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An Experimental Investigations on the Effects of Intake Manifold Design and Use of Bio fuel In DI Diesel Engine

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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 90o inclination perpendicular to the standard inlet manifold within the cylinder head of DI engine. The study in made to replace the existing diesel fuel with the blends of pine oil utilized. The main objective of this work is to discuss the impact of bio-fuel from Pine oil in blends of 10%,20%,30%,40% and 50% on performance, combustion and emission characteristics diesel.The experiment were carried out on a stationary direct injection Diesel engine with modified condition of 90^o and standard manifold. The results shows an decrease in 4.9% in the brake thermal efficiency of the engine for modified condition, the NOx level increased by 375 ppm for the modified condition whereas there is decrease in HC and smoke density by 75ppm and 35.7 HSU respectively. Increase in pressure and heat release was also observed in the modified inlet manifold condition.*

1. INTRODUCTION

Diesel engines are used as one of the primary prime movers for generating power and electricity in plentiful industrial and agricultural applications. Information from research studies on renewable or alternate fuels usually forecast an amazing demand for petroleum fuels by 2030 and the repercussions of this have been already felt by the fast surge in petroleum prices [1,2]. In many investigational studies by micro emulsion fuel have informed a fundamental reduction of NO emission in diesel engine [3]. Vallinayagam.et.al stated that pine oil is actually blended with diesel fuel lacking transesterification process. The pine oil has low viscosity compared to that of diesel. At the maximum load condition, 100% pine oil increases the brake thermal efficiency of the standard diesel engine by 5%[4]. Distinct other alcohol-based fuels, the pine oil is an oxygenated fuel, which is obtained from the resin of pine trees, and it is the renewable fuel, have a high heating rate and the viscosity and boiling point of pine oil is lower compared to diesel, which improve the fuel vaporization and atomization after injection. These kind tend pine oil an suitable for the using in diesel engines [5]. In addition, some reports are available concerning the application of pine oil in different diesel engines [6-9]. R. Vallinayagam et al. [10] have investigated the influences of diverse ratio pine oil/diesel blends on combustion and hazardous substance emitted from a single-cylinder, DI diesel engine under diverse loads. The results show that pine oil appreciably decreases the CO, HC, and soot emissions at the condition of full load, and increases the brake thermal efficiency and NOx emission. Nevertheless, the NOx emission on the performance and harmful substance emitted from a multi-cylinder diesel engine fuelled with pine oil-diesel blends. In this study, the effects of fuel injection pressure on the combustion, performance and emission characteristics of a common-rail diesel engine using pine oil blend (P50) have been deliberated. The specific fuel consumption (SFC) increased, and brake thermal efficiency decreased due to the reason for combustion characteristics and fuel properties of Pine oil blends. In order to better utilization of Pine oil blend, the inlet manifold has been modified for an angle of 90 degree.

2. PRODUCTION OF PINE OIL

Mostly the pine tree, widely grown for its bark, wood, turpentine, tar and essential oil, can grow up to 40 m. The necessary oil obtained from pine tree is called pine oil, which is pale yellow in colour, and has a fresh forest aroma. There are three dissimilar varieties of pine oil known as gum, wood and sulphate pine oil, each being produced from different parts of pine tree and has their individual distinction. Apparently, a pine tree can deliver an average of 2.75 kg of the pine oleoresin, which contains 20% of turpentine oil and 65% of rosin oil, and the turpentine oil present in it is used as a untreated material for producing pine oil. The pine oil attained from the resin ducts of living pine tree is called gum pine oil, which is being involved in the current study. Oleoresin, which contains 20% turpentine and 65% rosin, and the turpentine present in it used as a raw material for producing pine oil. The pine oil attained from the resin ducts of living pine tree is called gum pine oil, which is being employed in the current study. The pine oleoresin first washed and placed in a reactor surrounded by cylindrical coils, which help in simplicity passing hot steam. By benefit of this, the vapours of lower boiling fraction of oleoresins are formed and these were then condensed separately to distill turpentine and water. After the parting of low boiling fraction compounds, rosin is left behind as a residue, which has the features of camphor and finds applications in several industries.

Property	Diesel	P10	P20	P30	P40	P50
Density at 15°C Kg/m^3	822	827	830	834	837	838
Kinematic viscosity at 40 °C in m^2/s	3.6x10-6	2.54x10-6	2.44x10-6	2.33x10-6	2.21x10-6	2.12x10-6
Flash point in °C	74	60	57	55	54	55
Gross calorific value in kJ/kg	42,700	40,641	40,593	40,537	40,484	40,436
Sulphur content in %	Less than 0.005	0.035	0.029	0.027	0.028	0.027
Calculated cetane index	52	50.7	50.8	51.1	51.3	51.6

Source- ETA Labs, Chennai.

