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Performance Analysis of intake manifold for injection Systems of CNG Engine

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Abstract— The initial variations were pre-requisite in the internal-combustion engine, such as piston, exhaust, manifold for attaining effective torque, power and productivity. Moreover, it is also used for lessening poisonous gases of emission. These factors were the cause for enhancement of engine performance. The intent of intake manifold is disseminating the combination of air fuel equally over entire cylinders. Here, the objective of this manuscript is designing intake-manifold & examine the fuel injection position impact and mixture of air fuel on CNG SPFI performance. Here, modeling intake manifold is done by utilizing reverse data engineering. The multiple systems have been examined for deflection as well as stress. Moreover, the mixture of air-fuel has been assessed by utilizing analysis of computation fluid dynamics on the basis of uniformity index through changing location of injection. Furthermore, the turbulence impact was depicted by k turbulence method. Here, the performance of engine has been predicted by utilizing 1D experimentation software, where their outcomes have been compared to simulation outcomes.

Keywords: Manifold, SPFI, CFD, fuel injection, Injection locality

1. Introduction

In interior ignition motor the internal manifold is the aspect of the motor among the Cylinders and the choke body. In a multi-chamber motor, its main role is to equally convey the wind stream among every chamber, and to make the standardized fuel air blend. The mass stream pace of air that enters in the motors chambers huge effect on the volumetric productivity. We have 2 sorts of fuel injection approaches SPFI Single Point Fuel Injection indicated & MPFI Multi Point Fuel Injection indicated System. The SPFI is a method of solitary injector, or a gathering of injectors bunched together in one, generally unified mark on the internal manifold. In this framework the infusion area assumes indispensable job to get better the consistency of the Air-Fuel Mixture. Maji Luo Guohuaetal [1] has mathematically reproduced Three-dimensional consistent flow in 2 sorts of channel complex utilizing the discretionary Lagrangian – Eulerian (ALE) technique. The impacts of disturbance are spoken to by k-Ɛ confusion model. Mass stream paces of the frameworks are determined and contrasted with pick the effective internal manifold plan. The work in [2] have contemplated the air-fuel stream example of long and short sprinter internal manifold with various plenum chambers and the stream dissemination of air from plenum to singular sprinters utilizing CFD investigation. The work in [3] have researched the impacts of various admission sprinter length and breadth on the exhibition of a four stroke and single cylinder IC Engine and consequences are approved utilizing GT-Power recreation programming. The work in [4] has indicated that the structure of internal manifold and the valve port in IC Engine consequences for volumetric proficiency and stream power. CFD examination is executed on the admission valve of the rapid flash start Engine to explore the dependability of polyhedral matrices of various sizes and to survey the necessary work size. The work in [5] has completed the investigation to build up a winding internal manifold model to foresee gas stream in the admission arrangement of single chamber IC Engine. Internal manifold has huge impact on the volumetric proficiency and the presentation of the motor. The work in [6] dealt with the admission sprinter breadth and valve timing of complex framework by varying them independently.

Experimentation has been completed utilizing Engine reproduction programming Ricardo wave to discover the impact of admission sprinter width and timing on the motor execution and the outcomes are contrasted and skeleton dyno test results. The work in [7] has researched the impact of admission length for various speed of the Engine on volumetric proficiency. 1-D recreation is accepted out to foresee the weight wave at two distinct areas on consumption complex and contrasted and test information. The work in [8] have conveyed out the liquid stream investigation for the course during the intake complex with various cross area of choke body utilizing CFD examination. The idea of the stream during the valve and the relative reading of the weight and speed variety are made [10].

2. Modeling and Simulation of Spfi Manifold System

This area manages the expectation of pressure and distortion prompted in the internal manifold. The information base for internal manifold is acquired by Re-building of presented box complex utilized in cars. The presented H4TC CNG Engine SPFI internal manifold framework is altered with various Injections area is then demonstrated utilizing CATIA programming. The gathering of complex framework comprises of plenum, center, choke body; these are made independently and collected by relating proper resilience's and imperatives. In presented box complex framework, the infusion site 175 mm away from chokes body [12]. The created representation is expelled to meet 3.65-liter volume necessities. To procure improved consistency list the changed inner complex is Re-balanced with another mixture region at 155mm, 225mm, 145mm, 125 mm away from gag body notwithstanding 175mm. The ingestion complex evades to an engine part that arrangements the air and fuel mix to the chambers. Affirmation complex plenum encourages the appropriation of this mix [14]. It's of rectangular shape having volume 2.65 liters, length and width is 655mm and 113mm independently. Focus point is the part between stifle body and plenum. It's of indirect shaped channel having 60mm estimation. Gag body is liable for controlling the measure of Air-Fuel that streams into an engine. In Single point fuel infusion framework, the fuel infusion area plays a huge activity on Air-Fuel mix. The system has 14 deltas of 6mm estimations and 175mm length gone from choke body.

