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Study of IC Engine Manifold Design Developments

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ABSTRACT

IC Engines are classified as Spark Ignition (Petrol Engine) and CompressionIgnition (Diesel Engine). Constructionwise both the engines are same which consists of inlet port (intake manifold) and outlet port (exhaust manifold) and other parts. The air is entered from inlet port and mixed with fuel and power is produced. The important aspect of any engine is power output which is largely depends upon the proper combustion of air fuel mixture. If air fuel mixture are not coming in contact properly which causes loss of efficiency and increased percentage of exhaust gas emissions. The exhaust gas emissions will result into the increased air pollution. In order to overcome this issue many researchers are working for the design of Intake Manifold which will effectively circulate air into cylinder and results into complete combustion of fuel. The aim of this research article is to summarize various effort taken by the researchers towards design and development of IC Engine Manifolds.

Keywords(air, engine, manifold, power, swirl)

INTRODUCTION

Internal combustion engine technology is developing rapidly. Today's automobile engines are more powerful which is required for racing cars and bikes. The power output of any engine is result of proper combustion of air fuel mixture entered into combustion chamber. The air entry plays vital role for fuel ignition and its combustion. The efforts are taken by various designers, researchers and engine manufacturers to improve air fuel mixing and flow of air through intake manifold. Both Spark ignition and Compression ignition engines are having intake and exhaust manifolds. The various configurations or geometric modifications in the intake manifold are proposed by various researchers are summarized in this paper. Different authors have made comparative study of geometric modification in existing intake manifold, plenum length and Poppet valve. This paper also addresses types of engine for which the intake manifold modifications are carried out.