Table.1. Properties of Diesel and pine oil blends

3. ENGINE DESIGN

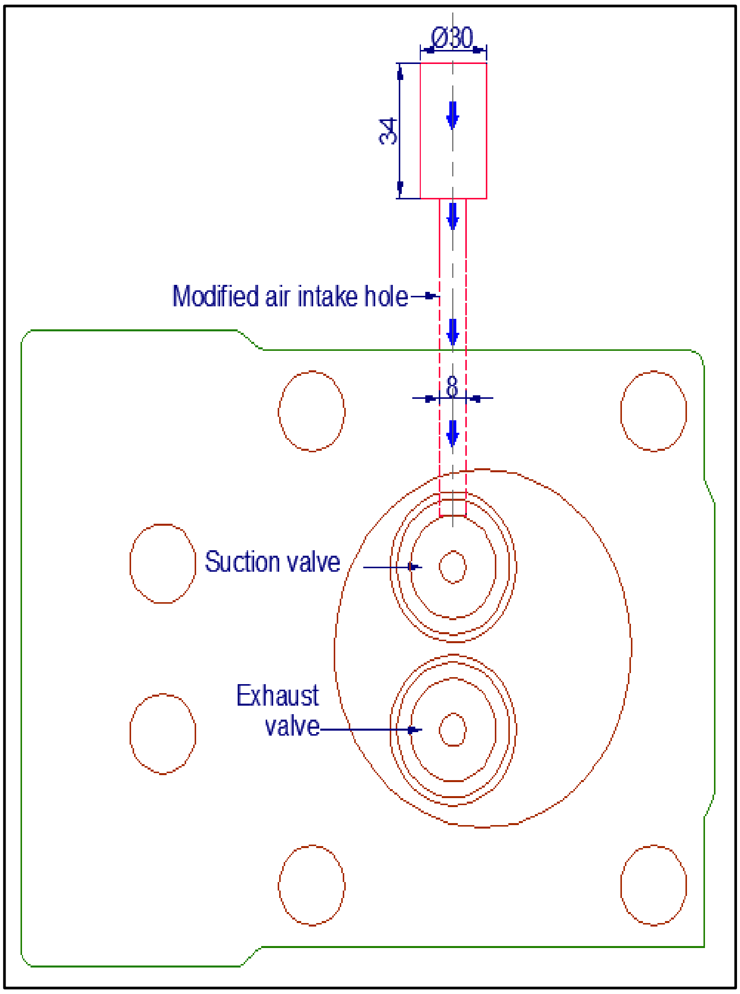

Fig.1. Modified Cylinder Head of 90°.

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 90° normal to that of the standard inlet manifold.

