Effect of Induced Turbulence in a C.I Engine by Varying Compression Ratio and Injection Timing on the Performance of the Engine

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***Abstract*- The depletion of world petroleum reserves results in, two crises that are rising of fuel prices and global warming problems. The energy security can be maintained by improving the efficiency of energy producing components. Efforts are being made to find the alternatives. In the present work the modification of C I engine, for inducing turbulence to improve the combustible mixture, a rotating blade has been provided in the cavity (bowl) of the reciprocating piston in the main combustion chamber. The oscillation of the connecting rod causes the blade to rotate by an angle of 60°. This arrangement induces the turbulence in combustible mixture during engine operation, through which better combustion can be achieved. The effects of induced turbulence, injection pressure, compression ratio, injection timing on combustion, performance and emission characteristics of diesel fuelled compression ignition engine are studied.**

Key words- Turbulence, rotating blades, modified piston

INTRODUCTION

Internal combustion engines have been a relatively inexpensive and reliable source of power for applications ranging from domestic use to large scale industrial and transportation applications for most of the twentieth century. DI Diesel engines, having the evident benefit of a higher thermal efficiency than all other engines, have served for both light- duty and heavy- duty vehicles. The in-cylinder fluid motion in internal combustion engines is one of the most important factors controlling the combustion process. It governs the fuel-air mixing and burning rates in diesel engines. The fluid flow prior to combustion in internal combustion engines is generated during the induction process and developed during the compression stroke. Therefore, a better understanding of fluid motion during the induction process is critical for developing engine designs with the most desirable operating and emission characteristics. To obtain a better combustion with lesser emissions in direct injection diesel engines, it is necessary to achieve a good spatial distribution of the injected fuel throughout the entire space. This requires matching of the fuel sprays with combustion chamber geometry to effectively make use of the gas flows. In other words, matching the combustion chamber geometry, fuel injection and gas flows is the most crucial factor for attaining a better combustion. In DI diesel engines, swirl can increase the rate of fuel-air mixing, reducing the combustion duration for re-entrant chambers at retarded injection timings. Swirl interaction with compression induced squish flow increases turbulence levels in the combustion bowl, promoting mixing. Since the flow in the combustion Chamber develops from interaction of the intake flow with the in-cylinder geometry, the goal of this work is to characterize the role of combustion chamber geometry on in-cylinder flow. It is evident that the effect of geometry has a negligible effect on the airflow during the intake stroke and early part of the compression stroke. But when the piston moves towards Top Dead Centre (TDC), the bowl geometry has a significant effect on air flow thereby resulting in better atomization, better mixing and better combustion. The re-entrant chamber without central projection and with sharp edges provides higher swirl number than all other chambers. Turbulence plays a very vital role in combustion phenomenon. The flame speed is very low in non-turbulent mixtures. A turbulent motion of the mixture intensifies the processes of heat transfer and mixing of the burned and unburned portions in the flame front (diffusion). These two factors cause the velocity of turbulent flame to increase practically in proportion to the turbulence velocity. The turbulence of the mixture is due to admission of fuel-air mixture through comparatively narrow sections of the intake pipe, valves, etc. in the suction stroke. The turbulence can be increased at the end of the compression by suitable design of combustion chamber, which involves the geometry of cylinder head and piston crown. The degree of turbulence increases directly with the piston speed. If there is no turbulence the time occupied by each explosion would be so great as to make the high speed internal combustion engines impracticable. Insufficient turbulence lowers the efficiency due to incomplete combustion of the fuel. However, excessive turbulence is also undesirable.

The effects of turbulence can be summarized as follows:
Turbulence accelerates chemical action by intimate mixing of fuel and oxygen. Hence Turbulence allows the ignition,

advance to be reduced and therefore weak mixtures can be burnt. The increase of flame speed due to turbulence reduces the combustion time and hence minimizes the tendency to detonate. Turbulence increases the heat flow to the cylinder wall and in the limit excessive turbulence may extinguish the flame. Excessive turbulence results in the more rapid pressure rise (though maximum pressure may be lowered) and the high rate of pressure rise causes the crankshaft to spring and rest of the engine to vibrate With high periodicity, resulting in rough and noisy running of the engine.

MODIFICATION OF ENGINE

Base piston is having simple bowl shaped structure on the crown of it. In the present work modified piston is made with three rotating blades at 120^0 to each other in piston bowl. The blades used for this work should be of same material which piston have. Aluminum alloy material is used in fabrication of blades. The modified piston is arranged in the combustion chamber.

Fig 1: Piston with the rotating blades inside the bowl.

Fig 2 : Arrangement of modified piston inside the engine cylinder

EXPERIEMENTAL DETAILS

Experiments are conducted on a 4-stroke single cylinder 3.68 Kw Kirlosker water cooled Diesel engine. All these tests are conducted at a rated speed of 1500 RPM . The experimental set up is shown in fig.

