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An Analysis on Effects of Performance, Combustion and Emission for Various Intake Flow in a DI Diesel Engine

K.Raj Kiran*[a], C.G.Saravanan[a], and Edward James Gunasekaran[a]

[a]*Department of Mechanical Engineering, FEAT, Annamalai University, Chidambaram, India.*

Abstract:-*The aim of work is to design of inlet manifold for the DI Diesel engine in order to create the turbulence for better mixing of air and fuel mixture. The Inlet Manifold was modified by inclining at 90^o inclination perpendicular to the Normal inlet manifold within the cylinder head of DI engine. The experiment was carried out on a stationary direct injection Diesel engine with and without modified inlet manifold condition for modified inlet open as well as air induction through both the openings. The results shows an increase in 1.87% in the brake thermal efficiency of the engine for modified condition, the NOx level reduced by 57.6% for the modified condition whereas there is increase in HC and smoke density by 21.2% and 4.65% respectively. Reduction in pressure and heat release was also found in the modified inlet manifold condition.*

Keywords- *Manifold Modification, IC engine Design, Emission, average cycle pressure,*

1. INTRODUCTION

The advancement of industrialization and automobiles has resulted in incredible progress but have led to a serious impact on the environment. Automobile emission by fossil fuel combustion engines, whether it is compression Ignition or Spark Ignition has an great impact on the quality of air around us which has exaggerated both the environment and human health. The incomplete combustion of fossil fuel within the vehicle engine causes the emission of unburned hydrocarbon (HC), Smoke and Particulate emission. Flow of air in the course of the manifold and mixing of the fuel with air inside the cylinder is additional important in the case of diesel engine because these factors, openly affect the combustion performance, and emission levels of the engine. Control of flow through the manifold is critical for meeting the emission policy and fuel economy needs. Parameters like engine speed, manifold and combustion chamber configuration directly control the swirl in DI diesel engines and subsequently, it plays a vital role in mixing air and fuel inside the cylinder. Optimization of swirl becomes an vital aspect in the design of intake systems of diesel engines. In-cylinder flow field structure in an internal combustion engine has a major influence on the combustion, emission and performance characteristics. Fluid flows into the combustion chamber of an I.C engine through the intake manifold with high velocity. Then the kinetic energy of the fluid resulting in turbulence causes rapid mixing of fuel and air, if the fuel is injected directly into the cylinder. With optimal turbulence, better mixing of fuel and air is possible which leads to effective combustion. To create an effective swirl velocity, the engine head has been modified for the angle of 30o perpendicular to that of the normal inlet manifold. In general, the presence of a swirl in the cylinder of an internal combustion engine improves the homogenization of the air - fuel mixture, and consequently, enhances fuel combustion. The aim of this work is to analyse the effect of the swirl on the combustion and emission by modifying the inlet manifold. the effect of the fuel injection pressure on performance and emission of the single cylinder diesel engine at [2] different intake manifold inclinations. The manifolds were manufactured with angle 90° w.r.t. normal manifold and a normal intake manifold. In the investigation, they studied the effects of injection pressure on the performance and emission of the engine, in fixed engine speed-variation engine loads and the fuel injection pressures were setting at 160,180 & 200 bar turn by turn. It was found that at 60° intakes manifold inclination, at 180 bar gives the maximum brake thermal efficiency and also emission levels were considerably reduced. [3] Generating a significant swirl and/or tumble motion inside the engine cylinder during the intake process was one of the promising ways to obtain high in-cylinder turbulent intensity. Way of complete combustion and reduced excess air supply, [4] it increases the thermal efficiency of the engine. In other words, reduces specific fuel consumption of the engine. [5] has stated that Air motion in CI engine influences the atomization and distribution of fuel injected in the combustion chamber and also supplies fresh air to the interior portion of the fuel drops and thereby ensures complete combustion. By way of complete combustion and reduced excess air supply, it increases the thermal efficiency of the engine. In other words, reduces specific fuel consumption of the engine. [8] studied the effect of cylinder swirl patterns along the cylinder axis obtained during early compression, on bowl flow velocities and generated turbulent kinetic energy at TDC. The operating speed for the simulation was fixed at 900 rpm, which is typical of idling speeds. For a fixed averaged cylinder swirl ratio, axial stratification of swirl with higher magnitude located near the piston surface at early compression (55° BTDC) results in high magnitude of swirl and turbulent kinetic energy inside the piston bowl near compression TDC. [10] stated that swirl is generated in the inlet manifold by inserting a loop inside the intake manifolds to increase the swirling in the air during induction[15] air intake system and filter play major role in getting good quality air into automobile engine.

