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ENHANCEMENT OF INTAKE GENERATED SWIRL TO ENHANCE LEAN COMBUSTION IN A FOUR STROKE DIESEL ENGINE

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ABSTARCT

The valves in the IC engine are primary and their design plays an important role in the inlet and exhaust strokes which help in the suction of fuel and exhaust the gases burned within the cylinder. At the starting of induction stroke, the exhaust valve be at stop position and usually, the inlet valve opens slightly before the top dead center and the exhaust valve remains open slightly after the top dead center. With the increase in the pressure during the compression and combustion, the tiny quantity of the air-fuel mixture is enforced about the edges of the exhaust valve, between the valves and the valve seat. Thus in order to have low mechanical losses, the engine should run at low speeds where the combustion should be fast for enabling good efficiencies. Therefore high turbulence should be produced prior to the combustion within the cylinder, so swirl is induced by inlet channel within the cylinder head. In this paper, to enhance the creation of turbulence by swirl, the inlet and exhaust valves are re-designed by keeping the pitch $0.5mm$ *and* $1mm$ *with a depth of cut of thread as* $4mm$*with* $3\ threads\ per\ inch$ *to improve the swirl motion in wild combustion as well as improve efficiency. The investigations are done in a Direct Injection Single Cylinder Diesel Engine to know how the performance techniques are considered to enhance the air swirl to achieve betterment in engine performance and emission and the results are compared with the normal engine.*

KEYWORDS: *Diesel Engine, Swirl, Inlet and Exhaust Valve*

Article History

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INTRODUCTION

Internal combustion engines are such equipment that works as a heat transfer medium rather than the working fluid using combustion products. To produce work, combustion is done in a way that produces high-pressure combustion products that can be expanded through the turbine or piston. The engineering of these high-pressure systems introduces many characteristics which deeply influence the formation of pollutants. The SI engine which is most of the automobiles adopted, CI engine (diesel engine) used in large & heavy duty Vehicles as well as the industrial systems.

The engine block and the parts of the engine are manufactured with various metal alloys, structural steel, and alloys, aluminum alloys coming to the intake and exhaust manifolds they carry different fuel mixtures to the engine cylinder and the burned exhaust gases with different elements of nitrogen, carbon oxides, etc., from the cylinder, thus the design and surface finish of the manifolds plays a major role in the smooth function of the engine. So the manifolds are designed according to the functions performed by them which are tabulated in table 1.

Table 1: Functions of the Manifolds

Intake Manifold	Exhaust Manifold
Deliver A/F mixture in equal quantities and proportions. Length of the passages should be as equal as possible to distribute the A/F mixture equally. Avoid the A/F mixture form condensing before reaching CC (combustion chamber). The ideal A/F mixture should be completely vaporized in the combustion chamber. Controlled system of heating which heat the mixture that aid in vaporization.	Create a scavenging action that causes all of the cylinders to help each other get rid of the gases. Delivers the emissions from the burnt gases into the atmosphere.

The manifolds are designed with smooth walls & minimum bends that help in increasing volumetric efficiency. The exhaust manifold tubing bolts to the engine head at different positions for different engines. By avoiding the sharp bends, the back pressure can be reduced. Many automotive manufacturers are constantly changing the design of the exhaust manifolds according to the emission controls they adopt. So with all these considerations the best feasible manifold is designed and manufactured which fit into the precincts of the compartment of the engine.

LITERATURE REVIEW

Many designs were repetitive before a suitable design was completed. Valve guides and seats were installed in the head. Inlet valve rotates in the air inside a cylinder. Air motion plays a very important role in fuel-air mixture, combustion and emission formation. Swirl motion is usually due to the design of the intake port. A good intake port design will create high sliver and will help to improve combustion. This helps reduce pollutant emissions and the better fuel economy. These engines achieve maximum efficiency. In the CFD (Virtual Flow Laboratory) enables numerical experiments (i.e. computer simulation), they contribute to improving engine performance. The inlet air for the engine can be optimized through the inlet poppet valve. The CFD simulation can recommend a better result. Improve the engine's vortex rate and internal brake thermal efficiency by masking the inlet valves. Fins also increase the rate of swirl and so we can get better thermal efficiency.