Fig 3 : View across the engine side

From the experiments observed that combustibility of the fuel is very important in order get a good power output and good thermal efficiencies. The turbulence was played an important role here. In the present work it can be obtained by arranging the rotating blades inside the piston bowl of the engine.

RESULTS ANS DISCUSSIONS

A variable load test is conducted on Diesel engine by arranging the modified piston inside the cylinder. The better combustibility of fuel is obtain by better turbulence due to the modified piston. The performance and emission characteristics are explained below in detail.

BRAKE THERMAL EFFICIENCY

The variation of break thermal efficiency with respect to load applied for 17.5 and 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons are shown in exhibits 1&2. Turbulence is caused by modified piston. Turbulence enhances mixing and probably produces a leaning effect. The turbulence in the combustion chamber makes the charge into homogeneous and increases the combustibility of fuel. So brake thermal efficiency of modified piston is 2% more than the normal piston. Brake thermal efficiency is increasing with load applied. Compared to normal piston the efficiency increased by 2.2% for modified piston with 17.5 compression ratio. For 20.1 compression ratio the improvement in brake thermal efficiency is less than 17.5 and is up to 2% only. Thus we can get better improvement in brake thermal efficiency at 17.5 compression ratio. Brake thermal efficiency is got max. for the advanced injection timing compared to standard and retard timings. So that the brake thermal efficiency can be increased by more than 2% for modified piston of 17.5 compression ratio and advanced injection timing.

VOLUMETRIC EFFICIENCY

The variation of volumetric efficiency with respect to load applied for 17.5 and 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons are shown in exhibits 3&4. Volumetric efficiency depends up on the intake air into the combustion chamber. As the intake air into cylinder is more then we get better volumetric efficiency. By Turbulence we get better results. The volumetric efficiency of modified piston is 2-3 % more than the normal piston. Compared to normal piston the efficiency increased by 2.6% for modified piston with 17.5 compression ratio. For 20.1 compression ratio the improvement in volumetric efficiency is almost same as 17.5 and is also varies between 2-3% only. Volumetric efficiency is got maximum at 17.5 compression ratio, 200 bar pressure and standard injection timing, for 20.1 compression ratio it is 250 bar pressure and advance timing. So that the brake thermal efficiency can be increased by more than 2% for modified piston of 17.5 compression ratio and advanced injection timing.

CARBON MONOXIDE (CO) EMISSIONS

The amount of Carbon monoxide (CO) emissions present in the exhaust with respect to load applied for 17.5 and 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons are shown in exhibits 5&6. As more amount of oxygen is available in cylinder results the reduction in CO emissions. Due to the turbulence there will be a good amount of oxygen supply to cylinder. Turbulence is caused by modified piston. So that carbon monoxide emissions are reduced by 15% vol with modified piston. Carbon monoxide emissions are reduced with load applied. Compared to normal piston the CO emissions are reduced by 14% vol for modified piston with 17.5 compression ratio. For 20.1 compression ratio the reduction in CO emissions is 17% vol for modified piston. Thus we can get good reduction in CO emissions at 17.5 compression ratio. CO emissions are got min. at 250 bar pressure and the standard injection timing for 20.1 compression ratio. So that the CO emissions are reduced by 15 % with modified piston.

HYDRO CARBON (HC) EMISSIONS

The amount of Hydrocarbon (HC) emissions present in the exhaust with respect to load applied for 17.5 and 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons are shown in exhibits 7&8. Here some amount of lean mixture present in the cylinder. Turbulence can be obtained by the modified piston. With the turbulence rich mixture is obtained. This causes the reduction of hydrocarbons in the exhaust. So that the hydrocarbon emissions are reduced with modified piston. So that HC emissions are reduced by 13% with modified piston. Compared to normal piston the HC emissions are reduced by 14% for modified piston with 17.5 compression ratio. For 20.1 compression ratio the reduction in HC emissions is 12% for modified piston. Thus we can get good reduction in HC emissions at 17.5 compression ratio and advanced injection timing.

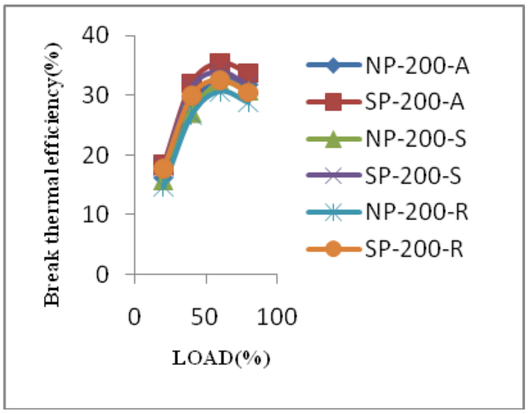

Exhibit 1.comparison of brake thermal efficiencies with load applied for 17.5 Compression ratio and different injection timings of normal& modified pistons.

