e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:11/November-2022 Impact Factor- 6.752 www.irjmets.com

REVIEW PAPER ON DESIGN AND FABRICATION OF INTAKE SYSTEM FOR FSAE VEHICLE

Mr. Mudigoudar Shashantgouda[*1], Mr. Shubham Ghorpade[*2], Mr. Sahil Londhe[*3], Mr. Adepu Shivakumar[*4], Prof. Chetan Thakur[*5]

[*1,2,3,4]Bachelor Of Engineering Students, Department Of Automobile Engineering, Saraswati College Of Engineering, Kharghar, Navi-Mumbai, Maharashtra, India.

[*5]Professor, Department Of Automobile Engineering, Saraswati College Of Engineering, Kharghar, Navi-Mumbai, Maharashtra, India.

DOI : https://www.doi.org/10.56726/IRJMETS31015

ABSTRACT

Formula SAE is a student competition run by the Society of Automobile Engineers in which students design, manufacture, and operate an open-wheel racing car prototype. While doing so, the student team must adhere to a number of rules set forth by the FSAE rules committee for designing the vehicle, some of which pertain to the design of the intake manifold. The primary goal of this article is to assess the available data or results related to designing an intake system for an FSAE vehicle, which is accomplished through analyzing, categorizing, comparing, and summarizing previously published literatures on the subject. For an FSAE vehicle, designing the air intake system mostly entails the design of the inlet-outlet (convergence-divergence) angle for the restrictor valve (Venturi), the determination of the volume and shape of the pressure stabilizing chamber (plenum) and the design of the intake manifold length (runner). Thus, this article covers all the factors, terminologies, mathematical equations, technical considerations, theories, and guidelines related to designing an air intake manifold as well as the disciplined steps which, in each instance, provide proper accessibility between the previous and next step that are followed by different teams or groups of students during their design phase.

Keywords: FSAE, Intake System, Venturi, Restrictor, Plenum, Runner, Manifold, Convergent, Divergent.

I. INTRODUCTION

The intake system is one of the engine's most important subsystems. The main purpose of the intake manifold is to direct air from the throttle body into the intake ports. The volume of air going into the engine must be maximized to boost the power output. However, the following guidelines must be followed while designing an FSAE vehicle's air intake system,

1. The engine utilized must be a four-stroke spark ignition engine with a displacement of no more than 610 cm3.
2. The intake system must only induct air through a single circular constraint positioned after the throttle and before the engine. For gasoline-powered vehicles, the constraint diameter must be 20mm.
3. None of the engine's Intake components should extend beyond the vehicle's surface envelope.
4. The maximum allowable internal diameter of the intake runner system between the restrictor and throttle body is 60 mm diameter, or the equivalent area of 2827 mm2 if non-circular.

Therefore, it is essential to design a quality intake system to lower pressure losses caused by the restrictor and achieve high mass flow rates and even air distribution at runner, which will increase the engine's efficiency.

An effective intake manifold design might offer significant performance gains over a less ideal one. The intake manifold must meet the following design objectives:

- ✓ Minimal airflow resistance.
- ✓ High air velocity for a specified flow rate.
- ✓ Throughout, there is excellent fuel and air distribution.

Since the restrictor, plenum, and runner of the manifold play a major role in the design of the FSAE vehicle's intake system, so the design engineers typically attempt,

- To improve the design of convergent-divergent restrictor.

- To optimize the geometry of the plenum for minimum flow resistance and maximum air flow velocity
- To get the best possible plenum volume.
- To achieve the best possible runner length and diameter.

II. LITERATURE REVIEW

We employed the exploratory research methodology for this relevant study. The papers that we looked at in terms of qualitative analysis and that dealt with the intake manifold of the FSAE vehicle are described below:

The Effects of Intake Plenum Volume on the Performance of a Small Naturally Aspirated Restricted Engine by Len Hamilton et al. has discussed in his research paper, that several conclusions can be drawn regarding the effect of varying intake plenum on a restricted 600cc motorcycle engine: Plenum size has little effect on torque and power until approximately 6500 engine RPM. At high RPM, gains were considerable; up to 31% in power and torque at 12,500 RPM with the largest plenum. For the plenums fitted with 5 cm intake runners in this study, the engine had torque peaks at approximately 7,000 and 10,000 RPM. Plenum size had a modest effect on peak torque and power location (RPM). The 6.0L plenum produced 17% higher peak power than the 1.2L plenum (63 kW at 12,500 RPM vs. 54 kW at 11,000 RPM). This was largely due to the significant reduction in torque at high RPM for the smaller plenum. When compared to the 1.2L plenum, the 6.0L plenum produced a 5% and 8% increase in area under the torque and power curves respectively. Due to resonant charging at high RPM, average pressure in the plenum adjacent to the intake runner throughout the intake valve open period was seen to increase as plenum volume was increased and was directly related to a rise in volumetric efficiency. The smaller plenums may have negated this charging effect due to stronger interference waves from neighboring cylinders. [1]