2. ENGINE DESIGN

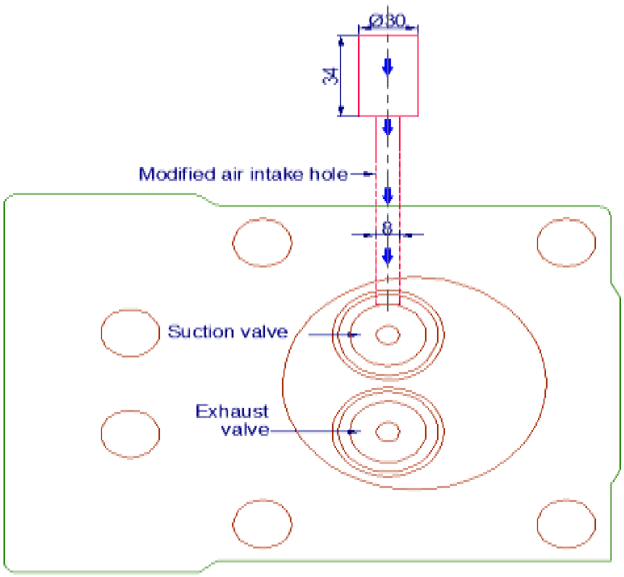

Fig.1. Modified manifold of 90°

Fig.1.shows the top view of the engine head, where the engine inlet of the air is aspirated through the inlet manifold at angle of 90o normal to that of the normal inlet manifold.