Figure.1. Intake manifold Core

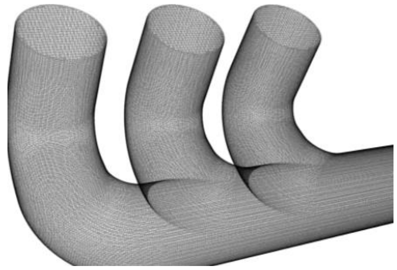

Figure.2. Mesh Geometry of Intake Manifold

CAD model has been spared in STP record and brought interested in ANSYS condition for the bring in geometry is hygienic for lost line, hole filling and equivocal areas and so forth. Bring in and fit sanitary calculation is coincided by tetrahedral component have 0.6433mm least size and 82.34mm most extreme dimension of the constituent.

3. 3D CFD SIMULATION: SPFI CONFIGURATION

Diverse mass stream rate is given during examination on CNG gulf and air bay while distinctive weight circumstances are specified at delta and outlet. Surrounding weight and temperature are specified at Air gulf and CNG channel

The 3D CFD margin Conditions are as, air channel temperature 300k, pressure 0p, & rate of mass-flow 0.09638kg/sec, & the value of CNG delta pressure 0 p, rate of stream is 0.005606kg/sec. the blend condition at the inlet of engine is - 3600pascal

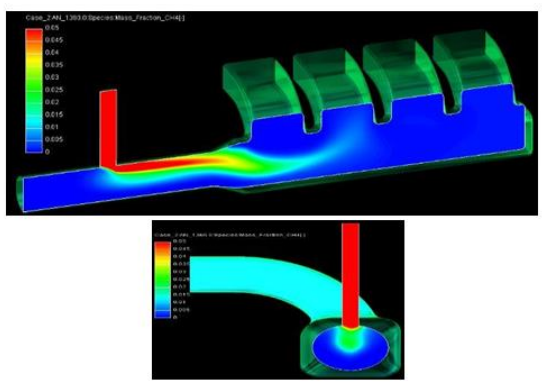

Figure.3. The simulation of 3D CFD for the configuration of SPFI

For the angle of 90 degrees position of injector, the combination of CNG along with air would be satisfactory. The required power is given by engine.

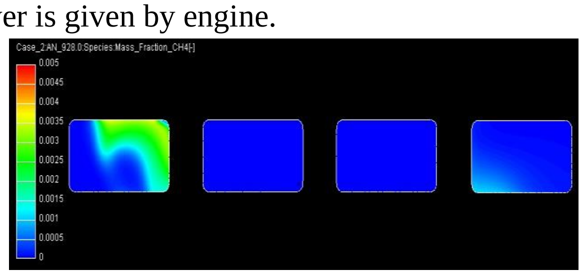

Figure.4. Flow in Cylinder 4, when active

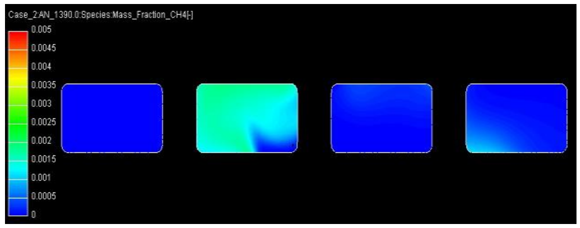

Figure.5. Flow in Cylinder 3, when active

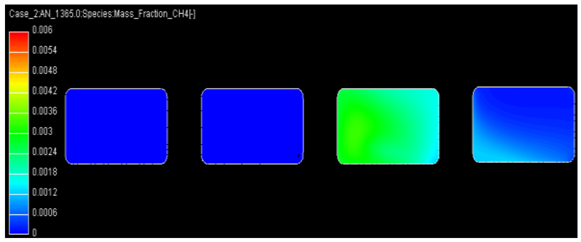

Figure.6. Flow in Cylinder 2, when active

Stream in sprinter outlet no.1, 2 and 3 is consistently dispersed over the cross segment. Nevertheless, flow has been relatively low through sprinter 1 as its position has been away from inlet of air. In outlet 4, the flow has been amassed in the top half in entire segment. Here, it is credited to way that, there is an abrupt preoccupation of approaching stream and through math thus; it isn't arriving at the inward corners of cross area. Anyway, stream is acceptable attributable to closest region of runner4 to the approaching air from air filter.

