Performance of CI engine with and without swirl in crown of piston with varying injection timing

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***Abstract*— The ever increasing consumption of fossil fuel and petroleum products has been a matter of great concern for India. The huge outflow of foreign exchange on one hand and the increase in the price of crude oil on the other hand have affected the development of the country in contest of energy security.**

The consumption of diesel fuel is six times higher than that of gasoline in India and even a minute percentage of efficiency improvement for diesel fuel will save a considerable amount of foreign exchange. The energy consumption can be minimized by improving the efficiency of equipment i.e. CI engine.

The present work where the modification of C I engine has been done, so as to induce turbulence for enhancing the vaporization characteristics of fuel in combustible mixture by providing a rotating blade in the crown (bowl) of the reciprocating piston located 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, there by facilitating a better combustion performance.

The effects of operating parameters by induced turbulence, varying injection pressure and injection timing on performance characteristics of diesel fuelled compression ignition engine are to be investigated.

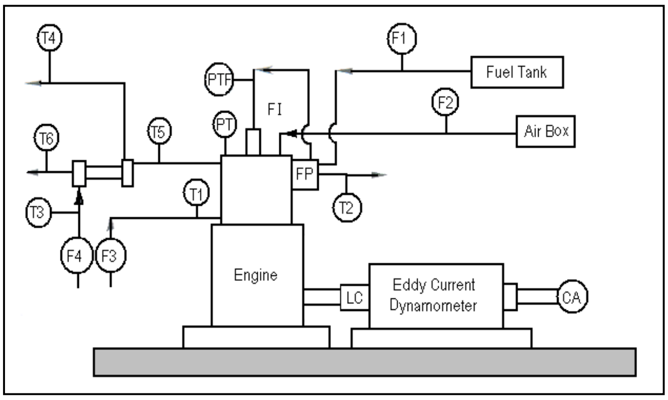
Keywords*— *C I Engine, Piston Crown, Swirl, Injection Pressure, Injection Timing and Performance.

I. INTRODUCTION

First standard engine is fully instrumented and connected to the dynamometer. The experiments are conducted at constant speed and at four different loads levels viz., 20%, 40%, 60% and 80% of full load. The required engine load percentage is adjusted by using the eddy current dynamometer.

Fig.1 shows the schematic diagram of a complete experimental setup for determining the effects of squish and tumble effect on the performance parameters of compression ignition engine. It consists of a single cylinder four stroke water cooled compression ignition engine connected to an eddy current dynamometer. It is provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperature. It is also provided with pressure sensors for the measurement of combustion gas pressure and fuel injection pressure. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display P-Θ, P-V and fuel injection pressure versus crank angle plots. The provision is also made for the measurement of volumetric fuel flow. The built-in program in the system calculates indicated power, brake power, thermal efficiency, volumetric efficiency and heat balance. The software package is fully configurable and averaged P-Θ diagram, P-V plot and liquid fuel injection pressure diagram can be obtained for various operating conditions.

Fig.1



II. ENGINE MODIFICATION

Figure 2 and 3 shows the base line piston and modified piston respectively**.** Base piston is having simple bowl shaped structure on the crown of it. But the modified piston is made with three chambers at 120^0 to each other. Same aluminum alloy material is used in fabrication of chamber. 2mm thick small strips are used to make the chambers.

Fig3

Fig2

III. EXPERIEMENTAL DETAILS

Experiments are conducted on an IV-stroke1cylinder 3.68Kw Kirlosker water cooled Diesel engine at the rated speed of 1500 rpm. 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.