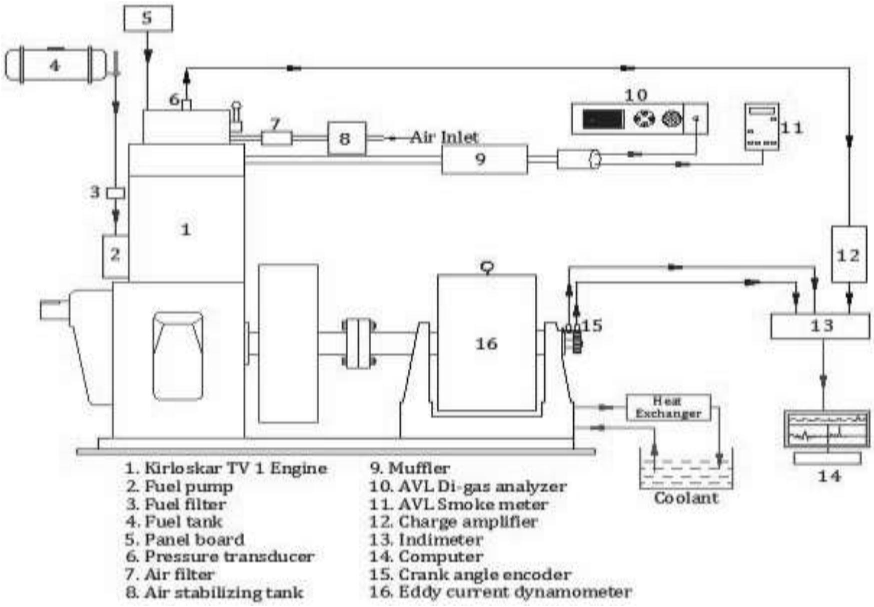

Fig.2. Experimental Setup of DI Diesel Engine

Fig.2. layout of the engine assembly and measuring devices

Engine	Kirloskar-TV1, Vertical, water cooled, DI diesel Engine
Bore	87.5mm
Stroke	110 mm
Compression ratio	17.5:1
Rated brake power	5.2 kW @1500 rpm
Injection timing	23o BTDC
Maximum injection pressure	210 bar
Combustion chamber type	Hemispherical Combustion Chamber (HCC)

Table.1. Engine specifications

3. EXPERIMENTAL SETUP

A single cylinder, four strokes, naturally aspirated, water cooled, D.I. engine was used to carry out experimental investigations. The experimental set-up consists of a Single Cylinder 4 - Stroke Diesel Engine along with several measuring instruments such as AVL DI gas analyser and AVL Smoke Meter. The engine is coupled to an Eddy current dynamometer. Necessary provisions were made to measure the flow rates of fuel and air flowing into the engine cylinder. The specification of the engine is shown in table. 1.

4. METHODOLOGY

The engine was first tested with Normal Intake Manifold and diesel as fuel for 10 minutes before each set of reading was taken to get stabilization. The load on the engine is varied from no load to 20%, 40%, 60%, 80% and maximum load condition. The engine speed was kept constant for the each set of readings to be taken through fuel control lever. The readings were taken at the speed 1500 rpm for each loading condition. Then, the orientation of the standard manifold was changed by inclining the manifold 90o perpendicular to the Standard intake manifold and this experimentation was carried out for modified as well as both side open of 90o.

5. RESULTS

5.1 Brake Thermal Efficiency

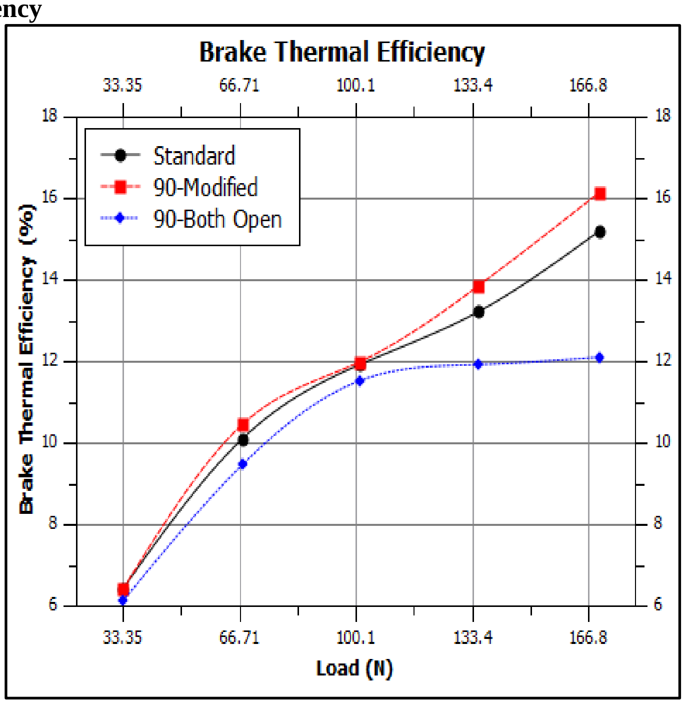

Fig.3 Brake thermal efficiency

Thermal efficiency is the exact sign of that the efficiency with the chemical energy input in the form of fuel which is converted into useful work. Figure.3 shows the effect of brake power on brake thermal efficiency. It is seen from the graph that when load increases brake thermal efficiency also gradually increases. This is due to the increase in brake power; when brake power increases, the heat generated in the cylinder increases and increases the thermal efficiency. It was observed from the graph that inlet of 90o with modification show higher brake thermal efficiency at all load conditions compared to that of standard manifold and modified manifold with both open condition. The variation of the brake thermal efficiency was from 6.3% at low load to 16.452 % at full load for 90o with modification. 90o both open manifold varied from 6.12% at low load to 12.18% at full load. This was 3% lower than that of the standard manifold in the full load.