LITERATURE REVIEW

Bandi.Ramanjuluet al. [1] reported effect of swirl on the performance of engine. Numerical simulation of inlet and exhaust manifold is carried out. Investigation of Effect of various configurations such as helical, spiral, helical-spiralforinlet manifold on volumetric efficiency, turbulence, and swirl in the engine. K.M Pandey et al.[2] Performed numerical analysis of inlet valve of single cylinder four stroke SI Engine in order to find the effect of temperature on the intake generated swirl. The numerical study is carried out for Poppet type valve. D Raj Kamal et al. [3] studied IC engine inlet valve for increasing swirl. The inlet valve (Poppet Type) is modified by providing two curve blades at the neck of inlet manifold. According to author two swirl has two types one is Inlet swirl and Outlet swirl. Inlet swirl is affected with any one of conditions such as masking a portion of the inlet valve, by angling the inlet port in the desired direction, by providing a lip in the inlet port, over one side of the inlet valve. In outlet swirl the piston pushes air into piston bowl resulting into higher swirl rate.Abdul Rahiman et al. [4] modified geometry of inlet manifold of engine in order to improve swirl strength and mass flow rate. The geometrical changes are done with respect to plenum shape, primary and secondary length, port diameter; primary pipe section shape. The numerical simulation is carried out with RNG k-ε model due to complexity of the geometry and fluid motion. A.S.Phulpagar et al. [5] simulated air intake system with filter and investigated air flow characteristics for filter geometry and filter media. Unstructured tetrahedral meshing is used. P. D. Solanki et al. [6] performed analysis of performance improvement in four cylinder Four stroke diesel engine with various intake manifold design configurations. The study is carried out for TATA INDICA engine, the bore to stroke dimensions are 75 mm to 79.5 mm respectively. The geometrical changes of intake manifold has resulted into four different models such as Model01: Original Intake Manifold, MODEL 02: No Taper plenum & Hook Type runner MODEL 03: Taper plenum Runner hook Type and MODEL 04: Circular plenum & Hook type runner. Frantisek Sedlacek et al. [7] performed design optimization study on intake manifold of Yamaha YZF-R6 motorbike engine with displacement 599.4 cc. The optimization process consists of four steps viz1. Determination of length and volume of intake manifold, 2. Finding input parameters for1 D modelling of engine, 3. Design of basic domain shape of intake manifold and 4. Checking and optimization of solution using CFD. Through number of simulations for resonant pipes varying in length from 18 to 500 mm and intake manifold volume ranges from 4-8dm^3. The length and volume are selected as 292 and 318 mm and 6.15dm^3.Mohd Faisal Hushim et al. [8] studied change in the intake manifold angle on the performance of engine using CFD. The various angular configurations of intake manifold varies from 30°, 60°,90°,120°,150° and 180°.9.Swapnil Vilas Nimkarde et al.[9] investigated reduction of exhaust gas emissions by improving homogeneity in SI engine. The study is conducted on 4 Stroke, Single Cylinder, Air Cooled engine with bore to length as 80 mm and 110 mm. The intake manifold are modified with three different geometries such as Simple inlet manifold. (SIM), Beads and simple inlet manifold (B&SIM), Threaded inlet manifold (TIM) and Beads and threaded inlet manifold (B&TIM). S.K. Sabale et al. [10] investigated helical shape inlet manifold of diesel engine. Mathematical formulations will benefit for calculating the port dimensions. The proposed helical inlet port is simulated in CFD for each valve lift and results are correlated with experimental set up. Suresh .Aadepu et al. [11] author performed design an Intake Manifold for an 870cc naturally aspirated diesel engine for Greaves Cotton Limited which will give high volumetric efficiency. The existing manifold is having maximum volumetric efficiency of 84% at speed of 2400 RPM.Different intake manifold configurations were designed by changing the five variables, such as primary pipe runner and diameter, plenum volume, and secondary pipe length and plenum volume.Giovanni Vichia et al. [12] the aim of present study is to develop variable geometry intake manifold for engine. The study is carried out for single cylinder, four stroke SI engine for SAE competition. The numerical results has shown that the plenum need to be modified for variable geometry intake system. The authors have simulated four different plenum types viz. Intake line without the plenum, Intake line with the plenum always open, Intake line with the plenum open only when WOT condition is reached and Intake line with the plenum open only whenTVO overcomes the 60% (CL1). The Simulations in stationary and transient conditions have shown that it is better to exclude the plenum from the suction line both at low engine speeds and when the throttle valve opening is less than 60%.A. Raj Kumar et al. [13] Authors have studied swirl producing devices in single cylinder diesel engine. Present study consists of modelling guide vane type swirl producing devices in intake manifold. The swirl producing deices are model with varying number of vanes as three, four five and six. The vane angle is kept between 0° to 40°. The design of vane should be such that the maximum amount of air will be circulated without affecting the volumetric efficiency of engine. M.A. Ceviz et al. [14] investigatedthe effects of intake plenum length/volume variation on the engine performance experimentally on a spark-ignited engine with multipoint injection systems with electronically controlled fuel injectors. During the experimentation engine was operated with speed range of 1500 to 5000 rpm with speed step of 500 rpm. The experimental results shows that intake manifold plenum length/volume improves engine performance. Further variable length plenum can be used high load and low engine speeds as required in urban and suburban roads. The present experimentation need to be carried out with other engine