4. 1D CFD ANALYSIS OF SPFI CONFIGURATION

The limit conditions for the 1 D investigation of Turbo charged 4 Cylinder SPFI CNG motor complex are the Engine chamber calculation, Valve timing profile, terminating request, fuel properties, choke body trademark, Turbo charger Map and attributes, Inlet port stream profile and coefficient, delta pipe breadth of the complex, Length of the bay complex (Plenum length), and so forth Motor execution is evaluated for speed rang of 1000 to 2600 rpm for adjusted SPFI framework from GT Power and on a real motor in motor test cell. The outcomes are as per the following-

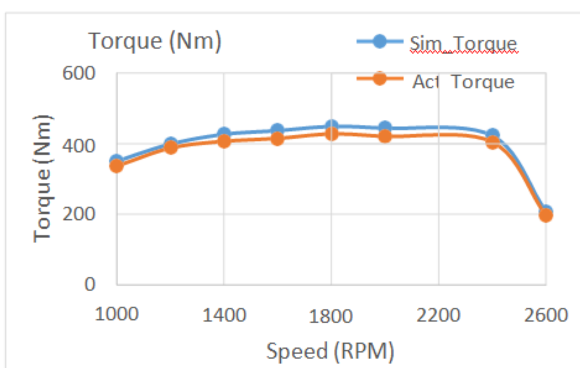

Figure.7. 1D CFD Analysis

5. MODELING AND SIMULATION OF MPFIMANIFOLD coordination

This category of injection method utilized injector rail for accepting CNG to the motor. These frameworks take a shot at the rule of velocity thickness and use MAP sensor to approximation the load on the engine.

The trait of the fuel-air blend, which is framed in the admission port, relies on a few variables. Among these are air speed and weight dissemination, choppiness valve and so on nonetheless; the temperature profile in the admission port is the factor that has a most articulated neighborhood impact upon the fuel vaporization process.

Internal manifold plenum encourages the conveyance of this blend. It's of rectangular shape having volume2.65litres, length is of 660mm, height and width of plenum is 65 × 80 mm individually. Center is the part between choke body and plenum. It's used to supply air fuel mixture towards the plenum. It's of square molded channel. Choke body is liable for calculating the measure of Air-Fuel that streams interested in a motor. It is having 55 mm internal breadth. Internal manifold Runners are the piece of internal manifold which supplies air-fuel blend to the individual chambers. The fuel infusion is done on the sprinters in MPFI System. They are of rectangular shape and having length 65mm and tallness and width is 48 mm and 53 mm.

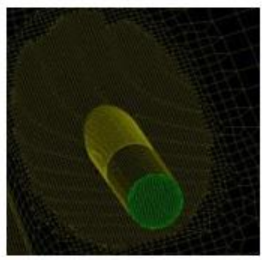

Figure.8. Meshed geometry of MPFI System

Introduce and fit cleaned calculation is coincided by tetrahedral component contains 0.5mm least size and 40mm most extreme size of the component. The less size of meshing is produced at the basic aspect of the calculation. The sort and size is chosen dependent on reasonableness and kind of investigation. Fit Intake complex framework comprise of 174012 components and 928472nodes.

6. 3D CFD SIMULATION OF MPFI CONFIGURATION

For the position of CNG injector when placed at 30º, the CNG blending along with air has been started at top territory & estimated as top cross-region since it courses by internal port. Moreover, engine has been providing ideal force.

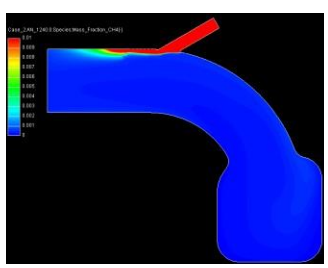

Figure.9. View from ‘Y

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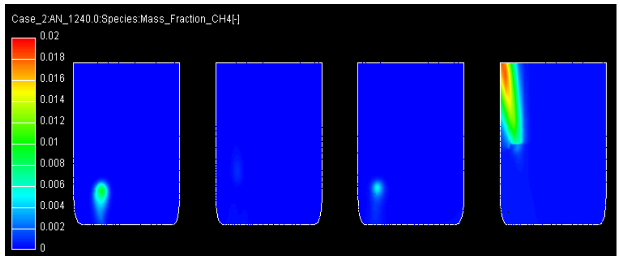

Figure.10. Flow in Runner Outlet, When Active

Stream design attach sprinter outlet is genuinely consistent. The curly nature is because of wave elements within the sprinter that goes about as a funnel. Normal deviation in stream at sprinter no. 1, 2 and 3 w.r.t. sprinter no.4 is 5.98%. Normal mass stream pace of the blend for the significant part of positive stream during the cycle is 0.1711Kg/s. This development over the standard reenactment (0.1678 Kg/s) is because of moving from SPFI to MPFI setup. SPFI may lessen the wind stream because of communication of approaching air with CNG at the delta of the internal various.

