# DESIGN OF A NEW IMPROVED INTAKE MANIFOLD FOR F-SAE CAR

Abhishek Raj[1], J.C. Mohanta[2], Bireswar Paul[3], Mohd. Nayab Zafar[4]
[1]pg Scholar, [2]assistant Professor, [3]assistant Professor, [4]research Scholar
Department of Mechanical Engineering, MNNIT Allahabad
E-mail:rajabhishek.me@gmail.com[1], jcmohnata@mnnit.ac.in[2], bipaul@mnnit.ac.in[3], nayab.zafar7@gmail.com[4]

**Abstract**
**This paper describes a modified intake manifold for F-SAE (Formula Society of Automotive Engineers) car along with a restrictor. In order to fulfill the criteria of formula SAE competition a restriction device must be placed in order to limit the engine's capability between the throttle and the engine so that all the flow must be take place through the restriction device. To achieve the maximum mass flow rate the output velocity should be high with an even distribution to each cylinder for efficient working of the engine. A series of computer simulation has been performed on the developed model in order to show the efficacy of the model. The simulation results has been compared with the similar results of the previous models, which shows improved performance in terms of even distributions and high velocity at outlet. Which ultimately responsible for greater mass flow rate from the intake manifold to the engine cylinder.**

**Index Terms-Intake Manifold, Plenum, Restrictor, Runner.**

## I.INTRODUCTION

The performance of any internal combustion engines are largely depends on its intake systems. For efficient working of an engine it is required that its intake system must be properly designed. All intake system consists of some basic components, such as air restrictor, intake plenum and intake runner etc. together to work as an intake manifold for an F-SAE car. An inlet manifold or intake manifold is a part of engine which supplies fuel/air mixture to the cylinder [3]. The most important function of intake manifold is to evenly distribute the mixture to each cylinder. Even distribution of charge is important to improve efficiency and performance of the engine.

In case of F-SAE air starts flow from air filter which separates abrasive particulates to reduce mechanical wear by cleaning the air which reduces the probability of damage of engine components. After air filter air comes to throttle body which regulates the speed and power of any engine by controlling the amount of air. In case of F-SAE cars restrictor is placed after throttle body and the maximum diameter allowed in F-SAE is 20 mm [1]. There are two types of restrictor devices are available one is orifice meter and other is venturi meter. After restrictor intake plenum is placed this Intake plenum works as a reservoir for air, size and area of Intake Plenum plays a very important role in the performance of a engine. Intake Plenum consists of series of tubes which is known as intake runners, runner length, volume and shape also play a very important role in the efficiency of the engine because if a intake system of a engine works properly and efficiently it improves the efficiency of a engine also [2].

## II. MODELING

### A) Design of Restrictor

The main objective in designing the air restrictor is to maintain a constant mass flow rate with optimum flow of air.

- Pressure is the most ideal parameter that can be varied to hold the flow rate constant.
- For the minimum pressure difference mass flow rate is maximum [1].

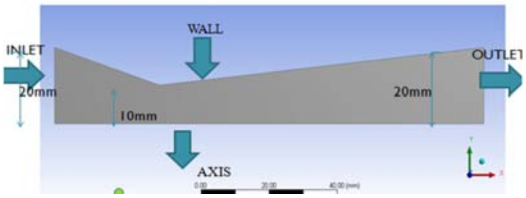


**Fig. 2.1** Geometry of restrictor

Inlet Diameter= 40 mm
Outlet Diameter= 40 mm
Throat Diameter= 20 mm

**CALCULATIONS**

- $P_t$ = 101325 Pa
- T = 300K
- $\gamma$ = 1.4
- R (air) =0.286 kJ/Kg-K
- A = 0.001256 $m^2$
- M = 1 (Choking Conditions)

Formula for Calculating Mass flow rate-

$$\dot{m} = \frac{AP_t}{\sqrt{T_t}} \sqrt{\gamma/_R} \, \frac{\gamma + 1}{2}^{-\frac{\gamma+1}{(\gamma-1)2}}$$

Result: Mass Flow Rate at Choking = 0.0703 kg/s

**B) PRESSURE VARIATION IN RESTRICTOR FOR DIFFERENT CONVERGING AND DIVERGING ANGLES-**

**I.** Pressure drop for $18^0$ Converging Angle-

| CONVERGING ANGLE(DEGREE) | DIVERGING ANGLE(DEGREE) | PRESSURE DROP(Pa) |
|---|---|---|
| $18^0$ | $4^0$ | 3447.6001 |
| $18^0$ | $5^0$ | 3201.5947 |
| $18^0$ | $6^0$ | 3447.6003 |

**II.** Pressure drop for $20^0$ Converging Angle-

| CONVERGING ANGLE(DEGREE) | DIVERGING ANGLE(DEGREE) | PRESSURE DROP(Pa) |
|---|---|---|
| $20^0$ | $4^0$ | **3151.9028** |
| $20^0$ | $5^0$ | 3334.8418 |
| $20^0$ | $6^0$ | 3590.7903 |

- As the angle increases, the separation increases however as the angle decreases the pipe becomes longer.
- 4 degree was the optimum angle as it allowed the minimum pressure drop.
- 20 degrees convergent and 4 degrees divergent angle is the optimum angle for this restrictor.

