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Design and Simulation of Helical Intake Manifold

S. Ravi[1], B. Rahul[2], E. Shibin Basil[3], V. Vijay[4]
[1]*Assistant Professor, Dept. of Mechanical Engineering, Sri Ramakrishna Engg. College, Coimbatore, India*
[2,3,4]*Student, Dept. of Mechanical Engineering, Sri Ramakrishna Engg. College, Coimbatore, India*

***Abstract*—The intake manifold is an arrangement of component which delivers either air or air/fuel mixture to the cylinders. It is used to evenly distribute the combustion mixture through the pipe through design and orientation engineering of the manifold. The manifold also acts as a connecting device between the other components of the system. The helical manifold which is often used now-a-days have a drawback with respect to pressure loss and friction loss. Another issue that is identified with spiral manifold is the volumetric efficiency. Though it brought a slight increase in efficiency further modification of design can be done. The proposed system is a helical intake manifold which mainly concentrates to overcome the pressure loss and also increase volumetric efficiency. This engineering method provides better results than the regular runner designs. Thus it may serve as a better design for future.**

***Index Terms*— volumetric efficiency, pressure, friction, spiral, helical.**

I. Introduction

When designing an engine for an automotive application it is necessary to design a quality intake system. The function of the intake system is to give the air for combustion process i.e. to distribute the air evenly to the engine system. Thus this increases the systems efficiency effectively. The geometric design of the manifold affects the performance as well as the volumetric efficiency. The intake manifold consists of three parts as follows,

1. Restrictor: It is a control device that is used to control the mass flow rate.
2. Plenum: It is a device used to equalize the pressure for more even distribution of air-fuel mixture in combustion chamber.
3. Runner: This is used to deliver the air from plenum to the combustion chamber as a part of air intake system.

To realize the ultimate objective of the design and supplying equivalent amount of combustion air to the cylinder, there are certain key factors to be followed.

1. To reduce the pressure loss, as it results in decrease of output power.
2. Minimize the mass of the system, a common aim of every domain of the vehicle.
3. To maximize the air flow velocity into cylinder as this provides great mixture of fuel and air which improves combustion and performance.

The increase in volumetric efficiency, reduced fuel emissions, etc. has been witnessed in many researches in the past few years. This idea of implementing a helical manifold will make a great impact in the future engineering.

II. Literature Survey

In the paper "Design & manufacturing of spiral intake manifold to improve Volumentric efficiency of injection diesel engine byAM process" the authors A.Manmadhachary ,M.Santosh Kumar and Y.Ravi Kumar has proposed a design of spiral intake manifold was altered with variable intake areas and the intake runners are bent around a common axis. The designed spiral intake manifold was fabricated using Additive Manufacturing (AM) technique. In this work, a Kriloskar single cylinder diesel engine has been used, which is coupled with tachometer and dynamometer. For the purpose of this study, the intake manifold was dismounted from the engine and the AM manufactured spiral intake manifold has been fitted. The spiral intake manifold was installed on the test rig and volumetric efficiency was calculated accordingly. Comparison is made with respect to volumetric efficiency using with and without using spiral intake manifolds.

The paper "Design of a new SI engine intake manifold with variable length plenum" by M.A.Ceviz M.Akın investigates the effects of intake plenum length/volume on the performance characteristics of a spark-ignited engine with electronically controlled fuel injectors. Previous work was carried out mainly on the engine with carburetor producing a mixture desirable for combustion and dispatching the mixture to the intake manifold. Since the intake manifolds transport mainly air, the supercharging effects of the variable length intake plenum will According to the test results, plenum length must be extended for low engine speeds and shortened as the engine speed increases. A system taking into account the results of the study was developed to adjust the intake plenum length.

