Influence of Shroud Intake Valve on Performance and Exhaust Emissions of a Diesel Engine-An Experimental Approach

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Abstract - In the present scenario, majority of transport vehicles are powered with Diesel engines. These engines emit emissions which are very harmful to the environment. One way to reduce emissions in diesel engine is that by improving combustion, which is possible by increasing intensity of the swirl of the air inside the combustion chamber through inlet valve. In this experimental study, an attempted is made to increase intensity of swirl by introducing a shroud on inlet valve. Three different intake valves are used, which are differing in length and number of shrouds present on intake valve and those are Single 180˚, Quadruple 45˚ and a Single 120˚. This paper presents the performance and emission characteristics of a single cylinder Diesel engine at constant speed using specified valves. The performance parameters of brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), Mechanical efficiency (ME), exhaust gas temperature (EGT) and Exhaust emissions (HC, CO, NOx) are evaluated. From the results, it is concluding that Single 120˚ Valve showed good performance and improved emissions compared standard and other tested valves.

Keywords*-Engine, Intake valve, Shroud, Swirl , Performance, Emissions*

I. INTRODUCTION

The combustion of the fuel inside the engine is a complex phenomenon and it depends on many parameters like injection pressure, combustion chamber design, degree of mixing inside the cylinder, characteristics of fuel, swirl created etc. Swirl flow in a diesel engine can promote combustion efficiency and help to suppress emissions. Swirl is usually defined as organised rotation of the charge about the cylinder axis. Swirl is created by bringing the intake flow into the cylinder with an initial angular momentum. Intake generated swirl usually persists through the compression, combustion and expansion process. Swirl is used in diesels and some stratified-charge engine concepts to promote more rapid mixing between inducted air charge and injected fuel. There are different ways to produce a Swirl in the combustion chamber of an engine, but this study introducing a Shroud on the inlet valve to produce Swirl, accordingly optimization done. A shroud is a protrusion towards the air inlet placed on the inlet valve, so as to enhance turbulence and create a swirl inside the combustion chamber. A shroud placed near the cylinder head would produce a swirl, axis of rotation of the swirl is parallel to the axis of the cylinder Mehta. P.S, investigated effects of swirl and injection conditions on fuel-air mixing pattern, the premixed mass fraction and the rate of energy release at the instant of ignition, and duration of combustion on engine combustion and emission characteristics. Nishida. K, A. Murakami, experimented swirling flow in a cylinder of a direct injection diesel engine under motored and fired conditions, reported that swirl motion inside the cavity radius is accelerated by the effect of combustion, especially by the effect of pre-mixed combustion in an early stage of diesel combustion. Kimbum Kim and K. Lee, investigated characteristics of the swirl flow generated by swirl control valves (SCVs) and effects of swirl flow on combustion and flame characteristics. And found that, swirl flow helped fuel to be distributed more uniformly in the combustion chamber, thereby decreasing ignition delay and promoting combustion efficiency. Molina. S, J.M. Garcia, studied effect of in-cylinder air swirl on diesel combustion and exhaust emissions of a heavy-duty diesel engine over a wide range of engine operating conditions. Ko Chun Sik, Kim Khwang Soo, made theoretical and experimental study to find optimum swirl ratio for a six cylinder naturally aspirated direct injection diesel engine. Choi. G.H, Y. H. Chang, used numerical model and Computational Fluid Dynamics (CFD) techniques for analysis of effects of swirl chamber passage hole geometry on combustion characteristics, results showed that combustion characteristics are affected by the passage hole areas and the passage hole inclination angles. Boemer. A, studied swirling in-cylinder flow in a Diesel engine using CFD technique. Meglas. A.G, J.V. Pastar, analyzed the swirling flow in the cylinder of DI diesel engines using both steady-state flow rig and CFD calculation techniques on three diesel engines at different configurations. Cosadia. I., J. Boree, made quantitative analysis based on circulation statistics from PIV data obtained in a transparent motored Diesel engine and reported that strong structure fluctuations of the swirling flow took place at TDC. Abraham. J, developed a multidimensional model for flows, sprays, and combustion in engines to study interactions between swirl and the fuel spray in a diesel engine. Fuchs T. R. and C. J. Rutland, revealed that swirl ratio, temperature, and turbulence, were dominant in describing a combustion or emission behaviour. Engine out soot levels are reduced by swirl enhanced mixing of fuel and soot with oxygen. Payri. F, J.V. Benajes, M. Lapuerta, reported that increasing the swirl intensity increases the air velocity entraining into the fuel jet inturn accelerating the mixing process and effects the combustion process. Auriemma.M, F. E. Corcione, U. Di Martino and G. Valentino, reported that the flow structure in direct injection engines is one of the key factors that affects mixture formation, combustion process, and consequently emissions levels.

II. EXPERIMENTAL WORK

In this work, experiments were conducted on a single-cylinder, four-stroke Diesel engine. The specifications of the engine are given in the Table1. The schematic of the experimental setup is as shown in the Fig.1(a&b). The test engine was coupled to a rope brake dynamometer for loading purpose. Fuel consumption was measured by a burette and a stopwatch. Air consumption was measured using an orifice meter connected through an air-box and U-tube manometer. Exhaust gas analyzer (Crypton-290) was used for the measurement of emissions.