5.2. Specific Fuel Consumption

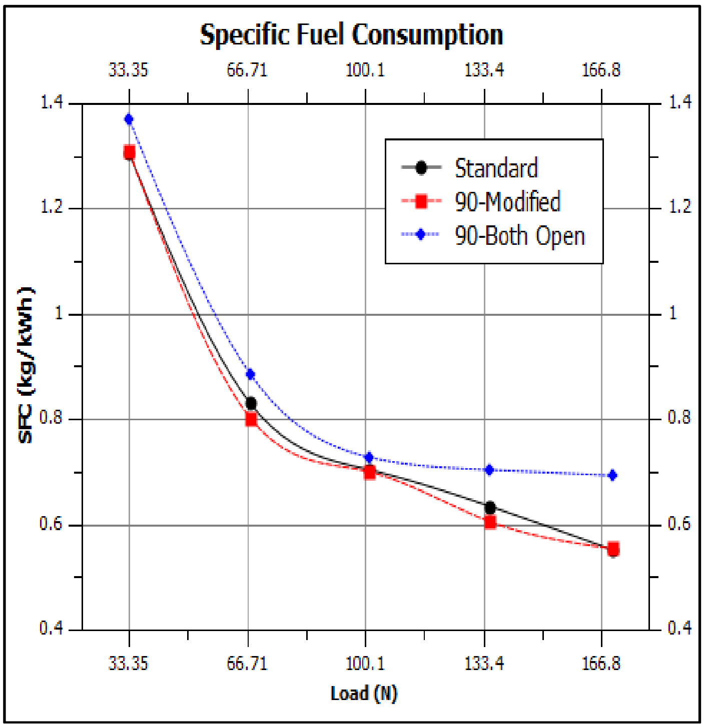

Fig.4. Specific fuel consumption

The variation in specific fuel consumption with brake power for standard and modified manifolds presented in the figure 4. As the load increases the cylinder wall temperature increases, which becomes more favourable for shortening the ignition delay and thus reduces the specific fuel consumption. It was observed from the graph that the specific fuel consumption for standard cylinder head was lesser than that of modified cylinder heads. For standard cylinder head, there was a 8.1 % reduction in the specific fuel consumption when compared to the modified manifold of 90o at full load.