for deciding the length of additional plenum. Rajesh Holkar et al. [15] authors have performed numerical simulation of steady air flow through intake manifold of IC engine.The objective of study is to Uniform distribution of air to all cylinders along with Minimum possible resistance in inlet manifold runners. Proper designs of inlet manifold profile reduce unwanted turbulence and eddies inside the intake manifold. The geometrical parameters inlet port, valve and cylinder consists of port axis offset from the cylinder axis by 4.00 mm in the x direction and 21.87 mm in the y direction and it is elevated from the horizontal plane by 40 degrees. The cylinder diameter is 93.65 mm,the inlet port diameter is 46.00 mm, and the valve diameter is 43.00 mm.In order to achieve high engine efficiency Swirl strength and mass flow rate must be moderate. Sachin Singla et al. [16] performed modifications in intake manifold for improving engine performance.The three different intake manifold configurations are modeled such as Model1 (actual model), Model2 (without internal projections) and Model3 (without internal projections at plenum and without curve at the end of runners. Madhusudan Barot et al. [17] authors have investigated single cylinder four stroke petrol engines to evaluate the performance parameters in suction stroke and power stroke. Numerical simulation is performed to find out mass flow rate of air with variable valve lift such as 2mm, 4mm and 6mm and with increase in valve lift mass flow rate increases. M. A. Jemni et al. [18] authors have investigated effect of modified intake manifold on air fuel mixture flow in LPG Heavy duty engine. Here two manifolds are designed First design consists of a limited volume plenum connecting directly with six runners. The runner's lengths are determined according phenomena of the acoustic wave's propagation in intake manifold. The second design consists of runners coupled to cylinders through a high volume plenum. The design of intake manifold is based on various parameters such as 1.Uniform distribution of mixture to all cylinders, 2.Minimum possible resistance in runners, 3.To provide as direct a flow as possible to each cylinder, 4.To assist fuel atomization and vaporization and 5.To provide equal aspiration intervals between the branch pipes.The engine is bi-fuel gasoline-LPG type IVECO with bore to stroke lengths are as 137 mm and 156 mm respectively. M.L.S Deva Kumar et al.[19] Experimental investigations are performed by authors to study the effect of the fuel injection pressure on performance and exhaust gas emissions of the single cylinder diesel engine at different intake manifold inclinations. A single cylinder 4-stroke water-cooled diesel engine with 5 HP as rated power at 1500 rpm.is used in present study with intake manifold inclination varies in the range of 0°, 30°, 60°and 90°. Dr. Hiregoudar Yerrennagoudaru et al. [20] authors have performed analysis of effect air swirl at intake manifold on the performance of four stroke single cylinder diesel engine. During this study geometry of inlet valve is modified as Base model-Conventional inlet poppet valves, Type2 valve- Inlet valve with masks on its back and Type3 valve- Inlet valve with fins on its back. The mask type valve consists of variable mask configurations from 2 masks, 4 masks and 6 masks. CFD simulations are performed by varying valve lift; the total valve lift is 12 mm and divided into three different types. The valve lifts are Low Lift (valve at 4mm downward movement), Medium lift (valve at 8mm downward movement) and High lift (valve at12mm downward movement). Pandey K. M et al.[21] Modified intake valve design in order to achieve high swirl rate. The study is performed on single-cylinder carbureted four stroke SI engine with bore to stroke length dimensions as 96 mm and 95 mm respectively.The numerical study is performed on three intake valve combinations with geometrical modifications in existing Poppet valve. Piotr Swiatek et al. [22] Experimental investigation of intake manifold of ultralight aircraft by using flow bench test methodology. The specifications of engine are four cylinder with maximum torque of 222 Nm at speed of 2200 rpm. The first manifold consists of one big throttle on the main inlet, smaller plenum and straight runners along with guide vanes, second manifold consists of prototype air tank with planned upper surface and welded flange. Arvindkumar K et al. [23] performed material optimization of intake manifold modeld with Fibre Reinforced Plastic (FRP) the objective is to reduce weight and cost. The study is conducted for 600cc YAMAHA ZF engine. The analysis of intake manifold is carried out in Solid Works with conditions as Runner diameter varying with engine speed and Runner length varying with engine speed. Result shows that FRP has good thermal resistance and low manufacturing cost than other metallic manifolds. Bayas Jagadishsingh G. et al. [24] authors have performed analysis of effect of intake manifold length variation on performance of IC engine. The engine used is Kirloskar TV1, Single Cylinder four stroke diesel engine having Bore *stroke length as 87.5 * 110 mm. During study Intake manifold lengths are changed for different engine speed between 1200-2000 rpm. Jianmin Xu [25] author has performed numerical simulation on three types of the intake system which consists of an inlet end, regulator chamber and intake manifold .The inlet ends of design 1 and 2 are located at the side of the regulator. The inlet end of design 3 is located in the middle of regulator.

CONCLUSION:

Effort taken by researcher in design and development of various alternatives in the field of internal combustion engine manifolds is presented in this paper. Authors have reported that modifications in the intake manifold design has led to improved engine performance. The parameters like swirl strength in intake manifold, volumetric efficiency, brake power and reduced exhaust gas emissions are outcomes of research done by different persons towards the development of internal combustion engine technology.

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