IV. METHODOLOGY

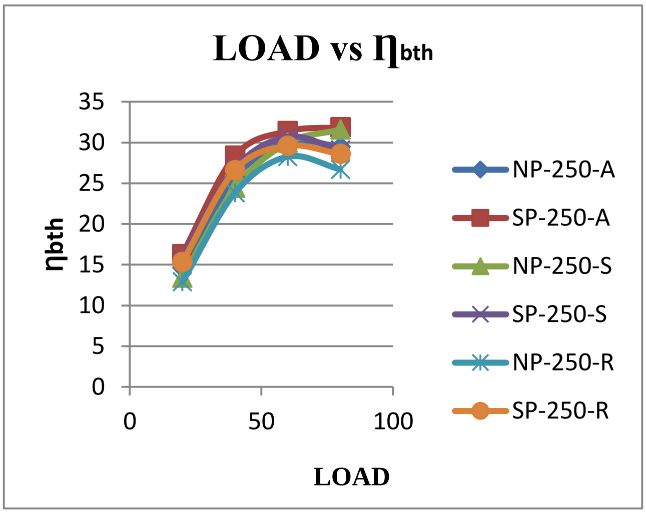
The engine has a compression ratio of 20.1 and a normal speed of 1500 rpm controlled by the governor. An injection pressure of 250bar, 300bar is used. The engine is first run with neat diesel at loading conditions such as 20%, 40%, 60% and 80%. Between two load trials the engine is allowed to become stable by running it for 3 minutes before taking the readings. At each loading conditions, performance parameters namely speed, exhaust gas temperature, brake power, peak pressure are measured under steady state conditions. The experiments are repeated for various pressures and injection timing. With the above experimental results, the parameters such as total fuel consumption, brake specific fuel consumption, brake specific energy consumption, brake thermal efficiency are calculated. And finally break specific fuel consumption, brake thermal efficiency is plotted with respect to loading conditions for diesel and each diesel oxygenate blend. From these plots, performance characteristics of the engine are determined.

V BRAKE THERMAL EFFICIENCY

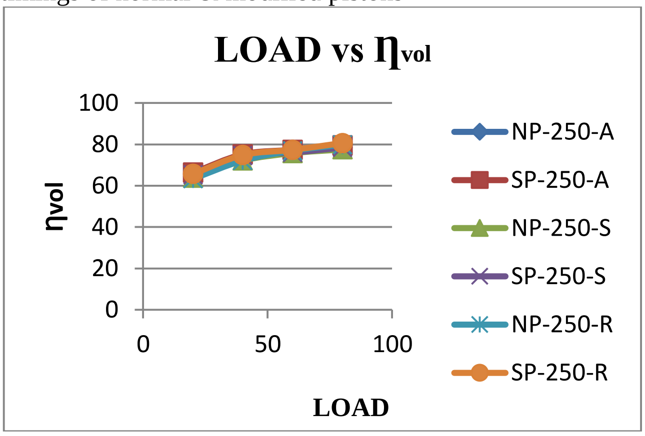
The variation of break thermal efficiency with respect to load applied 20.1 compression ratio and advanced, standard and retard injection timings for normal and modified pistons are shown in graph 1. Turbulence is caused by modified piston. Turbulence enhances mixing and probably produces a leaning effect. 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 20.1 compression ratio. Thus we can get better improvement in brake thermal efficiency. Brake thermal efficiency is maximum 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 20.1 compression ratio and advanced injection timing.

VI VOLUMETRIC EFFICIENCY

The variation of volumetric efficiency with respect to load applied for 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons are shown in graph 2. 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 20.1 compression ratio. 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%.



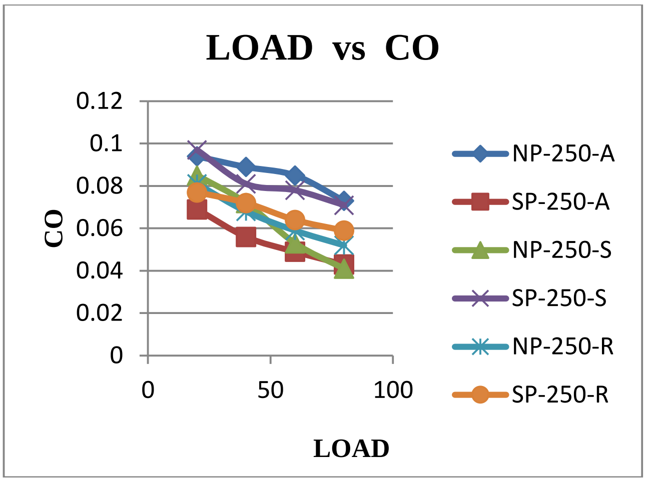
Graph1.comparison of brake thermal efficiencies with load applied for 20.1 Compression ratio and different injection timings of normal & modified pistons



Graph 2.comparison of volumetric efficiencies with load applied for 20.1 compression ratio and different injection timings of normal & modified pistons.