5.3. Smoke Density

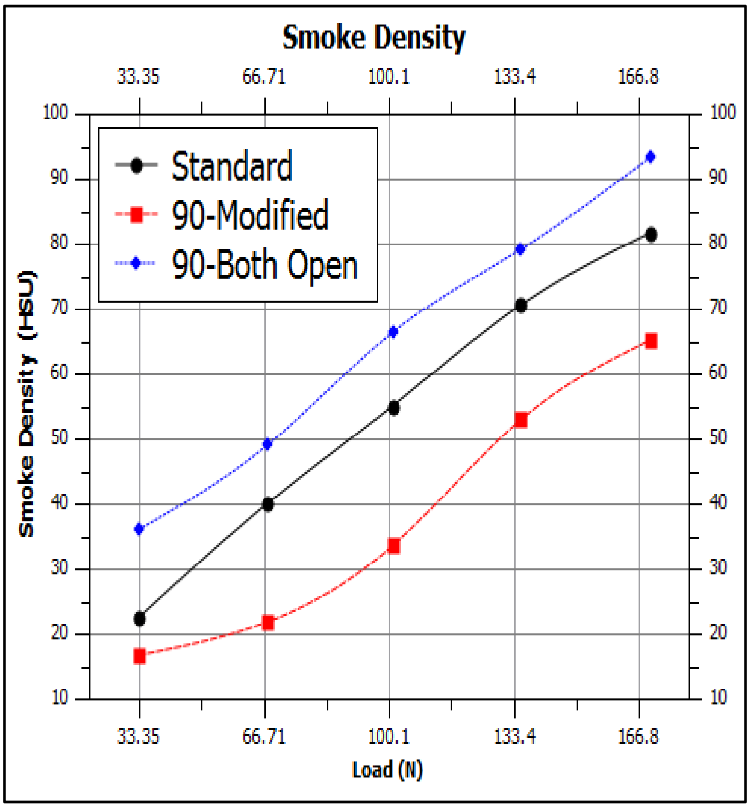

Fig.5. Smoke Density

Smoke emission is generally correlated with soot formation and is associated with low combustion temperature and with incomplete combustion in the cylinder [12,13]. The variation of the smoke emission with brake power is presented. The smoke emission increases with an increase in engine loads. The amount of fuel per unit time increases as load increases and consequently smoke emission increases. Fig.5 shows the smoke density for the different loads condition. There is an increase in the smoke density for both open flow of 95 HSU as compared to that of standard manifold flow 82 HSU at the full load condition where as the smoke density for 90o modified manifold was at 65 HSU. The increase in smoke emission is not of larger difference compared to that of the standard manifold condition. The increase in the smoke emission in modified flow may be due to the less amount of intake of the air due to the inlet design, which may lead to the incomplete combustion of fuel.

5.4. Hydrocarbon Emission

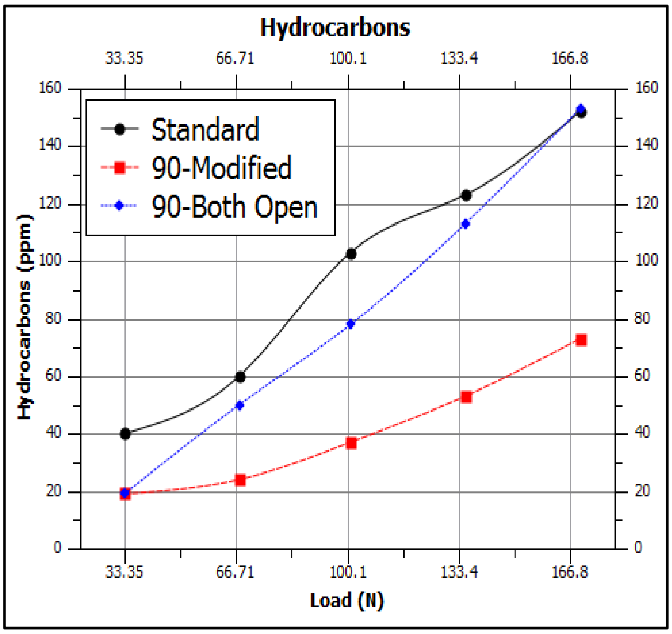

Fig.6 Hydrocarbon Emission

Variation of hydrocarbon emission depends on load and fuel composition of the engine. Hydrocarbon emission is mainly because of the incomplete combustion. As the load increases, hydrocarbon emission increases since at high load engine requires more oxygen but in diesel engine cycle the air intake remains constant. Fig.6 shows the variation of hydrocarbon emission for the different load condition. There is an increase in the hydrocarbon emission for 90o both open as well standard manifold as compared to that of 90o modified flow at the full load condition. The probable reason for emission may be some portion of the fuel-air mixture in the combustion chamber comes into direct contact with combustion chamber wall and are quenched. Some of this quenched fuel-air mixture is forced out during the exhaust, which contributes to the high HC emission from the results.