Enhancing the performance of single cylinder motorcycle engine for formula student vehicle by optimizing intake and exhaust system by Shubhamkumar Mangukiya et al., Mr. Ripen Shah et al., 3 Mr. Mazar Shaikh et al. investigates for improving single cylinder engine performance by analyzing non-variable length intake system, runner length & plenum volume. These are the most important factors for optimum design of Intake system. Ram theory is very helpful to decide accurate runner length according to Engine speed. The size and shape of the plenum of Intake system directly affects the performance of the engine. [2]

Intake Manifold Design Using Computational Fluid Dynamics by Awinash Pratap Singh et al. has discussed on the Ram theory and Helmholtz theory was very helpful for deciding the best runner length according to speed; and result comes out as, for lower speed vehicle cylinder runner length should be larger and runner diameter should be minimum for achieving higher volumetric efficiency and for higher speed vehicle runner length should be kept minimum and runner diameter should be higher. [3]

Combined effects of variable intake manifold length, Variable Valve Timing and duration on the performance of an internal combustion engine by P Sawant, S Bari et al. has proved that the presence of precisely tuned variable runner lengths and variable valve opening timing together eventually will boost the engine's performance. [4]

Modeling, Analysis and Fabrication of Intake System FSAE by B.Praveen Kumar et al, Ch.Rajkumar et al, D.Phanindhar et al, B.Srinivas Reddy et al, Ch. Vineeth Sai et al, has discussed on intake geometry makes considerable impact on engine performance. Namely volumetric efficiency of the engine, the length of manifold. [5]

Research and optimization of intake restrictor for Formula SAE car engine by Pranav Anil Shinde et al. In this paper performed analytical calculations based on standard results to get minimum air flow rate and CFD tool is used to calculate minimum pressure drop across the restrictor by varying converging and diverging angles of venturi. [6]

Air Intake System For Formula Student Vehicle by Siddhant Kadam et al. has reviewed on the design of their own Air Intake system according to the rules and regulations. They focused on the weight and performance optimization and stability of the system. [7]

Design And Fabrication of Air Intake For FSAE Race Car by S S Sawant et al., P N Gurav et al., P S Nivalkar et al., P M Sawant et al., Dr. S N Waghmare et al., has discussed on the entire intake system should be optimized to reduce pressure loss and improve engine performance. Convergent angle of 10.5° & Divergent angle of 6° are selected for restrictor because they give minimum pressure loss through the restrictor. [8]

Validation and Designing of Intake System for 1 Cylinder SI Engine in Formula Student Racing Vehicle by Shivam Garg et al., Nikhil Keswani, Rishav Sharma et al. has discussed on, the overall manifold design which is designed in accordance with engineering principles and empirical data. Increased fuel efficiency, power output, and improved flow. Overall philosophy of the design has been maintained with some compromises been made in some aspects of the design. [9]

Performance Analysis of Multiple Intake Design Methodologies for an open Wheel Race Car Vehicle using Different Simulations by Sudipta Karmakar et al., Rohan Rai et al., Sharat Anand et al., Shayak Choudhary et al. has differentiated between the two different intake manifolds. The comparisons are not about the shortcomings of one type of Manifold to the other but the development in the methodologies adapted to achieve better results and performance out of the same engine with lesser losses for overall betterment. [10]

III. METHODOLOGY

The procedure for designing an intake system starts with selecting the engine to be used by taking into consideration the budget, the optimal power-to-weight ratio, the accessibility of spare parts for better engine maintenance, and the condition that the engine's displacement be less than 610 cc. As a result, we decided to go with the 373.2 cc KTM Duke 360 engine.

The project is thereafter proceeded in the following manner:

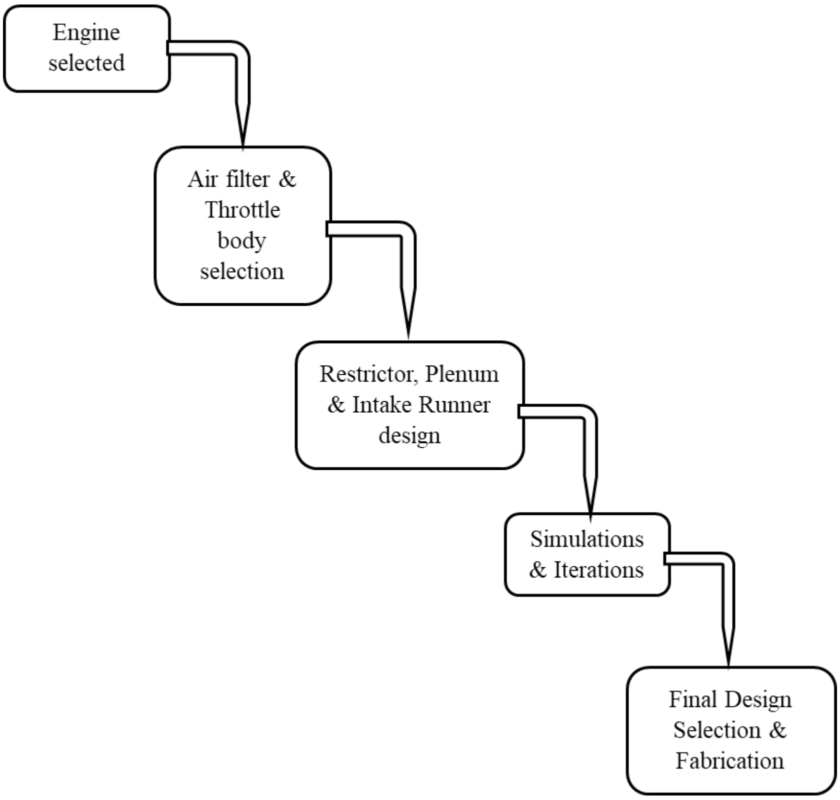

Figure 1: Project Flow

IV. CONCLUSION

Thus, the above-mentioned study took into account the performance characteristics of a restricted four-stroke spark ignition engine. On the basis of the papers we studied and reviewed as references, the following conclusions are made:

1. As the performance of an IC Engine is depended on the performance of the Intake system, the Intake system must be designed in an optimum way, and the efficiency should be improved.
2. Runner and Plenum geometry must be configured to reduce the amount of pressure losses, as a result there will be high mass flow and uniform distribution of air throughout the Intake system.

3. The length of Runner pipe can be varied for increasing the power and torque output of Engine specifically, as the short length of runner would result in an improvement in the Engine's power, and the longer length of Runner resulted in the increase of peak torque as the initial pickup of the Vehicle.

4. However, the purpose of compensating the pressure loss through a 20 mm restrictor is done by Intake Plenum by accumulating the air which will be piled up inside the Intake Manifold and as the Intake valve opens, the rich amount of air is supplied to it which improves the efficiency of Engine.

5. The manufacturing of the Intake System varies Vehicle to Vehicle as per other Teams and their Fabrication point of view. All the Engine's Intake Components are usually fitted at the Rear or on one side at the rear of the Vehicle, as the Vehicle is Rear-wheel drive with the Engine being fitter at the Driver's Rear End.

6. All the Intake System Components must be fitted inside an Envelope and must not go beyond the Envelope.

V. REFERENCES

[1] Len Hamilton, "The Effects of Intake Plenum Volume on the Performance of a Small Naturally Aspirated Restricted Engine", (Research Gate 2009)

[2] Shubham kumar Mangukiya, Mr. Ripen Shah, Mr. Mazar Shaikh, "Enhancing the performance of single cylinder motorcycle engine for formula student vehicle by optimizing intake and exhaust system", (JETIR July 2018, Volume 5, Issue 7) ISSN-2349-5162

[3] Awanish Pratap Singh, "Intake Manifold Design Using Computational Fluid Dynamics" (Research Gate 2016)

[4] P Sawant, S Bari, "Combined effects of variable intake manifold length, Variable Valve Timing and duration on the performance of an internal combustion engine", (November 2017), IMECE2017-70470

[5] B.Praveen Kumar, Ch.Rajkumar, D.Phanindhar, B.Srinivas Reddy, Ch. Vineeth Sai, "Modeling, Analysis and Fabrication of Intake System FSAE", (IJIRSET, Volume 9, Issue 5, May 2020), e-ISSN: 2319-8753, p-ISSN: 2320-6710

[6] Pranav Anil Shinde,"Research and optimization of intake restrictor for Formula SAE car engine", (IJSRP, Volume 4, Issue 4, April 2014) ISSN 2250-3153

[7] Siddhant Kadam, "Air Intake System For Formula Student Vehicle", (IJEDR, Year 2020, Volume 8, Issue 2) ISSN: 2321-9939

[8] S S Sawant, P N Gurav, P S Nivalkar, P M Sawant, Dr. S N Waghmare, "Design And Fabrication of Air Intake For FSAE Race Car", (2017), ISSN [ONLINE]: 2395-1052

[9] Shivam Garg, Nikhil Keswani, Rishav Sharma, "Validation and Designing of Intake System for 1 Cylinder SI Engine in Formula Student Racing Vehicle", (IRJEET Volume – 01, Issue – 01, March – 2020)

[10] Sudipta Karmakar, Rohan Rai, Sharat Anand, Shayak Choudhary, "Performance Analysis of Multiple Intake Design Methodologies for an open Wheel Race Car Vehicle using Different Simulations", (IJERT, Volume 9, Issue 07, July 2020), ISSN: 2278-0181