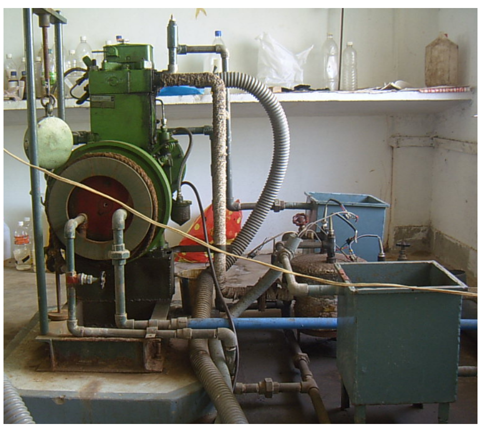
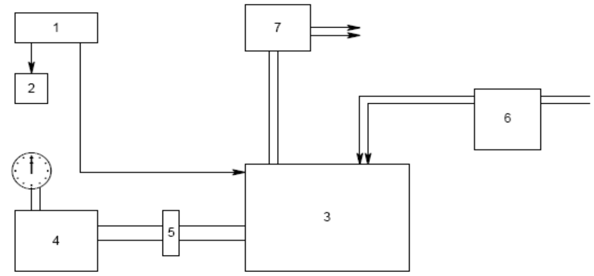


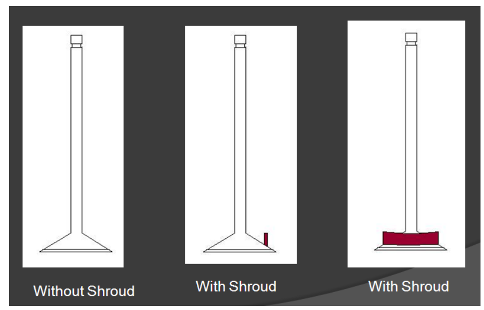
Fig.1(a). Photograph of Experimental setup

The experimental test procedure followed in this work starts with warming up the engine assembled with specified valves. The required engine load percentage is adjusted by using dynamometer. Instrument readings for a particular test case are recorded after a sufficiently long time that ensures steady state engine operation. These procedures are repeated for all the valves specified. Exhaust gas temperature was measured using K-type thermocouple. In this work, all the experiments were conducted at a constant speed of 1500 rpm with load varying from zero to full. Also, constant nozzle opening pressure (NOP) of 210 bar and fixed static injection timing (SIT) of 270 BTDC was maintained for all the tests. The investigations were done using different intake valves to evaluate performance and emission characteristics of the engine. Leak test was performed with basic valve and the three shrouded valves (Single 120° Valve, Single 180° Valve and the Quadruple 45° Valve) which are shown in Fig.2.



1. Fuel tank 2. Fuel Flow meter3. Engine 4. Dynamometer 5. Coupling 6. Air box with manometer 7. Exhaust analyzer

Figure 1(b). Schematic diagram of Experimental



i). Intake valve with shroud

ii). Single 120°, Single 180° and Quadruple 45° shroud valves

Figure 2. Intake valves with shroud and their configurations

Table 1. Engine Specifications

Type	4-stroke, Direct injection
No. of Cylinders	One, Vertical
Type of Ignition	Compression
Cooling	Water cooled
Bore	80 mm

Stroke	110 mm
Compression Ratio	16.5:1
Rated speed	1500 rpm
Rated Power	3.7 kW (diesel)
Starting Method	Manual Crank Start

III. RESULTS AND DISCUSSION

Experimental measurements for different performance parameters of a single cylinder, naturally aspirated, direct injection Diesel engine have been performed using different intake valves.

4.1. Brake Specific Fuel Consumption

The trends of the variations of BSFC with different valves have been verified by comparisons of these values at different load conditions and rated engine speed as shown in Fig. 3. The BSFC Single 120°, slightly lower compared to remain and standard intake valve.

4.2. Brake Thermal Efficiency

Figure 4 shows the variation of brake thermal efficiency (BTE) with load for all the valves considered.Fig.4 clearly illustrates that the Brake Thermal efficiency increases in each case as the load on the engine increases. Single 120˚ valve gave higher, probably due to lower fuel consumption.

4.3. Mechanical Efficiency

To determine mechanical efficiency (ME), initially friction power was estimated based on Willan's line method (Ganesan, 1994). Figure 5 shows the variation of mechanical efficiency with load for different valves. The trends showed an increase in efficiency with increase in loads. The mechanical efficiency depends on the brake power and the indicated power. The indicated power is again a function of the brake power and the frictional power. The Brake power for all the cases is almost same.

4.4. Volumetric Efficiency

The variation of volumetric efficiency (VE) with load for different fuels is as shown in Fig.6. It was observed that there was no significant change in the volumetric efficiency throughout operating range concerning to individual fuels tested, which is good agreement with Sarma et al (2005).

