Optimisation of Intake Manifold Design Using Fibre Reinforced Plastic

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Abstract

In this paper we discuss the design and manufacture of an intake system for a 600cc YAMAHA ZF engine. Intake system have a major effect on a vehicle's engine performance, noise and pollutants. Differences in engine outputs and applications require different designs of intake-air manifolds in order to achieve the best volumetric efficiency and thus the best engine performance. As a result, the geometry of the intake system has been redesigned to result in reduced weight by using FIBER REINFORCED POLYMERS (due to lower material density and lack of welds, thermal, heat aging, fatigue, impact, creep, stress and chemical resistance), improved charge distribution, and increased torque through a wide RPM range when compared to its traditionally-manufactured aluminum counterpart.

Keywords- Fiber Reinforced Polymers , Intake-air manifolds, plenum

1.Introduction

The first intake manifolds made of plastics were then called as in feed manifolds , used in a 6 – cylinder engine at Porsche company. They went into series production in 1972.These manifolds were manufactured by injection – moulding process. The material used was polyamide 6 6, which showed good results for ten years. In 1990 the fusible core technique went in mass production at BMW.Among Indian cars, only the new Maruthi Suzuki Alto 800 is using a plastic intake manifold

2.Literature Review

From the journal titled "Design of a new SI engine intake manifold with variable length plenum ,M.A. Ceviz, et.al., we came to the understanding that engine performance characteristics such as brake torque, brake power, thermal efficiency and specific fuel consumption were taken into consideration to evaluate the effects of the variation in the length of intake plenum. The results showed that the variation in the plenum length causes an improvement on the engine performance characteristics especially on the fuel consumption at high load and low engine speeds which are put forward the system using for urban roads. 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[1].

From the journal titled "Influence of intake manifold design on in-cylinder flow and engine performances in a bus diesel engine converted to LPG gas fuelled, using CFD analyses and experimental investigations ,Mohamed Ali Jemni et,al.,we came to the understanding that the influence of the intake manifold geometry is studied on a converted gas engine. In-cylinder flow modeling is made using CFD through two manifold designs. An experimental comparison is made between manifolds by testing engine performances[2].

From the journal"Modeling and online parameter estimation of intake manifold in gasoline engines using sliding mode observer Qarab Raza Butt et.al.,we came to the understanding that the 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 discharge coefficient is taken to be a varying parameter. Air mass flow across the throttle body is a critical variable in maintaining a closer to stoichiometric air fuel ratio; which is necessary to minimize the pollution contents in exhaust gases[3].

3.Experimental

The initial function of the intake manifold system is to deliver air-fuel mixture to the engine for combustion. The primary design goal is to distribute the combustion mixture evenly to each intake port, as it improves the engine's ability to produce torque and power efficiently and effectively. The geometry of the intake system affects the volumetric efficiency of the engine, and in turn affects the performance of the vehicle.

Pro e design of intake manifold:

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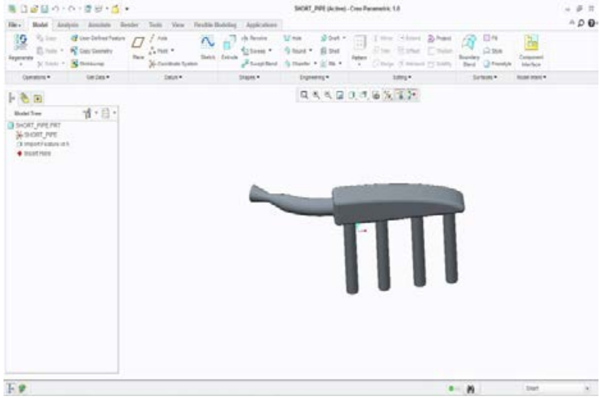


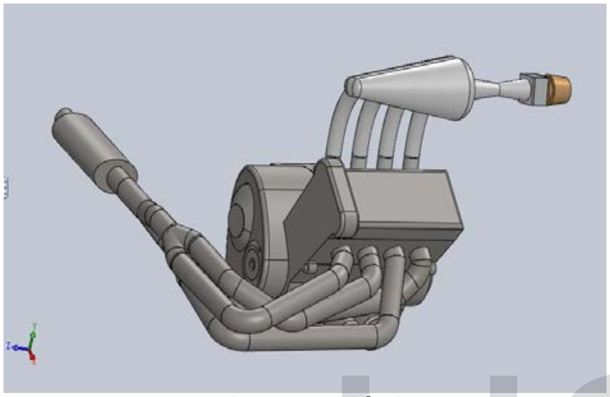


Fig. Assembled view

DESIGN CALCULATION

- Length of the runner

NL = 84000

Where N→ speed (rpm)

L→ length of the runner

For optimum speed (N=7200 rpm)

$$L = \frac{84000}{7200} = 29.63 \text{ cm}$$

For maximum speed (N= 13000 rpm)

$$L = \frac{84000}{7200} = 16.4 \text{ cm}$$

- Diameter of the runner

$$D = \sqrt{\frac{displacement \times VE \times speed}{velocity \times 18.5}}$$

Where VE → volumetric efficiency

For optimum speed (N= 7200 rpm)

$$D = \sqrt{\frac{0.6 \times 0.8 \times 7200}{3330}}$$

D = 1.01 inch

For maximum speed (N= 13000 rpm)