Swirls help to improve performance and reduce exhaust emissions. Compared to conventional valves the levels of pollution decreases with both valves. The manufacturing cost of masks and wings is low and can be easily prepared. The purpose of design modification in the engine exhaust is to modify the position and diameter of the exhaust valve so that the possibility of knocking can be reduced (in both SI and CI) the size of the inlet valve. The increased size of the exhaust valve increases manifold of multi-fold exhaust gas, which reduces the vulnerability of the engine's combustion chamber. Less dilution reduces the amount of unbalanced mixture/charge in the chamber, which reduces the hydrocarbon emissions from the engine. Helps in the development of low emission standards. Deficiency of unsaturated fuel inside the chamber increases strength with low consumption of fuel, thereby increasing its fuel efficiency. Due to the large size of the exhaust valve, a large amount of gas is saved and hence the heat energy coming out will be more that can be completely used for turbochargers, which increases its turbine efficiency. By using some of the earlier modifications to run the engines properly and smoothly, these benefits can be obtained using large exhaust valves.

TECHNICAL SPECIFICATIONS

The engine specifications used for the investigation are given in table 2.

Table 2: Specifications of Engine

Engine Type	Four Stroke Single Cylinder Diesel Engine
Engine capacity	5 kW (kilo Watt)
Fuel capacity	10 cc (Cubic Centimeters)
Speed	1500 rpm (revolutions per minute)
Current (volts)	230 V (Volts) single phase generator
Loading unit	Eddy Current Dynamometer
Diameter of the bore	0.095m
Length of the cylinder and bore	0.110m &0.080m

PROCEDURE

The procedure adopted for the experimental work provides threads on the inlet and exhaust valve diameter. Inlet valve head diameter 36 mm, and exhaust valve head diameter 28mm 9.5mm valve stem diameter was amplified, providing helical grooves on the valve stems, which had an inlet valve rod surface depth of 0.5 and 1 mm, where the designs are shown in Figure 1 & Figure 2.Number of threads per inch are 3. The size of the inlet valve is higher than the exhaust valve because the inlet gas (or) fuel-air mixture has less pressure than the exhaust gas. After the power stroke, the engine cylinder has more pressure in the exhaust gas and the temperatures and gases are ready to release in the combustion chamber.

Figure 1: Manifold Design with 0.5mm Pitch

Figure 2: Manifold Design with 1mm Pitch

The power of the engine is measured using the Eddy Current dynamometer, which is coupled with engine and engine exhaust emissions, measured by the gas analyzer on individual loads. This research work presents a way to increase movement and disturbance in the movement of inlet valves and internal combustion engines and their emission characteristics.

RESULTS AND DISCUSSIONS

The observations from the experiments suggest that manifold designed with $3/4$th of the rated load for three threads per inch, the manifold of the depth of cut with $1mm$ gave the good results than the manifold of $0.5mm$ depth of cut. Thus the results obtained for the $1mm$ depth of cut manifold are discussed below.

Brake Thermal Efficiency ($\eta_{Brake\ Thermal}$):

Figure 3 shows the comparison of variations of brake thermal efficiency with brake power. In this, we see that, at $3/4$th of the rated load for the three threads per inch, where the depth of cut is $1mm$ the brake thermal efficiency is increased by 7.9% over the normal piston. Thus the enhancement of turbulence with air swirl motion and proper air-fuel mixing can be achieved.

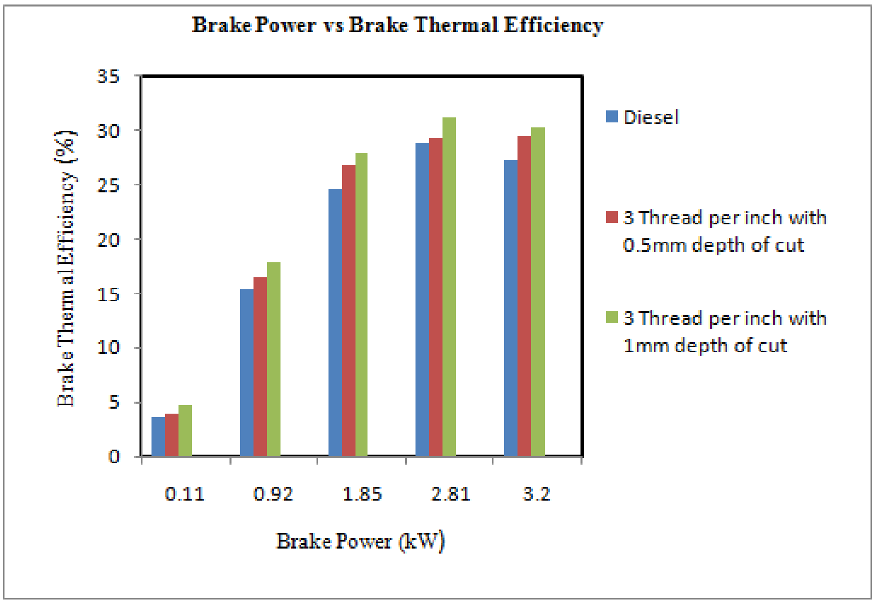

Figure 3: Variation of Brake Power Vs Brake Thermal Efficiency

Brake Specific Fuel Consumption (BSFC):