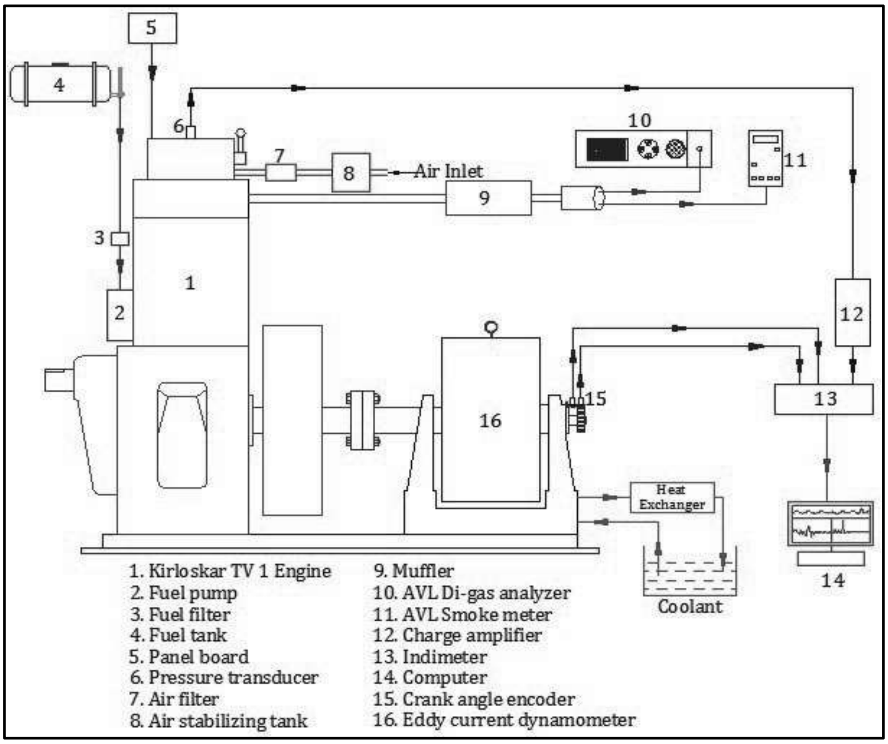

Fig.2. layout of the engine assembly and measuring devices

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.2. Engine Specification

4. 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 analyzer and AVL Smoke Meter. The engine is coupled to an Eddy current dynamometer. Necessary provisions were made to calculate the flow rates of fuel and air flowing into the engine cylinder. The specification of the engine is shown in table. 2.

5. METHODOLOGY

The engine was first tested with standard intake manifold and diesel and pine oil blends of 10,20,30,40,50 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 same procedure was applied for modified manifold of 90^o.

6. RESULTS

6.1. Brake Thermal Efficiency

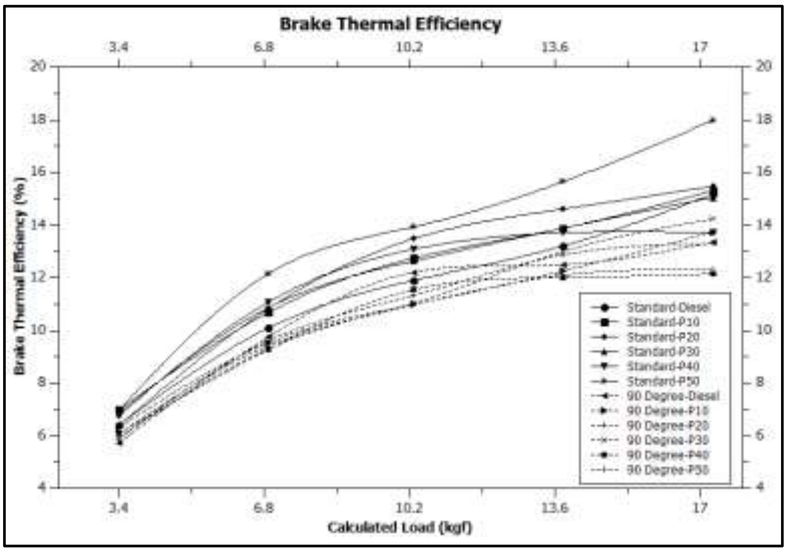

Fig.3. Brake Thermal Efficiency

Thermal efficiency is the true indication that the efficiency with the chemical energy input in the form of fuel 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 the standard inlet manifold with P50 blend exhibits maximum brake thermal efficiency of 18.2% at all load conditions compared to that of 90^o modified manifold for diesel and P50 blended fuel. The variation of the brake thermal efficiency was from 12.3% at low load to 18.2 % at full load for standard manifold. This is 4.9% higher than that of the 90^o modified manifold with diesel and pine oil blends at full load.

6.2. Specific Fuel Consumption

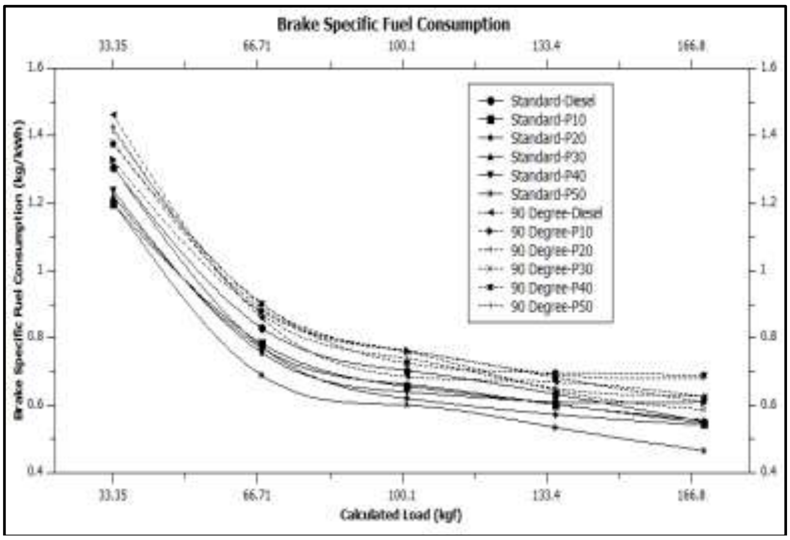

Fig.4. Specific Fuel consumption

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 manifold of 90 degree. the maximum fuel consumption was observed in 90^o modified manifold of 0.7kg/kWh when compared to standard P50 blend 0.43 kg/kWh. This may be attributed to the mass of air flow in the standard manifold has a good agreement in mixing the air and pine oil P50 blend.