"Influence of intake manifold design on in-cylinder flow and engine performances in a bus diesel engine converted to LPG gas fueled, using CFD analyses and experimental investigations" by author Mohamed AliJemni ,Gueorgu iKantchev and Mohamed SalahAbid proposes the system of diesel exhaust emissions are a major source of pollution in most urban centers around the world. Furthermore, the price of crude oil continues to increase rapidly. The use of alternative fuels and the optimization of combustion present effective solutions. Improving combustion is directly related to improving the intake aerodynamic movements which is influenced by the inlet system. This modeling made it possible to provide a fine knowledge of in-flow structures, in order to examine the adequate manifold. Experimental measurements are also carried out to validate this manifold by measuring the important engine performances. Brake power (BP), brake torque (BT) and brake thermal efficiency (BTE), are increased by 16%, 13.9%, and 12.5%, respectively, using optimal manifold. The brake specific fuel consumption (BSFC) is reduced by 28%. Simulation and experiments results confirmed the benefits of the optimized manifold geometry on the in-cylinder flow and engine performances.

Modeling and online parameter estimation of intake manifold in gasoline engines using sliding mode observer"by RazaButt, Aamer IqbalBhatti proposes a model based control of automotive engines for fuel economy and pollution minimization depends on accuracy of models used. A number of mathematical models of automotive engine processes are available for this purpose but critical model parameters are difficult to obtain and generalize. This paper presents a novel method of online estimation of discharge coefficient of throttle body at the intake manifold of gasoline engines. The resulting model shows a very good agreement with engine measurements in steady as well as transient state. The stability of the observer is shown by Lyapunov direct method and the validity of the online estimation is successfully demonstrated by experimental results.

In the paper, "Design and CFD analysis of the intake manifold for the Honda CBR250RR engine" by Subhash Seshadri, MS,the scope is to improve reliability issues on a turbocharged Honda CBR250RR engine and boost the performance by redesigning the intake manifold - one of the key components of this engine package. The new manifold is aimed at tackling these issues by supplying uniform amount of air to all four cylinders. 3D modeling is done using SolidWorks and the internal flow distribution will be calculated and tuned using CFD analysis on Star CCM+. A 1D simulation of the complete engine was set up using Ricardo Wave to optimize the runner lengths and to predict the performance of the engine. The intake will be manufactured out of thermoplastic using rapid prototype printing or what is also called as 3D printing.

III. Proposed System

A. Design of Helical Intake Manifold

Intake manifolds contains of a chamber called plenum, to the inlet of which run off the restrictor, with the certain feeds to pipes it leads to each cylinder. Standard intake manifolds for automobiles have fixed air flow to the intake port. At one particular rpm stable intake manifold can be perfect, so it is beneficial to create a process to vary the intake length/volume, since the engine runs at different speeds. Combustion air intake manifold deliver more air as possible for a given size (volumetric efficiency). The design of the intake manifold has an important effect on the engine efficiency parameters. The combustion air intake manifold increases the engine efficiency by feeding the amount of air to the combustion chamber of an IC engine. Generally, the testing of intake manifold is done by direct prototypes & running the engine. In most automobiles the design of the runner in the manifold is in form a cylindrical runner shape. This shape has a streamlined air flowing to the combustion chamber. In order to increase the turbulence model the shape and design of the runner is changed into helical shape. The helical shape is provided in to increase the air flow turbulence and also the combustion process, which in turn increase the volumetric efficiency which is primary goal. To increase airflow there are three ways. The first is to control the force of the air velocity to fill the combustion chambers. By this cams keep the valves open before top dead center (TDC) and after bottom dead center (BDC). If all the causing parts are balance to the same rpm range air carriers to fill the combustion chamber as the piston moves upward. It causes to the speed of the intake charge gives the inertia to oppose backward flow, to a point. The second, this is related to inertia tuning, it's complicated to run at a particular rpm. Ports works well by induction wave tuning. The third, shapes of port and valve improves the flow. Swirl is one of the principal means to ensure rapid mixing between fuel and air in diesel engine and is used in engines to promote rapid combustion. The swirl level at the end of the compression process dependent upon the swirl generated during intake process and how much it is amplified during the compression process. In diesel engine, as fuel is injected, the swirl converts it away from the fuel injector making fresh air available for the fuel about to be injected .In this work, our aim is try to improve the airflow in intake manifold by changing cross-section shape to get swirl motion of intake air.

B. Aim of the Intake Manifold

A well designed intake manifold will deliver a uniform air to the cylinder in as direct a flow as possible, with appropriate air velocity to sufficiently maintain volumetric efficiency at low and high engine speeds. For example, in drag racing, a max effort design is desired where peak horsepower, between shift points, is ideal to maintain the highest possible acceleration. As stated earlier, a road racing vehicle, where the primary focus is suspension design and driver feedback, a long and flat torque curve is desired.