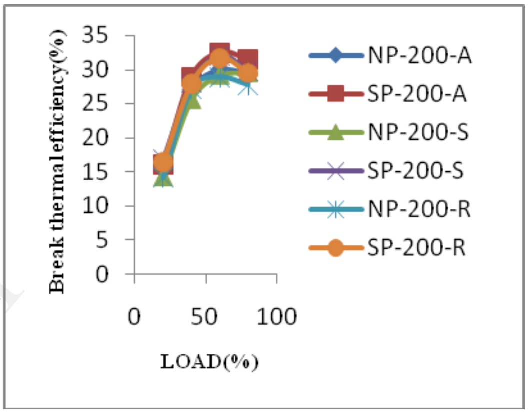

Exhibit 2.comparison of brake thermal efficiencies with load applied for 20.1 Compression ratio and different injection timings normal& modified pistons.

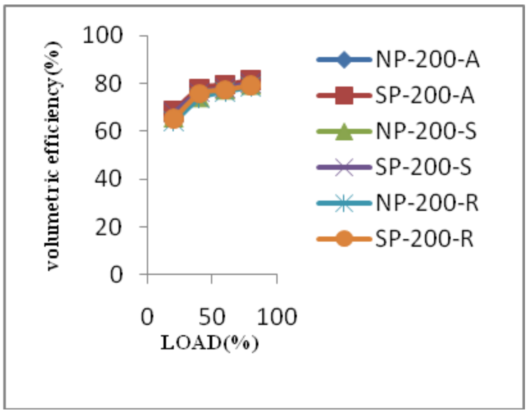

Exhibit 3.comparison of volumetric efficiencies with load applied for 17.5 compression ratio and different injection timings of normal& modified pistons

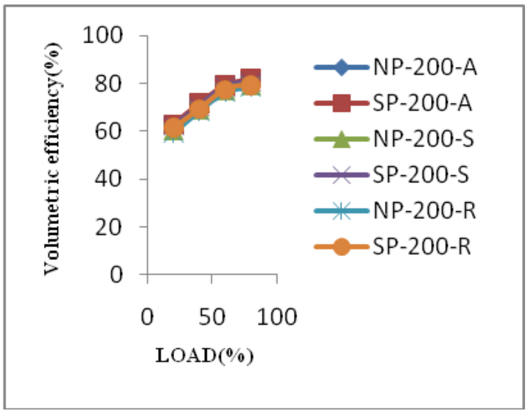

Exhibit 4.comparison of volumetric efficiencies with load applied for 20.1 compression ratio and different injection timings of normal& modified pistons

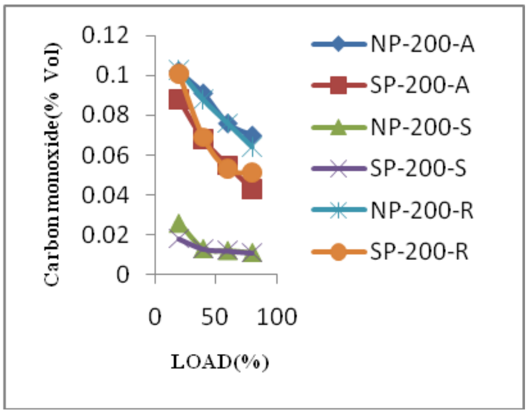

Exhibit5.comparison of carbon monoxide emissions with load applied for 17.5 compression ratio and different injection timings of normal& modified pistons.

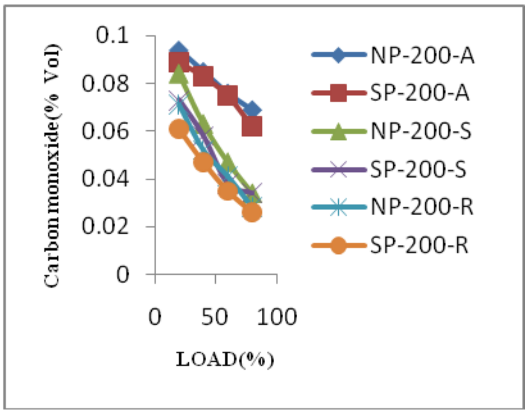

Exhibit6.comparison of carbon monoxide emissions with load applied for 20.1 compression ratio and different injection timings of normal& modified pistons.