The modified manifold allows the A/F mixture to enter into the cylinder through the recessed port where the swirl motion happens with raise in turbulence, hence brake specific fuel Consumption is decreased once the swirl motion takes place freely then the entire combustion is wiped out of the combustion chamber. Thus the overall consumption is decreased by 0.6% and the BSFC values are shown in Figure 4.

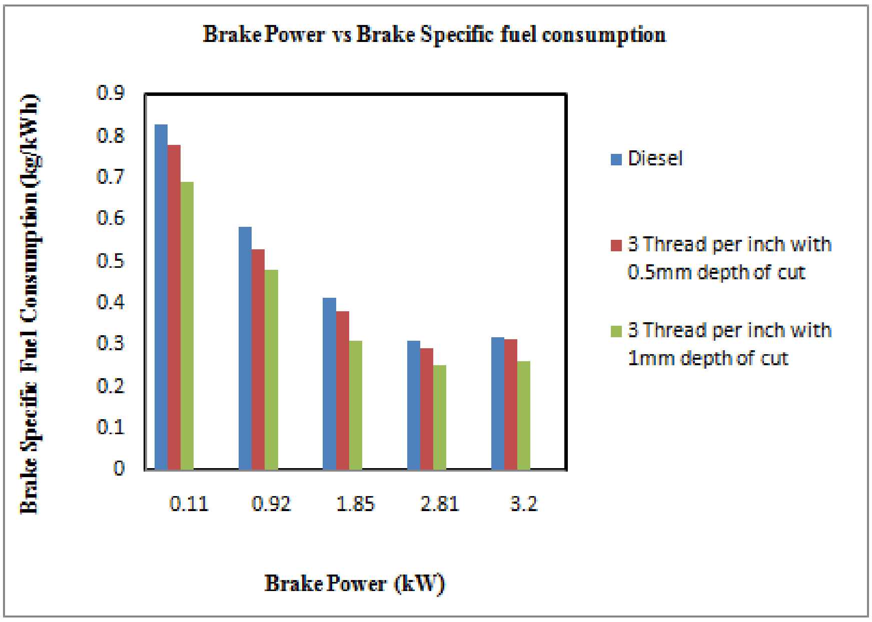

Figure 4: Variation of Brake Power Vs Brake Specific Fuel Consumption

Exhaust Gas Temperature

The Exhaust Gas Temperature decreases due to swirling motion within the combustion chamber because of the enhanced combustion. Thus the results from the Figure 5 show that the engine load increases as the temperature of the piston for normal engine decreases.