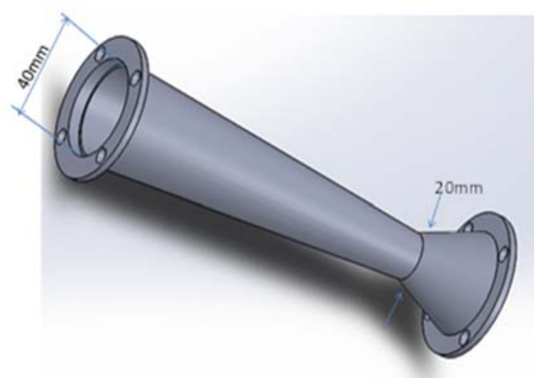


**Fig.2.2** Final Design of Restrictor

### C) Concept of new design

In order to enhance the flow into all cylinders the plenum must be fed from centre in place of one edge flow.

- If the flow had to turn too much flow rate was significantly diminished, so the concept of equidistant runners from the centerline of plenum suggested.
- Intake ports of cylinder head of the engine are in a line configuration so the runners would need a bend to transform a circular arrangement into inline one.

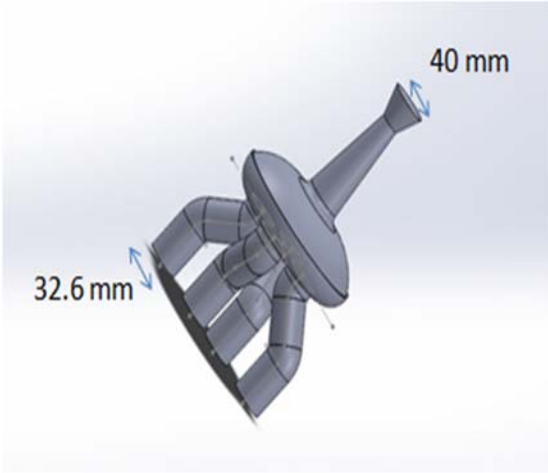


**Fig. 2.3** Model of New Manifold

**D) Meshing of New Intake Manifold Model**

**Skewness (cell size/optimal cell size)**

Min. skewness = 5.3165E-04

Max. skewness = 0.82426

**Aspect Ratio**

Minimum=1.1368

Maximum=41.522

**Orthogonal quality-**

Minimum=2.5035E-02

Maximum=0.998

**Nodes**=41542

**Elements**=159350

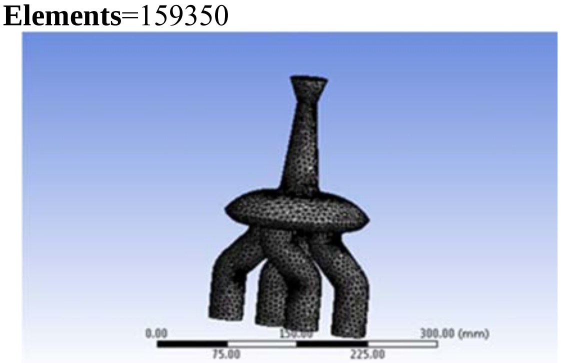


**Fig. 2.4** Meshing of New Intake Manifold

## III. RESULTS AND DISCUSSION

**Flow through Runner 1-**

After performing simulation on previous models we come on conclusion that there is need of improvement to enhance the performance of the manifold and for even distribution of air simulation on new model is performed and at outlet we found that design take the advantage of a straight line passage for the air through restrictor and plenum and we get velocity of 69.38 m/sec in runner 1.