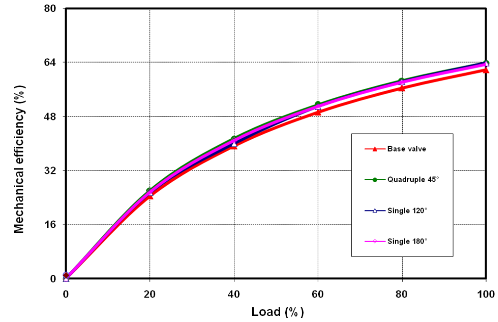


Figure 5. Variation of mechanical efficiency with load

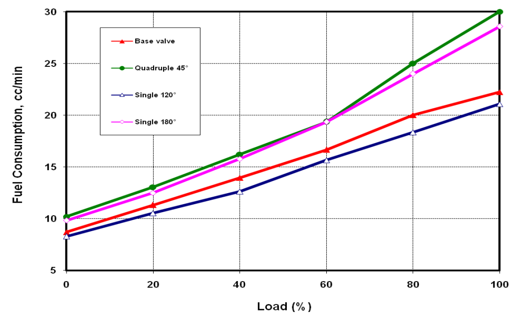


Figure 3. Variation of brake specific fuel consumption with load

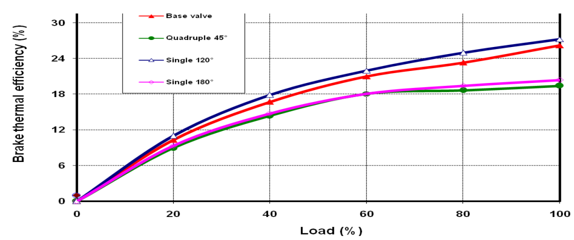


Figure 4. Variation of brake thermal efficiency with load

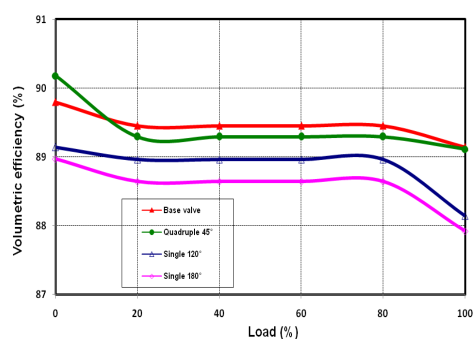


Figure 6. Variation of volumetric efficiency with load

4.5. Hydro-carbon (HC) emissions

Figure7 shows variation of Hydro-carbon (HC) emissions with different loads. The HC emissions for Single 120° valve were lower compared to all. HC emissions are high when incomplete combustion occurs due to two reasons; over lean mixture (air-fuel ratio), or an over rich mixture (air-fuel ratio).

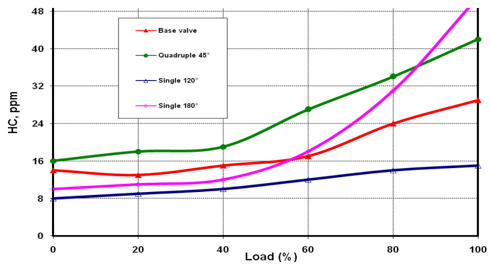


Figure 7. Variation of Hydro-carbon (HC) emissions with load

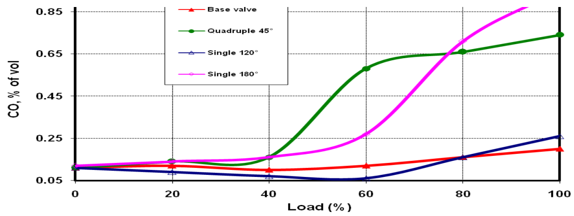


Figure 8. Variation of Carbon Monoxide (CO) emissions with load

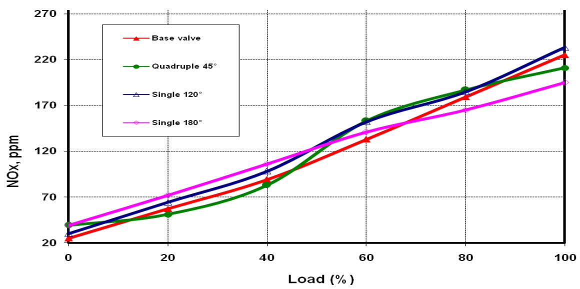


Figure 9. Variation of Nitrogen Oxides (NO_x) emissions with load

4.6. Carbon Monoxide (CO) Emissions

Figure 8 shows variation of Carbon Monoxide (CO) emissions with different loads. The Fig.8 suggests that CO emissions were lower for the Single 120° valve compared to all. CO levels are known to decrease as the air-fuel ratio increases.

4.7. Nitrogen Oxides (NOx) Emissions

Figure 9 shows variation of Nitrogen Oxides (NOx) emissions with different loads. The graph shows that the Single 120° valve has the lowest emissions compared to all tested may be due to high swirl.

IV. CONCLUSIONS

The Single 120° intake valve is the best one compared all specified and standard with reference to performance and low HC, CO and NOx emissions, this is due to better combustion which is achieved by better mixing of the air and fuel.

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