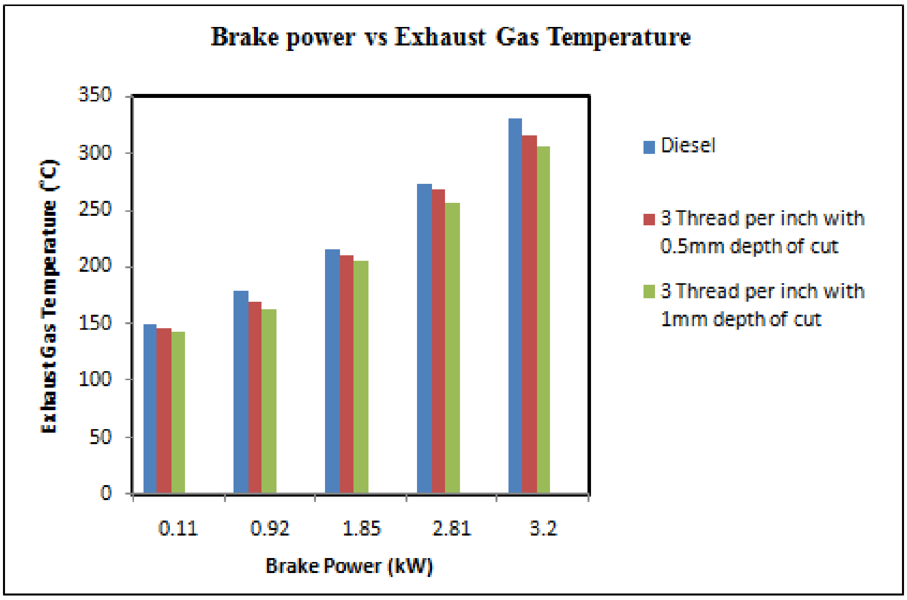

Figure 5: Variation of Brake Power Vs Exhaust Gas Temperature

Emissions of Hydro Carbons

The comparisons of hydrocarbon emissions with load are shown in Figure 6. The HC emissions for three threads per inch with a 1mm depth of cut is 34ppm at 3/4th of the load, whereas for normal piston it is 41ppm. Using the above technique HC emissions can be decreased by 17%when compare with a conventional engine with Diesel as fuel. The rate of the burning depends on the speed of fuel-air compounding inside the combustion chamber.

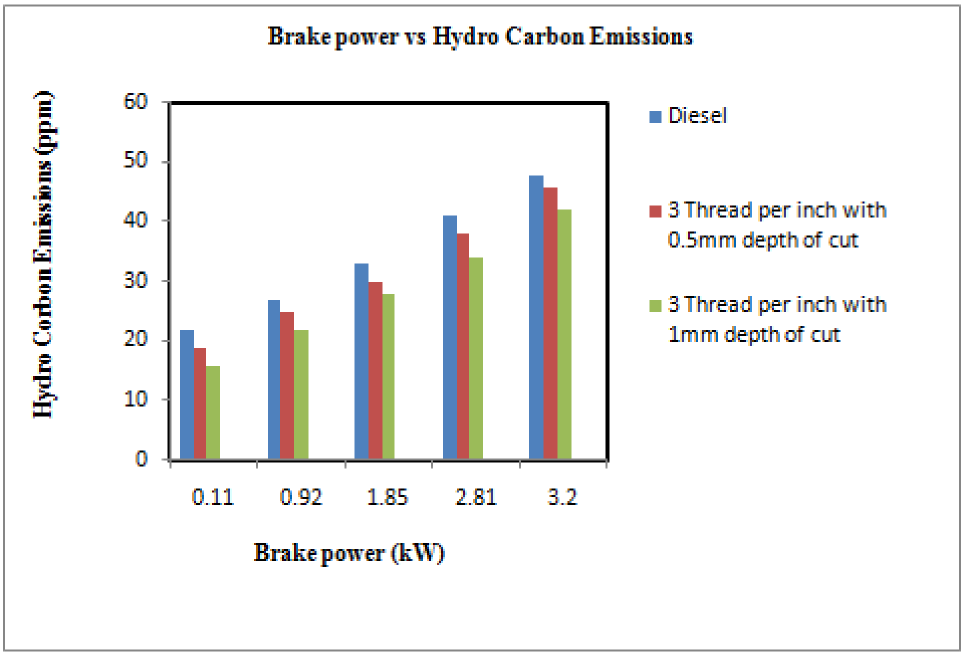

Figure 6: Variation of Brake Power Vs Hydro Carbon Emissions

Emissions of Carbon Monoxides

The lean mixture causes the CO gas emissions due to the insufficient fuel or an excessive amount of air which cause the engine to backfire. CO formation can be seen in low amount in diesel engine when the droplets sizes in an IC engine are large/short turbulence/ fewer swirls are made. From the comparison of results shown in Figure 7 forcarbon monoxide emissions made at isof the rated load is 0.046%, whereas for normal piston is0.062%. Thus CO emissions are decreased by 25.8%when compared with the conventional Diesel engine.

