumption) with brake power for various arrangements are appeared in Figure 4. For typical engine at 3/4 of evaluated load is 0.31 kg/kW-hr. It very well may be seen that the 1mm, 1.5mm, and 2mm of cut the values are 0.25kg/kW-hr 0.23 kg/kW-hr and 0.24 kg/kW-hr individually, at 3/4 of evaluated load. From fig 4, it is demonstrated that it is expanding with an expansion in brake control for arrangements that are under thought. It is likewise seen that the 1.5mm has the most reduced fuel utilization of 25.8% when contrasted and ordinary motor. This is because of the fast and complete burning of the charge in the ignition chamber by the upgraded air swirl.

Exhaust Gas Temperature:

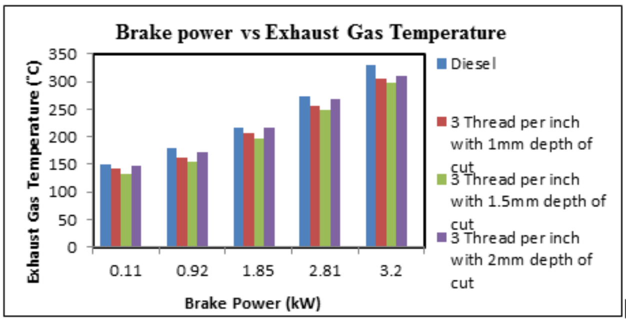

Fig 5: Variation of Brake Power Vs Exhaust Gas Temperature

The variety of EGT(Exhaust gas Temperature) with brake Power for various design is appeared in the fig 5. This is for 1.5mm profundity of cut is 247.90Ccompared with the ordinary diesel engine at ¾ burden is 273.30C. Lower fumes gas temperature for 1.5mm profundity of slice can be credited because of higher disturbance made in the ignition chamber. It is seen that there is a 9.2 %decrease of for1.5mm profundity of cut with typical motor.

Hydro Carbon Emissions:

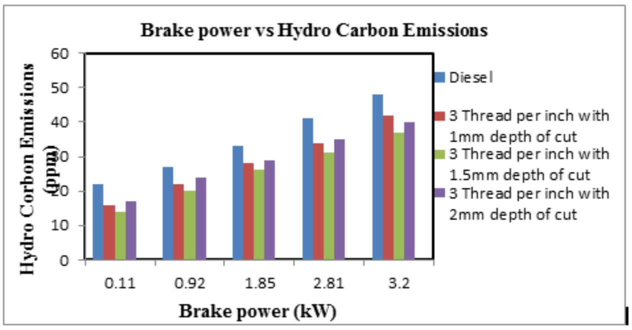

Fig 6: Variation of Brake Power Vs Hydro Carbon emissions

The correlation of Hydrocarbon emissions in exhaust gas is appeared in Fig 6. Un-consumed hydrocarbon emanation is the immediate consequence of fragmented burning. It is clear that the hydrocarbon emanation is diminishing with the expansion in the choppiness, which results in complete ignition. At 3/4 of the evaluated burden with three strings for each inch at 1.5mmdepth of cut gives most extreme decrease of hydrocarbon outflow level is watched and is about 31% contrasted with ordinary motor at 41%. It is likewise seen that with1.5mm profundity of cut the decrease in hydrocarbon levels is about 24.4% contrasted with typical motor.

Carbon Monoxide Emissions:

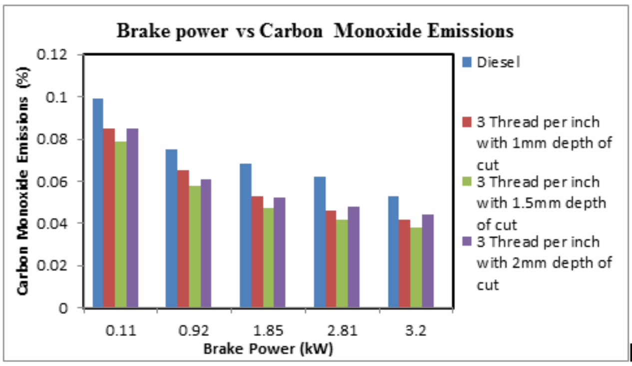

Fig 7: Variation of Brake Power Vs Carbon Monoxide emissions

Fig7. Demonstrates the examination of Carbon monoxide outflow with brake control. For the most part, C.I engines work with lean blends and consequently the CO outflow would be low. With the higher turbulence in the burning chamber, the oxidation of carbon monoxide is improved and which lessens the CO emanations. The least carbon monoxide outflow is with 1.5mm profundity of sliced arrangement 0.042% when contrasted with typical motor is about 0.062% at 3/4 of appraised load. It is likewise seen that with 1.5mm profundity of cut the decrease in CO levels is about 32.2%at 3/4 of evaluated load when contrasted with typical motor.

Nitrogen Oxide Emissions:

Fig8. Demonstrates the examination of Nitrogen oxide outflow with brake control. The measure of created NOx is an element of the most extreme temperature in the chamber, oxygen focuses, and living arrangement time. A large portion of the discharged NOx is framed from the get-go in the ignition procedure, when the cylinder is still close to the highest point of its stroke. This is the point at which the fire temperature is the most elevated. The higher Nitrogen oxide discharge is with 1.5mm profundity of cut design is 1000ppm when contrasted with typical motor is about 792ppm at 3/4 of evaluated load. It is additionally seen that with 1.5mm profundity of cut increment in the nitrogen oxide emanation levels is about 1000ppm at 3/4 of evaluated burden is 26.2% when contrasted with typical motor.

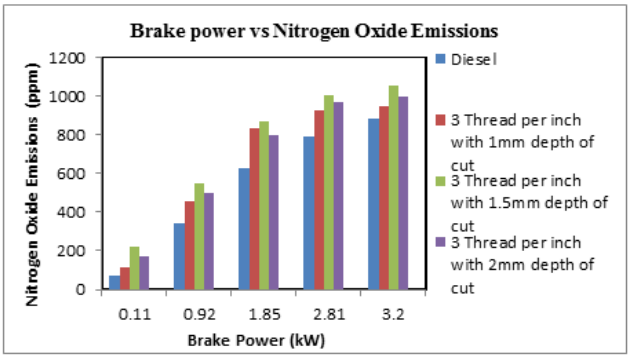

Fig 8: Variation of Brake Power Vs Nitrogen Oxide emissions

5. RESULTS AND CONCLUSIONS

The following results are drawn based on the effect of air swirl in the cylinder:

- The brake thermal efficiency of three threads per inch with 1.5mm depth of cut is increased by about 14.4 % when compared to normal engine at 3/4 of the rated load.
- The improvement in brake specific fuel consumption of three threads per inch with 1.5mm depth of cut is about 25.8% when compared normal engine at 3/4 of the rated load.
- The exhaust gas temperature with three threads per inch with 1.5mmd depth of cut is minimum than any other and at 3/4 rated load, it is 9.2% less than normal engine.
- The maximum reduction in HC emissions for three threads per inch with 1.5mm depth of cut is about 24.4% at 3/4 of the rated load compared to normal engine.
- The carbon monoxide emissions for three threads per inch with 1.5mm depth of cut are found to be reduced by about 32.2%.
- The maximum risen NOx emissions for three threads per inch with 1.5mm depth of cut is about 26.2% at 3/4 of rated load compared to normal engine

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