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STUDY ON INTENAL COMBUSTION ENGINE SWIRL FORMATION

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ABSTRACT

Internal Combustion Engine the air fuel mixture enters in to the cylinder from inlet valve and combustion takes place. The air entering into the cylinder will crates swirl motion at intake manifold. Swirl is defined as organized rotation of the air fuel mixture about the cylinder axis. Swirl is created by bringing the intake flow into the cylinder with an initial angular momentum. Swirl is used in compression ignition and spark ignition engines for rapid combustion of air fuel mixture. More the swirl inside the combustion chamber faster will be the combustion of air fuel mixture which results into improved power output of engine. Swirl is generated by two methods during the induction process. First method the flow is directed into the cylinder tangentially toward the cylinder wall, where it is deflected sideways and downward in a swirling motion. In second method swirl is generated within the inlet port where the flow is forced to rotate about the valve axis before it enters the cylinder. The aim of this paper is to summarize efforts taken by various searchers about investigations carried in the swirl mechanism observed in engines.

Keywords : Analysis, Engine, Inlet, Motion, Swirl

I. INTRODUCTION

Swirl is generated in some of the engines with the help of port and valve assembly inside the engine cylinder during the induction process or the cylinder head can be shaped to restrict the flow through one side of the valve open area to generate swirl motion. The combustion chamber is usually a bowl-in-piston design, and a higher air swirl is created during intake and enhanced in the piston bowl during compression to achieve rapid air-fuel mixing. It should be noted that swirling air motion within the cylinder of an operating engine is not uniform. Swirl is used to obtain much more rapid mixing of air-fuel mixture than would occur in the absence of swirl. The tangential velocity of the swirling air flow inside the cylinder during induction is very high. Thus swirl mechanism helps for boosting the efficiency of engine. Swirl makes the turbulence intensity more homogeneous in internal combustion engines. The swirl mechanism in spark ignition and compression ignition is different and depends upon the shape of piston. Swirl can be generated during intake stroke as well as compression stroke of the engine. Through this paper effort are made to present swirling mechanisms in different engines and there effect on the system.