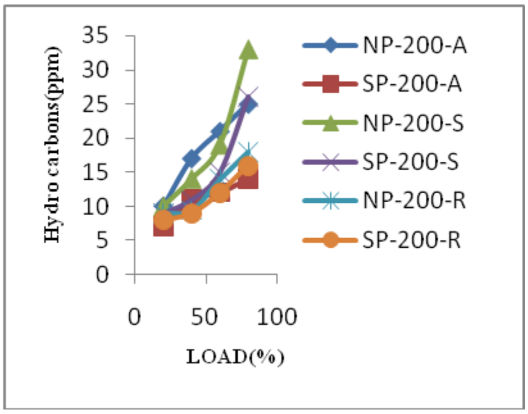

Exhibit7.comparison of Hydro carbon emissions with load applied for 17.5 compression ratio and different injection timings of normal& modified pistons

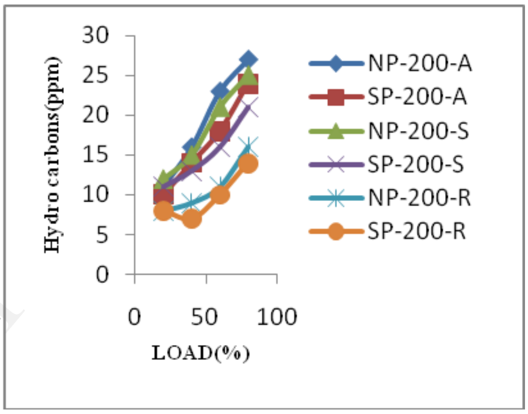

Exhibit8.comparison of Hydro carbon emissions with load applied for 20.1 compression ratio and different injection timings of normal& modified pistons.

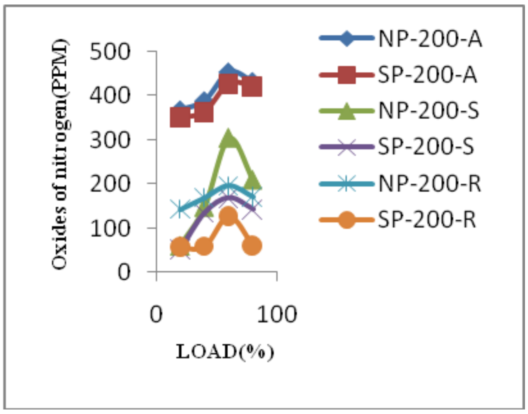

Exhibit 9.comparison of Oxides of Nitrogen with load applied for 17.5 compression ratio and different injection timings of normal& modified pistons.

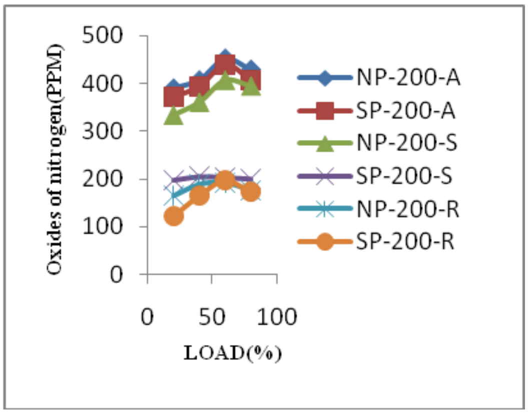

Exhibit 10.comparison of Oxides of Nitrogen
With load applied for 20.1compression ratio and different injection timings of normal& modified pistons.

OXIDES OF NITROGEN (NO_X)

The amount of Oxides of Nitrogen (NOx) emissions present in the exhaust with respect to load applied for 17.5 and 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons is shown in exhibits 9&10. NOx is created mostly from nitrogen in the air. NO_X is a very undesirable emission, and regulations that restrict the allowable amount continue to become more stringent. Released NOx reacts in the atmosphere to form ozone and is one of the major causes of photochemical smog. Most of this will be nitrogen oxide (NO), with a small amount of nitrogen dioxide (NO_2), and traces of other nitrogen-oxygen combinations. NOx emissions are reduced by 7% with modified piston. Compared to normal piston the NOx emissions are reduced by 6% for modified piston with 17.5 compression ratio. For 20.1 compression ratio the reduction in NOx emissions is 8% for modified piston. Thus we can get good reduction in NOx emissions at 20.1 compression ratio and standard injection timing.

CONCLUSIONS

Based on the above results and discussions, the following conclusions are drawn:

- With the rotating blades inside the piston, turbulence is generated inside the combustion chamber. This further increases the combustibility of the mixture.
- The homogeneous mixture inside the combustion chamber increases the break thermal efficiency of modified piston by 2% compared to normal piston.
- The turbulence in the combustion chamber provides the homogeneous mixture, This increases the volumetric efficiency by 2% with modified piston.
- The turbulence in the combustion chamber increases the oxygen present in it. With this emissions are drastically reduced.
- The NOx emissions are increased due to the high temperatures in the combustion chamber caused by the turbulence.

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