6.3. Smoke Density

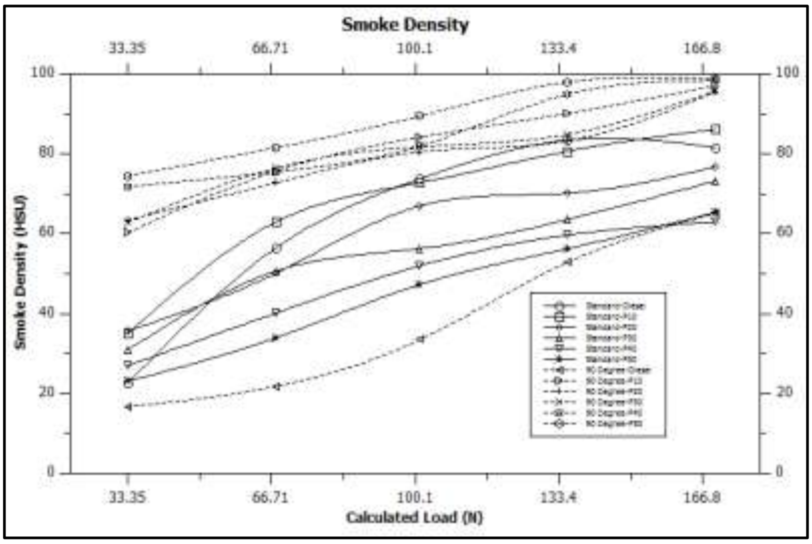

Fig.5. Smoke Density

Smoke emission is generally correlated with soot formation and is associated with low combustion temperature and with incomplete combustion in the cylinder. The variation of the smoke emission with brake power is presented. The smoke emission increases with an increase in engine loads. The quantity of fuel per unit time increases as load increases and subsequently smoke emission increases. Fig.5. shows the smoke density for the different loads condition. 90o modified manifold with P20 blend produced maximum smoke of 98.2 HSU in comparison with the standard manifold for diesel and pine oil blends. The least smoke was observed in standard with P50 blend of around 62.5 HSU. 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.

6.4.UnburntHydrocarbon Emission

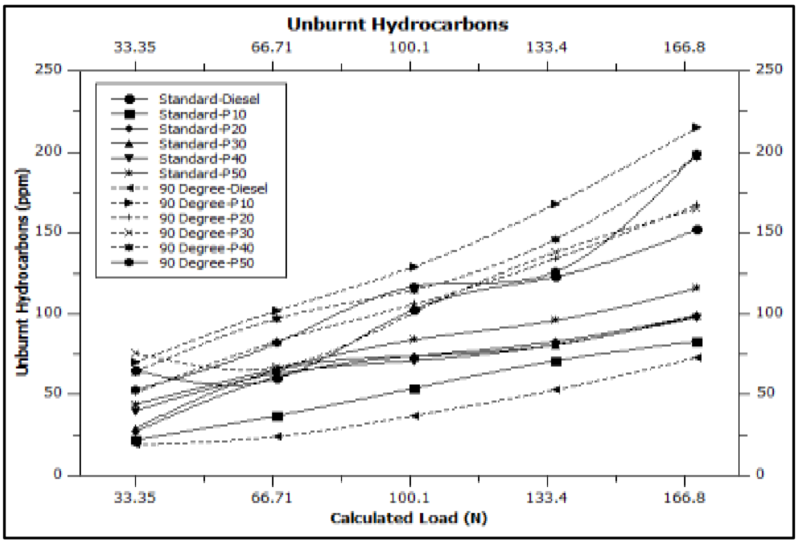

Fig.6. Unburnt Hydrocarbons

Variation of hydrocarbon emission depends on load and fuel composition of the engine. Hydrocarbon emission is primarily 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 of 215 ppm for 90^{o} modified manifold with diesel fuel as compared to that of standard manifold 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 result.