II. LITERATURE REVIEW:

Wendy Hardyono Kurniawan et al. [1] investigated two piston crowns for studying behavior and pattern of swirl, tumble and turbulence intensity field occurred inside cylinder. Based on this study suitable piston shape for engine is selected. The study is carried out for a CNG-DI engine with Piston A has a bowl at the center of its crown while piston B has the deeper bowl volume than piston A and not located in the center. The numerical simulation of piston design is validated with experimental results**. Suleeporn Sombut et al. [2]** authors have investigated effect of Swirl Ratio on In-cylinder Mixture Distribution by CFD approach. The engine used in study has two fuels used one is diesel and other one as natural gas. The numerical analysis consists of, 1) steady-flow simulation to know the swirl ratio and discharge coefficients across the ports, and 2) the engine flow simulation to examine the in-cylinder mixture formation before combustion. The study result show that by providing narrower opening angles of the swirl flap causes promoted turbulent kinetic energy and vorticity, causing the mixture distribution to become more leveled and high swirl ratio with low discharge coefficients. **Bandi.Ramanjulu et al. [3]** performed numerical analysis of different intake manifold Configurations to investigate its effect on air flow structure. The three manifold configurations evaluated are as helical, spiral and helical-spiral. The result shows that helical-spiral intake manifold has higher swirl inside the cylinder, than other two intake configurations of manifolds. **K.M Pandey et al. [4]** performed numerical Analysis of Intake Valve Port of single cylinder four stroke Petrol Engine. The aim of this study is to estimate amount of intake swirl induced by poppet inlet valve and its reduction along the length of the cylinder. Finally simulation results confirmed that intensity of intake swirl reduces along the length of the engine cylinder**. Abhilash M Bharadwaj et al. [5]** author has performed CFD analysis to explore swirl motion in engine. Swirl is two-dimensional solid body rotation, obtained through the compression and combustion cycle. Swirl increases turbulence inside the engine cylinder by Turbulence generated with the shear at the wall is transported throughout the bulk of the flow by diffusion and swirl generated secondary flows or any projective objects not on the axis of rotation of the swirl vortex. Thus swirl requires large intake valve for more air intake and small inlet valve for better swirl intensity. **Robert S. Larame et al. [6]** author has investigated swirl flow motion by comparing Visualization Techniques as direct flow visualization, Geometric flow visualization and Dense, texture-based flow visualization. Normally, the optimum flow visualization technique depends on the needs of the user and the nature of vector field. For example, visualizing swirl flow using 3D streamlines is easier than for the case of tumble motion. Use of different characteristics of the flow with different tools is also possible. Some methods are better for visualizing 2D flow rather than 3D flow. **R. Mikalsen et al. [7]** investigated in cylinder gas flow motion of free-piston diesel engine. Swirl levels are decided by the initial swirl generated within intake system. The swirl momentum losses during the compression stroke are not affected by the piston motion profile because of differences between the free-piston and conventional engines. Gas motion inside the engine depends upon the swirl and the displacement of gas as the piston moves. **N. A. Mohamad Shafie et al. [8]** performed cold flow analysis on internal combustion engine with different piston bowl configurations. During this study three modified piston bowl configurations are considered piston A is Original, Piston B has similar piston bowl shape as piston A except for higher throat diameter than A. For piston C, the bowl diameter and throat diameter is the same as piston A but it is modified into toroidal shape. The numerical results performed with respect to swirl flow motion Simulation values shows that, piston bowl shapes have no significant effect on swirl. The difference in the value of swirl ratio due to piston bowl geometries is up to 2 - 7% during intake stroke. During compression stroke, the effect of piston bowl geometries has significant effect on flow. When modified Piston (with wider throat diameter) is at TDC, reduces swirl ratio, piston modified into toroidal shape enhance the swirl. Thus piston bowl geometric configuration will aid in the development of efficient engines. **F. Payri et al. [9]** performed numerical simulation of in-cylinder flow motion in diesel engines with variable piston geometry configurations. The maximum swirl and turbulence velocities are seen with maximum valve lift in the upper part of cylinder. The maximum swirl level is reported at second cycle of intake stroke, but, swirl decreases rapidly as the valves slowly close. Compression stroke, the swirl velocity is homogeneous in the complete cylinder as the piston moves upwards. The turbulence velocity reduces slightly after the closing of the intake valves. **Idris Saad et al. [10]** authors have studied effect of vane height for generating better in-cylinder air flow motion. During this study Ten guide vane swirl and tumble device models were developed by varying vane heights by 10% to 100% from radius of intake runner. In this paper four vane arranged perpendicular to each other with length three time that of the radius of intake runner. Result shows that lower vane height will provide better in-cylinder air flow motion rather than higher vane height which give more resistance to the flow rather