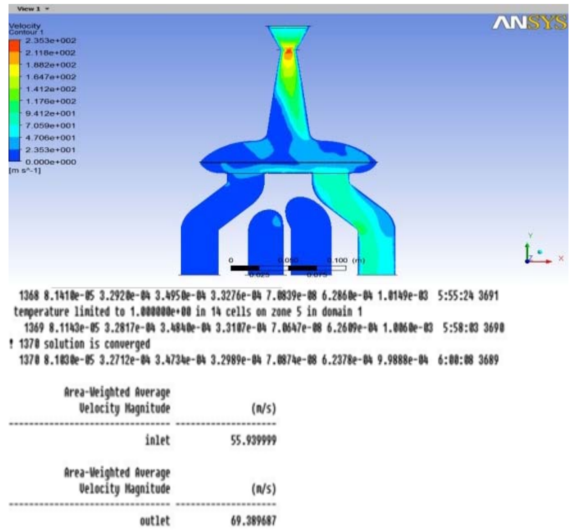


**Fig. 3.1** Contour for Runner 1

**Flow through Runner 2-**

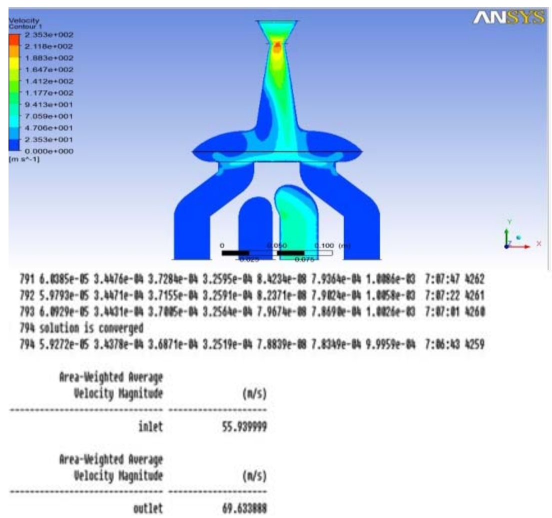


**Fig. 3.2** Contour for Runner 2

On performing simulation through runner 2 we get almost same velocity of magnitude 69.6338 m/sec as similar to runner 1 this shows that improvement over previous models of the manifold as this shows even distribution to each runner.

**Flow through Runner 3-**

The intake runner arrangement is equidistant arrangement from the centerline of the manifold. On observing the flow from runner 3 one of the most important objectives is fulfilling of very less pressure losses due to which equal amount of velocity is observed in runner 3 also of amount 69.36 m/sec.

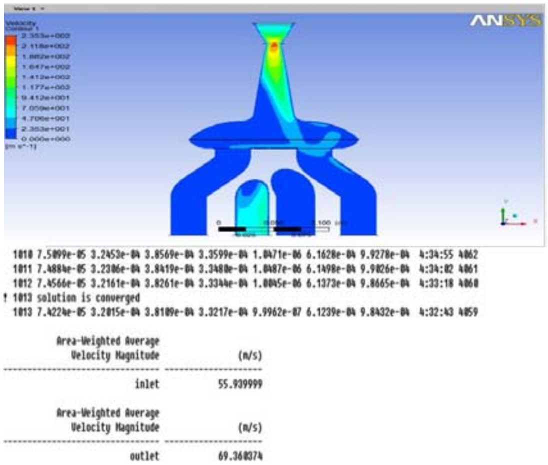


**Fig. 3.3** Contour for Runner 3

. **Flow through Runner 4-**

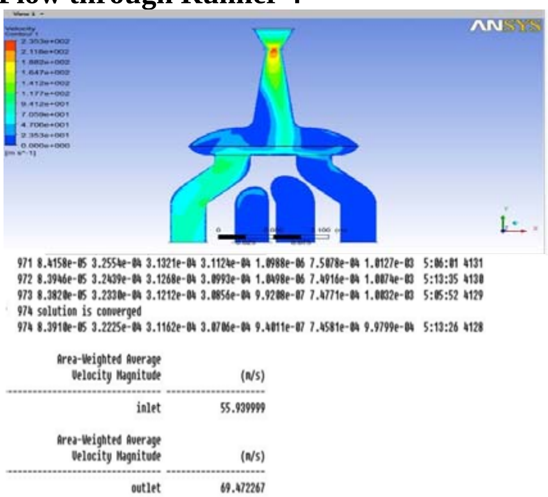


**Fig. 3.4** Contour for Runner 4

In the design of the plenum we are using bulbous shape due to which it allows best route for air to reach each runner with large amount of plenum volume and this equals the mass flow rate through each runner. This new design shows clearly modification over previous two models by providing even distribution in each runner in terms of velocity of magnitude 69 m/sec.

A) **Comparison of all the three intake Manifolds-**

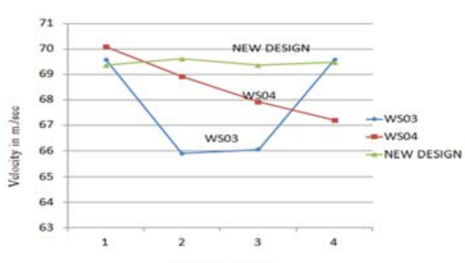


**Fig 3.5** Velocity variation in different runners through different manifolds

From the above graph it is clear that WS04 performance is better than the performance of WS03 manifold and at last new design of manifold is performing better in all the intake manifold models.

## IV CONCLUSION

From the present work the conclusion can be drawn which are summarized as follows.

- By performing several simulations on different manifold model it has been found that the flow characteristics inside the manifold are greatly depends upon the manifold design.
- The objective of the present work is to improve the design of the manifold by considering the critical areas where the losses are prominent. In the new model the above aspects have been taken into account to achieve higher output velocity as compare to other model with even distribution to each cylinder [7].

In order to improve the performance of internal combustion engine the performance of intake manifold must be improve because efficiency of IC engine is highly depends upon the performance of intake manifold. In order to improve the performance of intake manifold the geometry of runner and plenum must be improve to reduce the pressure losses so that there must be high mass flow rate and even distribution of fuel/air to each runner[4]. If the plenum was fed from centre rather than from one edge flow was enhanced significantly in all cylinders. If the flow had to turn too much after a centre feed like the cases of cylinders at the extremities of the plenum and the flow was diminished new concept of design was incorporated that all the runners must be equidistant from the centerline of the plenum for even distribution.

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