5.5 NO_X Emission

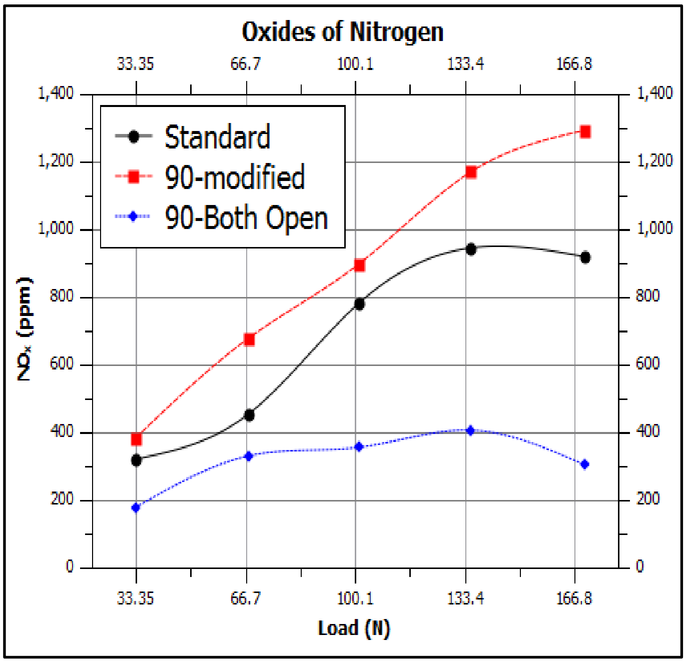

Fig.7 NOx emissions

The oxides of nitrogen in the emission contain nitric oxide (NO) and nitrogen dioxide (NO2). Nitrogen oxide is formed as a result of the oxidation of nitrogen in the air during burning of the air-fuel mixture in the combustion chamber [10]. The main factor to facilitate and accelerate the reaction between oxygen and nitrogen to increase NOx formation is temperature. Fig.7 shows the variation in NOx emission for the different loads condition. There is a decrease in NOx emission of 650 ppm for 90o both open modified manifold compared to that of standard manifolds 850 ppm at the full load condition and modified manifold of 90o has the highest NOx emi. The reduction in the NOx emission is due to the reduction in the heat released at the modified inlet flow compared to that of the normal flow.