7. 1D CFD ANALYSIS OF MPFI CONFIGURATION

The boundary conditions for the 1 D analysis of Turbo charged 4 Cylinder MPFI CNG engine manifold are the Engine cylinder geometry, Valve timing profile, Firing order, Fuel properties, Injectors characteristics, Injector location angle, Turbo charger Map and characteristics, Inlet port flow profile and coefficient, Inlet pipe diameter of The manifold, Length of the inlet manifold (Plenum length),etc….

Engine performance is assessed for speed rang of 1000to2600rpmformodifiedMPFIsystemfrom GT Power and on an actual engine in engine test cell. The results are as follows

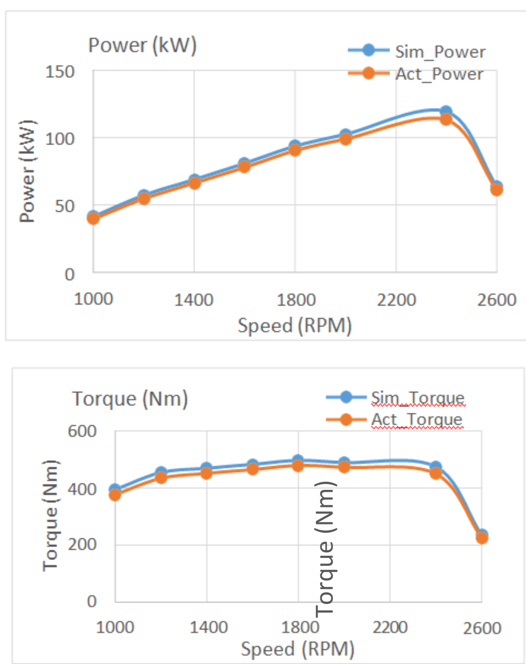

Figure.11. Compare MPFI system from GT power analysis

From the result of both systems it is found that the nature of both curves is same and the modified MPFI system from GT power analysis provides 3.5% to 5% greater power as compared to actual engine test results collected from engine test laboratory.

8. PERFORMANCE COMPARISON OF SPFI AND MPFI CNG ENGINE

With that analysis we can summarized the data for air fuel mixture flow in MPFI & SPFI engines. In case of MPFI configuration, Air+CNG mixture flow is improved as compared to SPFI configuration. SPFI might lessen the flow of air because of inflowing air along with CNG near internal manifold inlet.

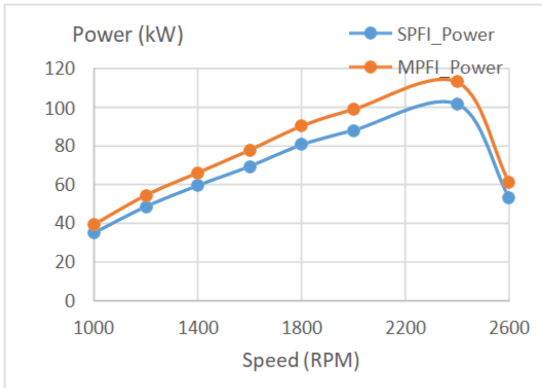

Figure.12. Analysis on the basis of Engine tests in test cells

The same engines are tested in the test lab on engine test bed. Engines warm up and conduct the full throttle performance from 1000RPM to 2600RPM.Afteranalysisofboththeresults, power and torque observed in the MPFI engine is approximately 10% more as compare to SPFI engine.

9. Conclusion

The following conclusions are obtained from the research work carried out using 3D CFD analysis, 1D analysis and Experimental test results of intake manifold.

SPFI system

The90°CNGinjectorpositionissatisfactory for required engine performance and observed that the air fuel mixture is uniformly distributed at each manifold port outlet.

When compared to 4 runner outlets, here distribution flow has been comparatively low by runner 1, as their position is far away from inlet of air. Furthermore, the runner outlet flow at no 4 has been focused on top half across the segment. It has been featured that, there could be drift diversion of inflowing flow and through geometry; therefore, it has not been attaining cross section inner corners or edges.

From 1D analysis, it is observed that the nature of both curves is same and the modified SPFI system from GT power analysis provides 4% to 5% greater power as compared to actual engine test results collected from engine test cell.

MPFI System

The injector position of CNG is 30 degrees and is adequate for combining the CNG along with air could be started at upper region and has been estimated to fill the cross-segment since it flows along intake-port.

Average variance in flow at runner no. 1, 2 & 3w.r.t. runnerno.4is5.98%. moreover, average rate of mass flow over mixture for the maximum portion of positive flow at the time of cycle is 0.1711Kg/s.

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