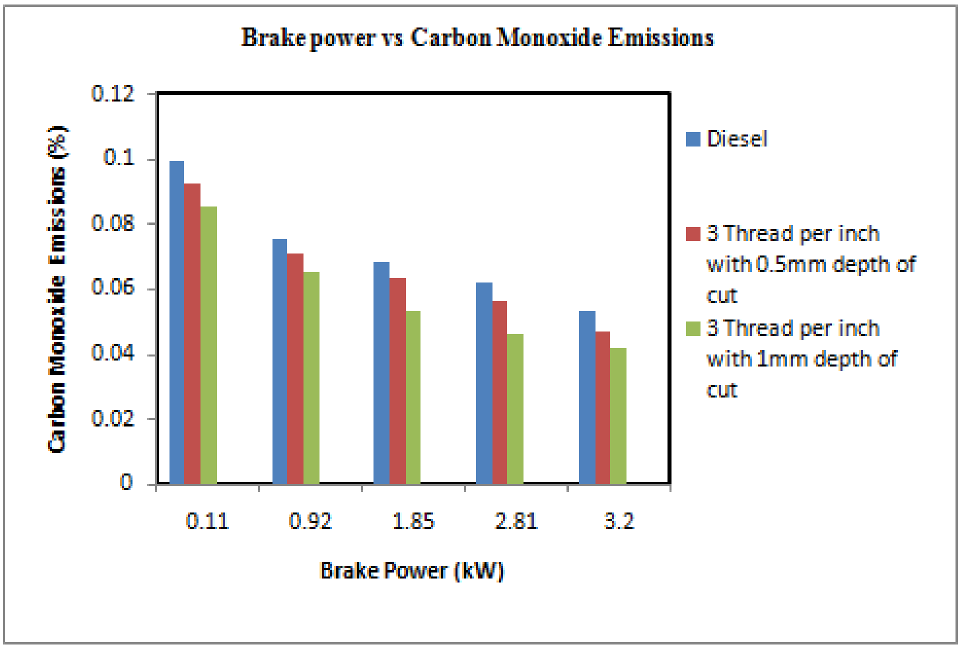

Figure 7: Variation of Brake Power Vs Carbon Monoxide Emissions

Emissions of Nitrogen Oxides

The data from the Figure 8 shows that the NOx emissions for three thread per inch with a 1mm depth of cut are 923 ppm at three fourth of the rated load, whereas for normal pistonthe NOx emissions are792 ppm. Using the above technique NOx emissions are increased by 16.5% when compared with conventional Diesel engine. Normally in this process, the nitrogen in the air does not react with oxygen in the combustion chamber and it is emitted identically out of the engine. Increasing the temperature of combustion increases the amount of NOx Emissions.

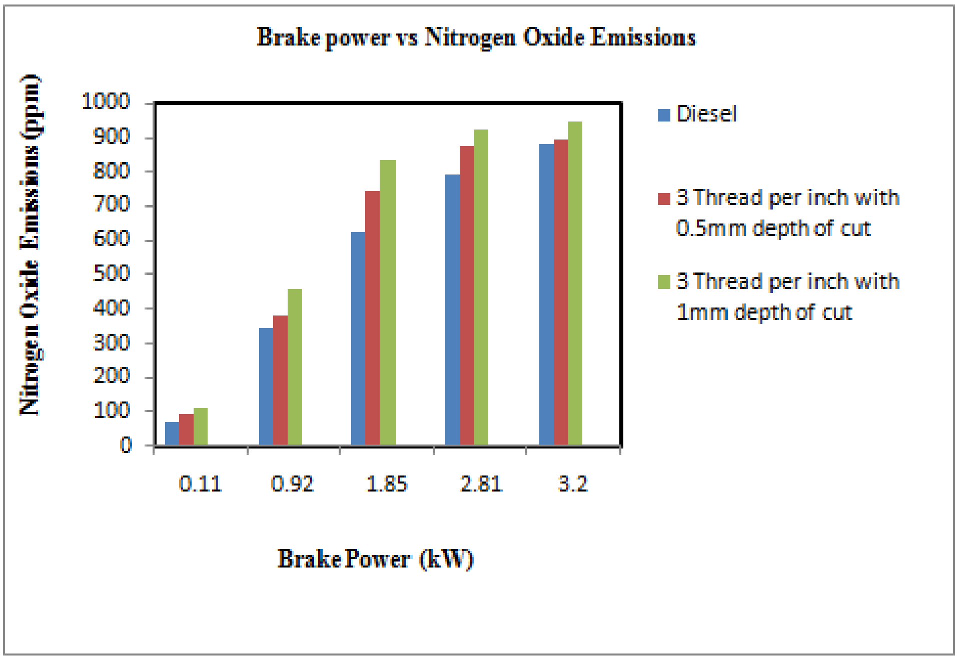

Figure 8: Variation of Brake Power Vs Nitrogen Oxide Emissions

CONCLUSIONS

From all the observations of the experimental investigation, it can be suggested that manifold designed with 3/4th of the rated load for three threads per inch, the manifold of the depth of cut with $1mm$ gave the good results than the manifold of $0.5mm$ depth of cut and normal conventional diesel engine. The drawn results say that achievement of 7.9% of $\eta_{\text{Brake Thermal}}$ is observed along with a decrement of brake specific fuel consumption by 0.6%. The emissions of hydrocarbon are decreased by 17% where there is also a decrement in the CO emissions and in the exhaust gas temperature by25.8%&6%. The enhanced combustion raised the NOx emissions by16.5%.

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