5.6. Pressure

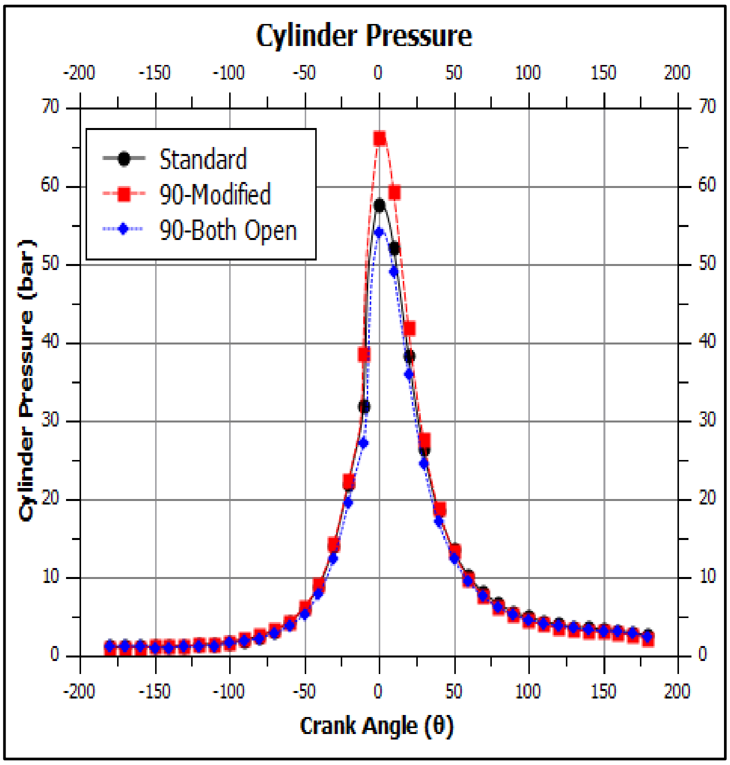

Fig.8 Cylinder Pressure

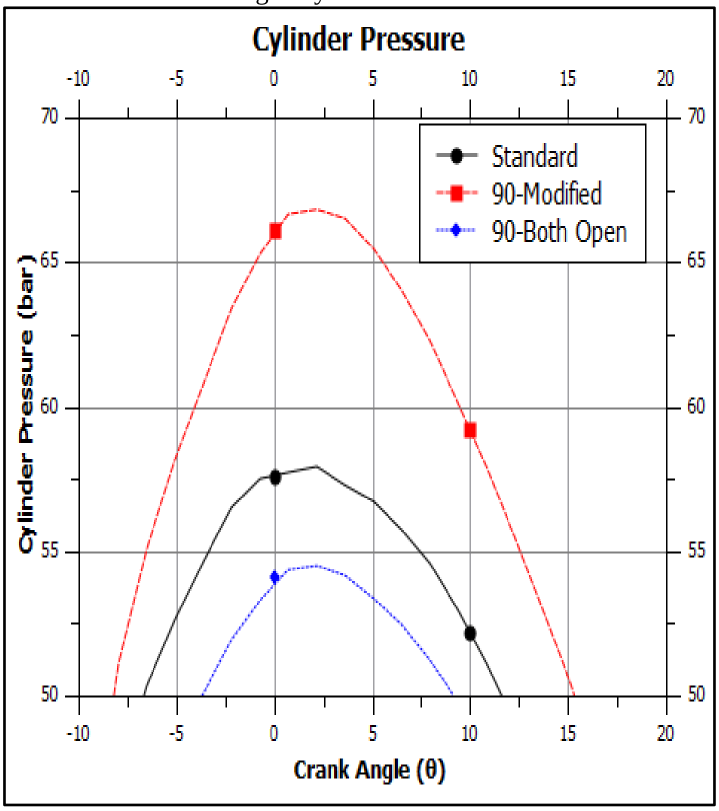

Fig.9 Cylinder pressure peak curve

Fig.7 and fig. 8 shows the variation in the cylinder pressure for standard manifold as well and modified manifold 90^{o} and both open condition maximum load condition. The cylinder pressure for standard manifold was found to be 57 bar and 68 bar for modified 90o manifold which has the highest cylinder pressure. The least cylinder pressure was observed in 90o both open manifold. The drop in pressure is may be due to the amount of air fuel quenching process and higher the turbulence may be a reason for drop in the cylinder pressure. The effect of pressure drop significantly affects the combustion and emissions of the engine.