than of generating more swirl and tumble. **Ekrem Buyukkaya et al. [11]** investigated CFD analysis of the air flow motion inside the cylinder provided with different piston configurations of a heavy-duty direct injection Diesel engine. Simulation results conclude that the bowl shapes of the combustion chambers largely influenced the pressure, velocity and temperature distributions at the end of the compression stroke. **Chun Xu. C. et al. [12]** Computational Fluid Dynamics (CFD) simulations are performed to investigate the effect of two piston crowns on the air flow motion in the combustion chamber of a four-stroke direct injection engine. Numerical results shows that piston with shoulder has high swirl ratio than piston with shoulder. **V.V. Prathibha Bharathi et al. [13]** have done work on effect of the air swirl in the cylinder upon the performance and exhaust gas emission of a single cylinder diesel engine. In order to achieve the Different swirl intensities are obtained, by varying the design parameters as the cylinder head, piston crown, and inlet duct. Further by cutting grooves on the crown of the piston swirl intensities are increased, the number of grooves considered are 3, 6 and 9 for intensified swirl and which results into better mixing of fuel and air and their effects on the performance and emissions of engine are noted. **M. N Channappagoudra et al. [14]** authors have studied the effect of air swirl in the cylinder on the performance and emission of a single cylinder diesel direct injection engine with Honge biodiesel. The standard baseline piston is altered by cutting grooves on the piston the number of groves is varies from3, 6 and 9. Piston with 6 grooves has low exhaust gas emissions and at the same time due to high content of oxygen in the Hongebiodiesel gives better air swirl**. S.L.V. Prasad at al. [15]** performed experimental investigation on effect of swirl on single cylinder diesel engine at intake manifold. In order to achieve better air flow motion geometric modifications are done at intake manifold and six configurations are tested. A helical grove of 1 mm wide & 2 mm deep cut into the intake manifold and pitch of groove helix are varied from 2 to 10 mm with step size of 2mm. For configuration MM8 operating temperature in the cylinder is reduced by the air swirl and leads to less exhaust gases. The configuration MM8 has high turbulence and better air-fuel mixing observed**. Balaji M et al. [16]** Investigations are carried out on the effect of various piston designs on air flow and turbulence inside the cylinder of a Direct Injection (DI) diesel engine using Numerical simulations. Pistons are provided with grooves for the rise of swirl intensity for getting uniform mixing of air and fuel. The piston design modifications may lead to rise in Swirl Velocities during compression. The piston design type 3 has high swirl and turbulence than rest two types. Dan **Moldovanu et al. [17]** performed CFD analysis of direct injection single cylinder engine working with biodiesel. During the study swirl coefficient and its effect are evaluated. From swirl coefficient data we may conclude that the swirl axis almost coincides with the cylinder axis, which is good, because it affects the injection process. With rotation of injection cone better air fuel mixing is observed that means better is the swirl**. Jorge Martins et al. [18]** performed redesign of the inlet port of a small Internal Combustion Engine for increasing of turbulence by swirl with CFD simulations. Increase of valve lift results in a decrease of both the swirl number and the swirl component. The best results for swirl are observed with valve lift of 1.5mm. Comparing the swirl number with the swirl component, the values of both numbers at the top are nearly same, because both numbers are calculated in the same way, but the swirl number is calculated in the center of the swirl and the swirl component is calculated in the center of the cylinder. **Pavan Chandra P V et al. [19]** CFD simulation of modified inlet valve and conventional inlet valve is done .The performance is measured in terms of swirl ratio. The swirl ratio of the modified valve (Valve with helical guide ways) is obtained as 1.45 which is much higher than a normal valve with swirl ratio 0.65 as derived in this paper. **Tianyou Wang et al. [20]** investigated in-cylinder swirl flow and tumble flow under reduced Maximum Valve Lift (MVL). A Particle image velocimetry is used for the swirl flow analysis. With reduced valve lift total swirl strength increases significantly. PIV study showed that reduced MVL could improve swirl flow velocity, which resulted in a very regular swirl motion in the late stage of the intake cycle and the strong swirl flow observed at late compression cycle. If swirl ratio for different MVL values, are compared then result shows that reduced MLV can Significantly increase swirl ratio at all almost measured Crank Angles (CA) and on different measured planes.

III. CONCLUSION

In this paper swirl produced in the various internal combustion engines such as, diesel engine, direct injection type, duel fuel and engines operated with biodiesel are reported. The swirl motion is important aspect in relation with ICE because with moderate swirl, the air-fuel mixing will be proper and efficiency of engine is also improved. The effect of geometric parameters of piston on swirl strength is reported by some of authors in this work. Also, note that by modifying inlet valve geometry and changing valve lift results into improvement in swirl strength to greater extent. The intensity of swirl reduces across the length of engine cylinder during inlet valve modification.

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