Fig. 1. Regular intake manifold

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C. Losses in Manifold

Pressure losses in pipes are split into two categories, major and minor. Major losses is due to the physical length of the pipe and the viscous losses associated with the friction between the wall and the fluid. Minor losses occur due to variations in geometry through the piping such as bends, elbows, valves, entrances and re-entrances. The terms major and minor do not refer to the relative sizes of the losses necessarily, but in typical piping systems involving many long straight sections with few bends and valves the major losses are more substantial than the minor. In the case of an intake manifold however, the minor losses are far more significant, and typically dominate the pressure losses experienced. Several text books quote pressure loss coefficients for various geometries whether they be entrances, re-entrances, bends or valves. While these particular values are important in an analysis of a pipe system their values are not important specifically for the design of a new intake, but their relative size is.

D. Effect of Runner Size

The runner of an intake manifold is the predominant tuning tool for modifying volumetric efficiency. Changes in size of the runner is usually the simplest approach with a given engine design, with the cross sectional area, and therefore diameter, already known basis based on the cylinder head cross sectional area prior to the valve. Changing the runner size also has the advantage of being infinitely adjustable, where the diameter is limited to available pipe diameters unless more expensive manufacturing processes such as machining or rapid prototyping are used. For these reasons, runner length modification is practical and the basis for experimentation.

E. Helical Shaped Runner

The intake manifold was designed with 3-Dimenstional (3D) solid modelling software (Catia). It works based on feature-based, parametric modelling methods.

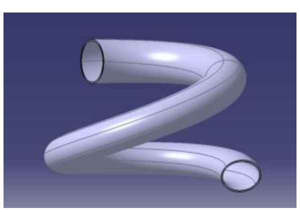

Fig. 2. Helical runner

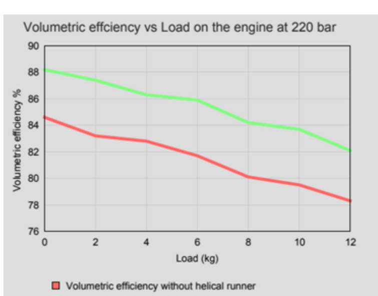

Fig. 3. Volume efficiency vs. Load on the engine at 220 bar.

While design a manifold, considered a spiral shape to get swirl motion of air in to intake manifold. Both the ends of the manifold have an elliptical cross section, with the various diameters. It's one end is considered same as exist uniform intake manifold diameter of internal combustion engine and other end of manifold diameter considered as ratio of 1:1, i.e. "a" parameter of the ellipse has a diameter of 45 mm where as the "b" parameter of the ellipse has a diameter of 135 mm.

The circular mouth cross is not used in the design for the following reasons. In the circular cross section the pressure losses are high due to the concentration of air at single place and frictional losses, so this is the appropriate reason to not use circular shape plenum for final intake manifold design.

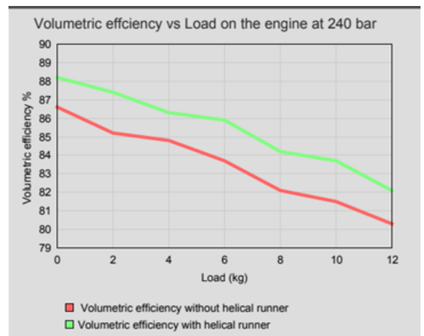

Fig. 4. Volume efficiency vs. Load on the engine at 240 bar

The reason for choosing elliptical cross section is that higher volumetric efficiency can be achieved by using such type of cross section and less pressure and frictional losses compared to circular cross section, because it is fulfilling the objective up to some extent. So that elliptical cross section is taken for this final intake manifold design. The performance comparison with respect to volumetric efficiency vs. load on the engine at different levels as represented in graphs Fig. 3 and Fig. 4 is observed and the conclusions are made.

IV. CONCLUSION

Thus, the change in manifold designs have been through various phases in the past years. The helical manifold design is such a kind of a design which is expected to give high volumetric efficiency with less frictional a pressure loss. This design can serve a great purpose to increase fuel efficiency in future.

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