5.7. Average Cylinder Pressure

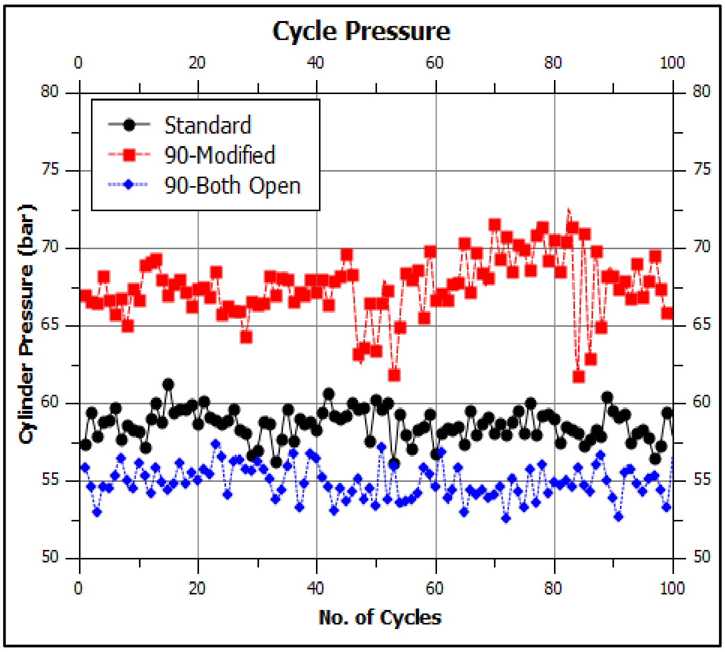

Fig.9 Average cylinder pressure

By analysis of maximum cylinder pressure for 100 cycles pattern is shown in the figure. It is concluded that the contribution of premixed phase is lower than that of diesel fuel and significantly higher for 90omodified flow. Further complete combustion achieved in the case of 90omodified manifold and the mean cylinder pressure is about 55 bar which is almost above 5 bar lesser than that of than average pressure of standard manifold.

5.8. Heat Release

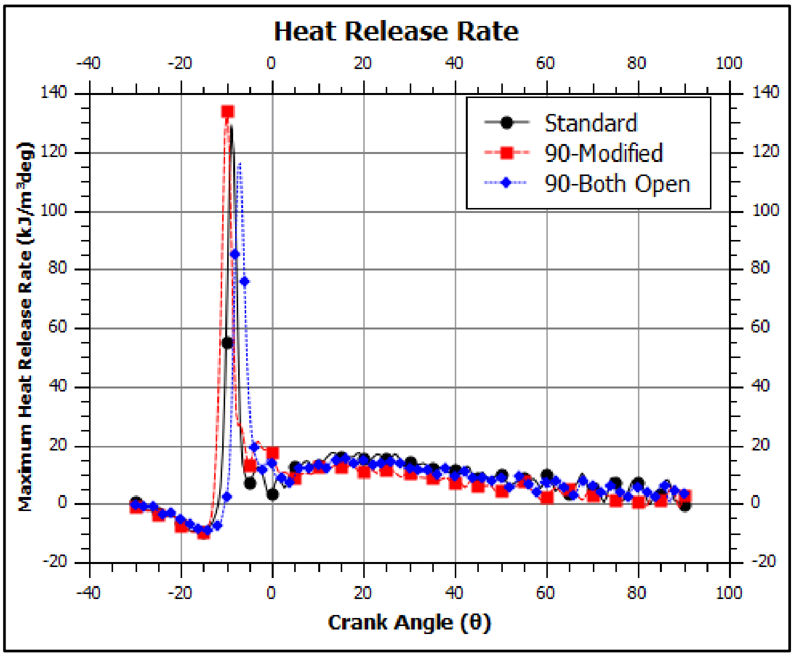

Fig.10 Maximum Heat transfer

Fig.10. shows the variation of heat release for standard and 90o modified manifolds for maximum load condition. There is also a shift seen in the crank angle of 4o lag in the modified manifold of 90o as compared to the standard manifold. Where the 90o modified manifold has the highest heat release of 140kJ/m3deg as compared to that of the standard flow of 132 kJ/m3 deg. The least heat release rate was observed in 90o both open which is around 118

kJ/m3 deg. Higher heat released may be due the better airflow rate inside the cylinder, which causes better combustion in the normal flow condition.

6. CONCLUSION

The following conclusions were drawn on performance characteristics of single cylinder, four strokes, and water-cooled engine while running the engine with standard and modified inlet manifold of 90o for single open and both open conditions

1. Brake thermal efficiency increases by 1.87% for the 30o modified flow as compared to the standard flow.
2. NOx emission is reduced in the modified condition by 57.6% as compared to that of standard condition.
3. HC content increase by 21.2 % for modified flow condition than that of the standard condition.
4. Increase in Smoke emission by 4.65% for the modified condition to the standard condition is the important condition to look out.
5. The cylinder pressure reduced by 19.9% in the modified flow condition compared to that of the standard and there is reduction in the heat release by 12.15% for the modified flow to that of the standard flow.

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