VII CARBON MONOXIDE (CO) EMISSIONS

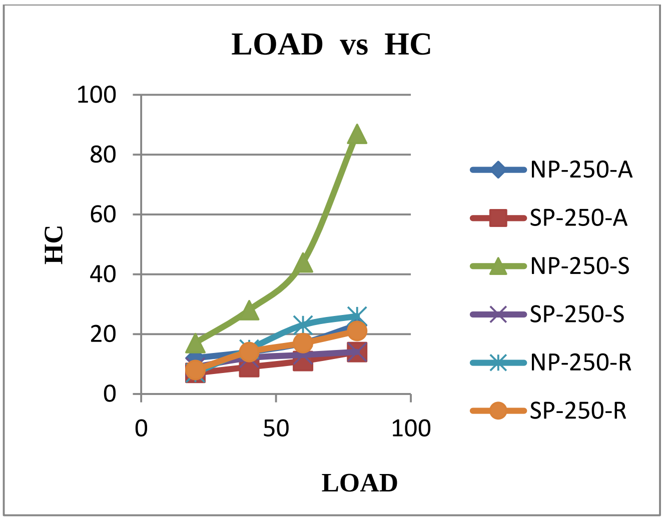
Amount of Carbon monoxide (CO) emissions present in the exhaust with respect to load applied for 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons are shown in graph 3. As more amount of oxygen is available in cylinder results the reduction in 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. For 20.1 compression ratio the reduction in CO emissions is 17% vol for modified piston. At 250 bar pressure and the standard injection timing for 20.1 compression ratio CO emissions are reduced by 15 % with modified piston



Graph 3.comparison of carbon monoxide emissions with load applied for 20.1 compression ratio and different injection timings of normal & modified pistons.

VII HYDRO CARBON (HC) EMISSIONS

The HC emission for normal piston is 6 ppm and 4 ppm for swirl piston. This is shown in graph 4. Hence with the use of swirl piston there has been a considerable decrease of 2 ppm in HC emissions.



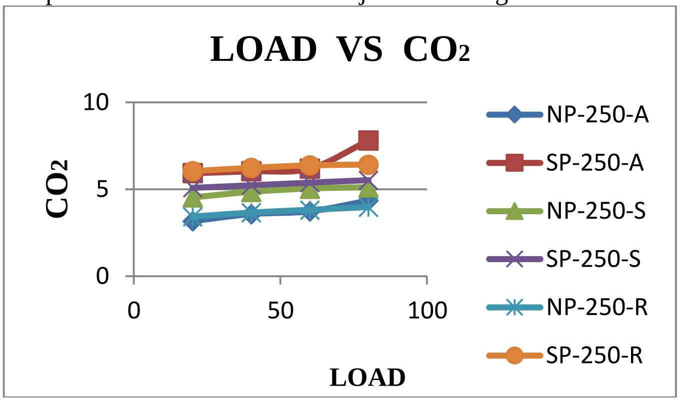
Graph 4.comparison of Hydro carbon emissions with load applied for 20.1 compression ratio and different injection timings of normal & modified pistons.

VIII CARBON DIOXIDE EMMISION

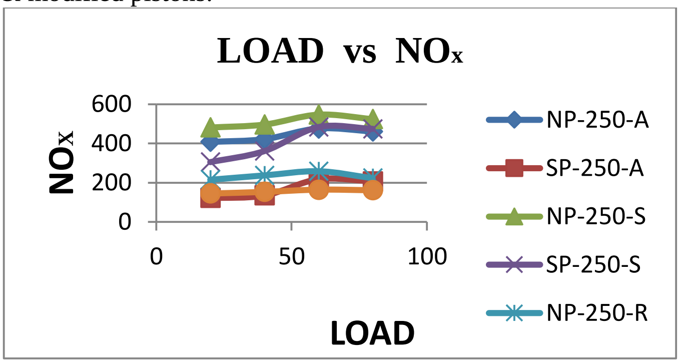
The CO2 emissions are 2.43 %vol for swirl piston and 3.54 %vol for normal piston. This is shown in graph 5. There by there is an increase of 1-2 % in CO2 emissions.