6.5. NO_XEmission

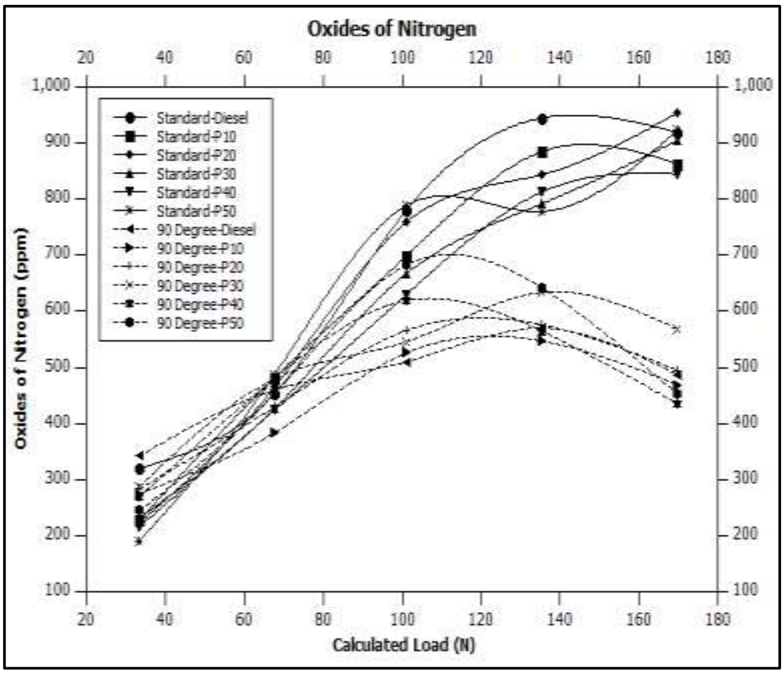

Fig.7. Oxides of Nitrogen

The oxides of nitrogen in the emission have nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrogen oxide is formed because of the oxidation of nitrogen in the air during burning of the air-fuel mixture in the combustion chamber. 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 for diesel and all blends of pine oil for 90o degree modified manifold compared to that of standard manifold for diesel and other pine oil blends at the full load condition. The NOx emission for standard manifold for P20 blend and 90^{o}modified manifold for P30 blend at maximum load is found to be 950 ppm and 575 ppm respectively. The decrease in the NOx emission is due to the decline in the heat released at the modified inlet flow compared to that of the normal flow.