$$D = \sqrt{\frac{0.6 \times 0.8 \times 13000}{3330}}$$

D = 1.36 inch

- Percentage of weight reduction

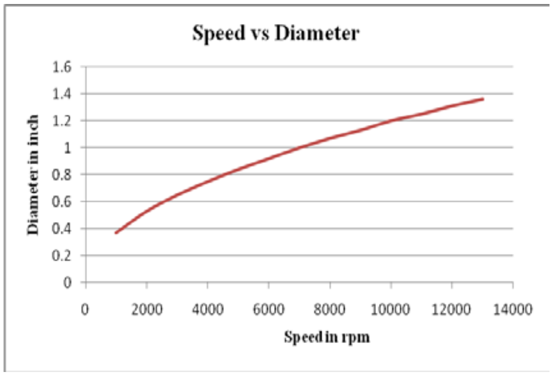
$$weight\ reduction = \frac{weight\ of\ present\ plenum \times weight\ of\ replacing\ plenum}{weight\ of\ present\ plenum}$$

$$= \frac{2700-1700}{2700} = 37\%$$

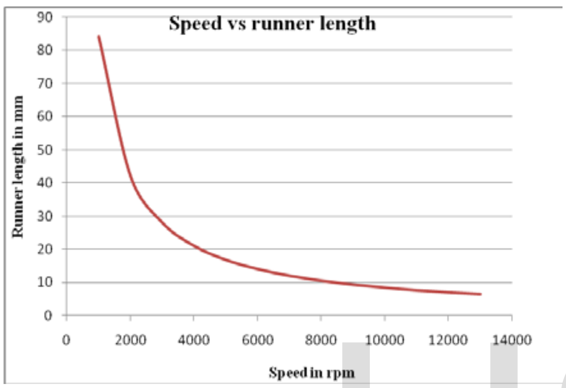
- Variation Of Runner Length And Diameter For Various Speeds

Speed(rpm)	Length(cm)	Diameter(inch)
1000	84	0.37
2000	42	0.53
3000	28	0.65
4000	21	0.75
5000	16.8	0.84
6000	14	0.92
7000	12	1
8000	10.5	1.07
9000	9.33	1.13
10000	8.4	1.2
11000	7.6	1.25
12000	7	1.31
13000	6.46	1.36

- Runner diameter varying with engine speed



➢ Runner length varying with engine speed



4.Methodology

Design of plenum:

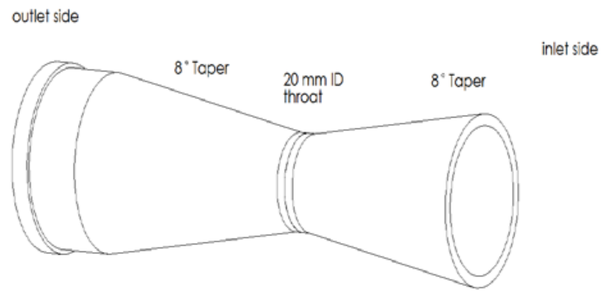
In designing the plenum, it is important to achieve an even static pressure as this will cause the cylinders to pull the same vacuum, leading to even flow in each cylinder. For that, the manifold should have no sharp bends and the interior wall surface should be smooth. The plenum's job is to gather air and deliver it to the runners so that the cylinders can be properly filled during their intake strokes. The three most important design considerations of the plenum are its volume, equal distribution of air to the runners and smooth intersection of plenum with the runners. As these three areas receive more attention, the shape of the plenum doesn't affect the performance. The volume of the plenum should be directly related to the engine displacement volume.

Design of Runner:

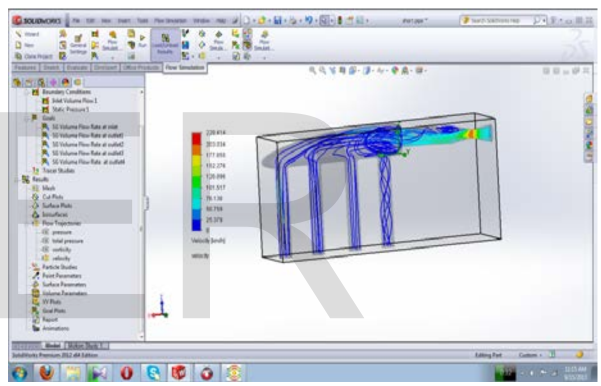
Runner geometry design focus on minimizing pressure losses at the transition from the plenum to the runner. They have a tapered shape starting from large at the plenum and gradually getting smaller near the cylinder head(to increase velocity) .Short and wide runners are optimal for higher engine function and Long and narrow runners are optimal for low-mid rpm function.

Design of restrictor:

All air which enters the engine must pass through a 20 mm diameter restrictor. The goal is to design the restrictor in such a way that it minimizes the pressure drop between the inlet and the exit. This will facilitate better charging of the plenum and ultimately increase the amount of air entering the cylinders. The design of the 20mm diameter restrictor, a converging-diverging nozzle have inlet diameters equal to the throttle body bore diameter and exit diameters equal to the inlet diameter of the plenum.



Analysis using solid works:



5.Conclusions

The simulations conducted in this thesis provided the bulk of the work load of the project, however they also returned the most benefits in terms of knowledge gained into the workings of an intake manifold. From the study given in this paper, the followings can be deduced:

- ➢ With the limits of our study, we have designed the intake manifold to achieve considerable performance.
- ➢ Replacing metal with FRP is a part of small step towards the use of plastics in a convenient manner.
- ➢ The concept is inspired by a thought of designing cost efficient components, as the manufacturing cost of intake manifold using GRP is less compared to Aluminium , Cast iron, or other metals.
- ➢ It also reduces the weight of manifold drastically.

- Further it is found that GRP has excellent thermal resistance and toughness too
- Overall, the result has been satisfactory with respect to the analysis

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Fig :Fabricated image

Fig: Implemented image

7.Reference:

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