IX OXIDES OF NITROGEN

The amount of Oxides of Nitrogen (NOx) emissions present in the exhaust with respect to load applied for 20.1 compression ratios and advanced, standard and retard injection timings for normal and modified pistons is shown in graph 6. NOx is created mostly from nitrogen in the air. NOx 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. 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.



Graph 5.comparison of Carbon dioxide with load applied for 20.1compression ratio and different injection timings of normal & modified pistons.



Graph 6.comparison of Oxides of Nitrogen with load applied for 20.1compression ratio and different injection timings of normal & modified pistons.

VI CONCLUSIONS

Fuel economy is most important factor for any I.C. engine. But environmental protection is much more important than fuel economy. It is necessary that modification in the engine may be incorporated so as to minimize the exhaust emissions which are of topmost priority. In this connection, the geometry of the piston is modified by accommodating rotating blades in the piston crown to induce turbulence by means of swirl motion of charge.

- 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.

References

1. Katasuhika Moyamito Yoshiyuki Hosiba, Kiyotaka Hosono, Syunichi Hirao "Enhancement of Combustion by Means of Squish Pistons" MITSUBISHI MOTORS technical review 2006, NO 18.

2. B. Murali Krishna and J. M. Mallikarjuna "Tumble Flow Analysis in an Unfired Engine Using Particle Image elocimetry" World Academy of Science, Engineering and Technology 5-4- 2009.

3. John B. Heywood "Internal combustion Engine fundamentals". McGraw-Hill International Edition, Automotive technology series. year 1998.

4. S. Baghdar Hosseini, K. Bashirnezhad, A.R. Moghiman, Y. Khazraii, N. and Nikoofal, "Experimental Comparison of Combustion Characteristic and Pollutant Emission of Gas oiland Biodiesel," International Journal of Mechanical and Materials Engineering 1:1 2010.

5. Lu¨ Xingcai *, Hou Yuchun, Zu Linlin, Huang Zhen "Experimental Study on The Auto-Ignition and Combustion Characteristics in the Homogeneous Charge Compression Ignition (HCCI) Combustion Operation with Ethanol/n-heptanes Blend Fuels," by Port Injection School of Mechanic and Power Engineering, Shanghai Jiaotong University, Shanghai, People's Republic of China. Received 2 August 2005; received in revised form 23 April 2006.

6. Z.H.Huang, .W.Wang, H.Y.Chen,L.B.Zhou & D.M.Jiang"Study of combustion characteristics of a compression ignition engine fuelled with dimethyl ether," Xi'an Jiao tong University Institute of Internal Combustion Engines, School of Energy and Power Engineering Xi'an, People's Republic of China.

7. M. Pugazhvadivu1 and S. Rajagopan Dept. of Mechanical Engineering, "Investigations on a Diesel Engine Fuelled with Biodiesel Blends and Diethyl Ether as an additive," Dept. of Chemistry, Pondicherry Engineering College, Pondicherry, India- 605 014 ,Vol.2 No 5 (May 2009) ISSN: 0974- 6846.

8. Yi Ren, Zuohua Huang , Deming Jiang, Liangxin Liu, Ke Zeng, Bing Liu, Xibin Wang, "Combustion Characteristics of a Compression-Ignition Engine Fuelled with Diesel–di-Methoxy Methane Blends Under Various Fuel Injection Advance Angles," State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University, Xi'an 710049, People's Republic of China.

9. Kidoguchi Yoshiyuki (univ. Of Tokushima) Miwa Kei (univ. Of Tokushima) Yang.C (zexel corp., jpn) kato ryoji (Isuzu Motor Ltd.)"Effect of High Squish Combustion Chamber on Smoke and NOx Emissions of a Direct-Injection Diesel Engine" ISSN: VOL.2000; NO.Vol.4; PAGE.335- 336(2000).

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