6.6. Pressure

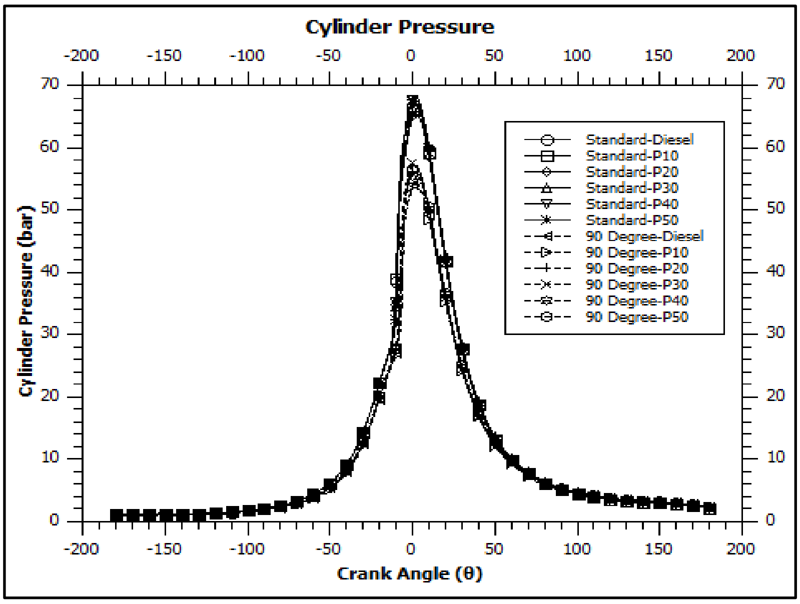

Fig.8. Cylinder Pressure

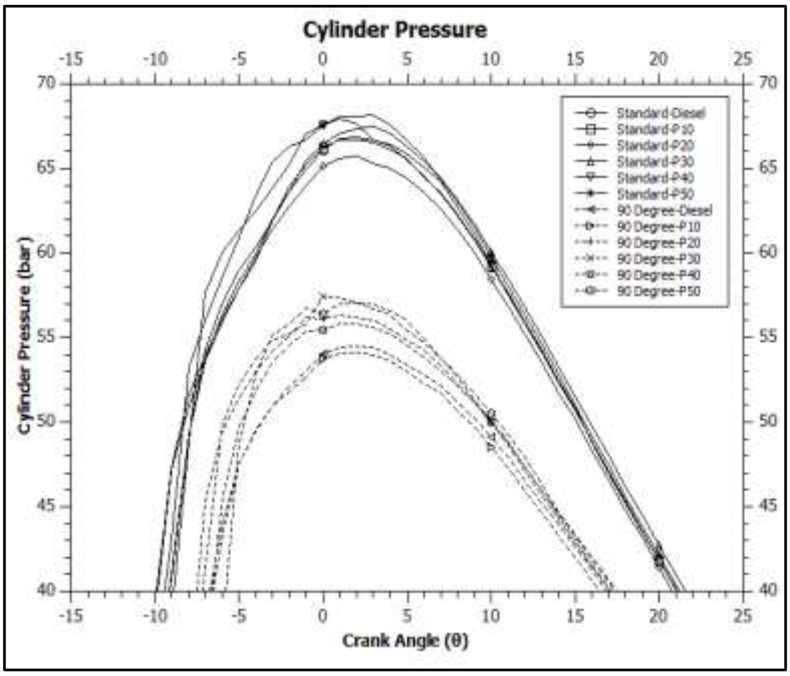

Fig.9. Curves of Peak Cylinder Pressure

Fig.8and fig.9shows the variation in the cylinder pressure for standard manifold and modified manifold of 90o for diesel and pine oil blends as fuel. The maximum cylinder pressure of 68 bars was observed in standard manifold with P50 blend as fuel, whereas minimum pressure of 53 bar was observed for 90^{o} modified manifold with diesel as fuel. 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.

6.7. Heat Release

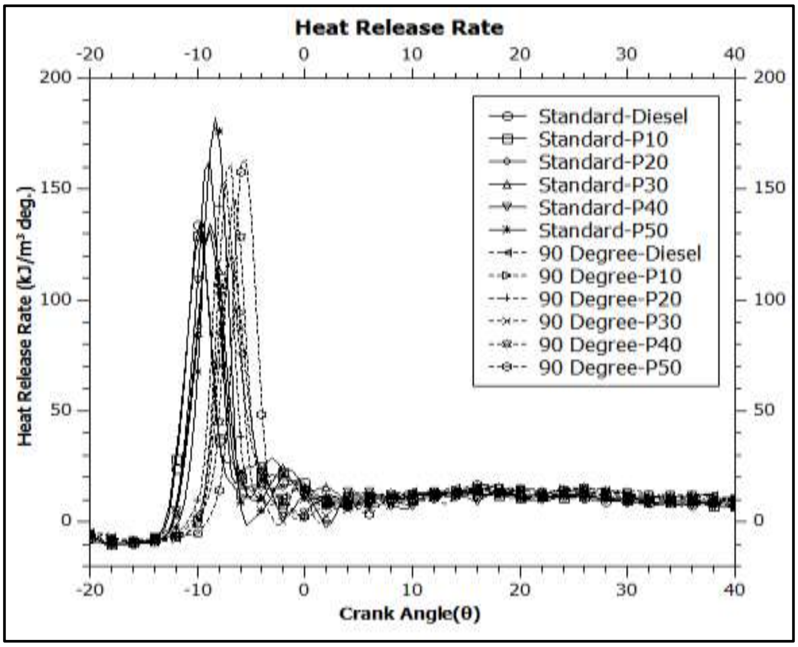

Fig.10. Heat Release Rate

Fig.10. shows the variation of heat release for standard and 90^{o} modified manifold for maximum load condition. There is also a shift seen in the crank angle of 4^{o} lag in the modified manifold of 90^{o} with P50 as fuel as compared to the standard manifold. Maximum heat release rate of 175 kJ/m3 deg was observed in standard manifold with P50 as fuel. Higher heat released may be due the better airflow rate inside the cylinder, which causes better combustion in the normal flow condition.

7. CONCLUSION

The following conclusions were drawn on performance characteristics of single cylinder, four strokes, and water-cooled engine while running the

1. Brake thermal efficiency reduced by 4.9% for the 90° modified manifold as compared to the standard flow. Standard manifold with P50 blend show the maximum BTE.
2. NOx emission decreased 375ppm in the 90° modified manifold using P50 as fuel compared to that of standard manifold for all fuel.
3. HC content decreased by 75ppm for 90° modified manifold using diesel as fuel.
4. Decrease in smoke emission by 35.7 HSU for the standard manifold using diesel as fuel is the important condition to look out.

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