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Design & Analysis for Intake System of Formula SAE Car

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Abstract: *RSSCOER Pune University's, Team Supra 2.0 performed the study of intake restrictor design. The study was adotpted in order to improve engine performance by analyzing the inlet flow parameters and increase team's competitiveness at Formula SAE competitions. The most important objective of this project was to optimize the venture type of restrictor included in the intake system as imposed in the FSAE rule. Various intake designs like top/center feed intake, side entry intake, and conical spline intake designs were brought into influence. Implementation of CFD flow modeling software was achieved to analyze the fluid flow through the intake.The minimum pressure drop was achieved by careful observation of converging and diverging angles of 12 degree and 6 degree respectively.*

I. Introduction

Society of Automotive Engineers have catalogued FORMULA SAE, a competiotion to acknowledge the manufacturing of a vehicle from beginning till its final. The first competition was started back in 1979 after Mark Marshek, then at the University of Houston contacted SAE Educational Relations Department in 1978.
The FSAE rules committee imposed a rule limitation of 20 mm intake restrictor on power of any four-stroke engine used in the competition . The Engines used in FSAE are limited to 610 cc engines with output of 120 horsepower with 15000 revolutions. Team Supra 2.0 has used dual cylinder, liquid cool 296cc engine having an output of 38.5bhp at 11000 RPM and torque 27N-m at 10000 rpm. The flow of air takes place firstly in throttle body and then to the plenum of intake system before entering the intake manifolds which feeds to the engine. Fresh air is taken inside by an Internal Combustion engine and according to appropriate air fuel ratios the combustion of mixture takes place. Air flows from single 20mm restrictor to intake manifold so engine have two cylinder and two throttle intake having 25mm diameter of each cylinder. This change reduces the air flow to the engine thereby regulating its power output. The objective behind designing the intake system is to allow minimum pressure drop with maximum air flow.

Engine Performance And Research Engine Specification:

Sr.no	Parameter	Specification
1	Displacement	296cc
2	Max. power	38.5 bhp@11000rpm
3	Max. torque	27N-m @10000rpm
4	Engine description	Liquid cooled, 4 stroke Parallel twin
5	Cooling	Liquid cooled
6	Fuel system	Fuel injection Ø32mm*2 with dual throttle valve
7	Ignition	Digital
9	Compression ratio	10.6: 1
10	Bore	62mm
11	Stroke-	49 mm
12	No. of cylinder	2

13	Power to weight ratio-	223.83bhp per tone
14	Torque to weight ratio	156.97N-m per tone
15	Specific output	130.06bhp per liter

Table No. 1 Engine specification[8]

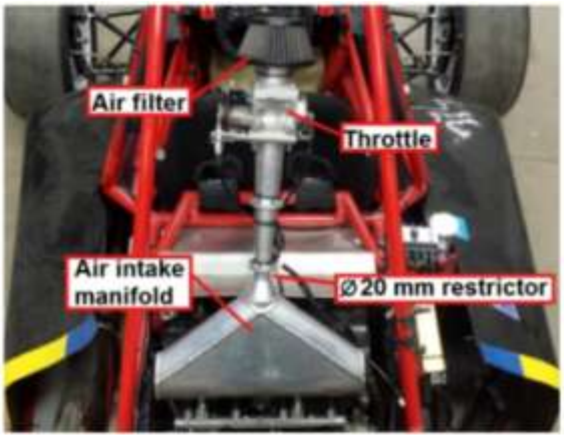

Fig1. Manifold with Ø20mm air restrictor.

II. Intake Restrictor

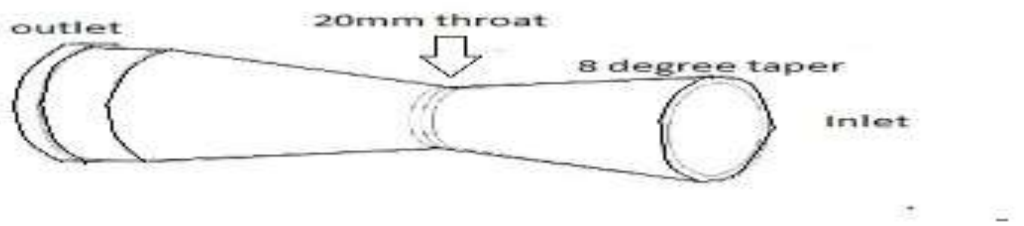

Fig (2). Basic Design of Intake Restrictor

In order to limit the power capability from the engine, a single circular restrictor must is placed in the intake system between the throttle and the engine and all engine airflow passes through the restrictor. The intake restrictor is a device adapting a venture portion at its throat, for the increase of velocity of inlet air. The throat venture diameter is maintained at 20.0 mm (0.7874 inch) according to the rules initiated by SAE Supra .[2] The restrictor is a non-movable portion of the throttle barrel. The velocity of charge in the intake system should not decrease to such limits so that fuel will start falling out of suspension. But the design should be careful so that fuel mixture is sufficient for supporting peal torque RPM. For 3 to 6 cylinder engines the plenum volume of 0.8 to 1.5 works well while engines with 8, 10 and 12 cylinders run well with even lesser. But with the restrictor, the plenum has to be slightly large. If the engine is left to the air purely higher RPM it may suffocate.[5]

Design Constants and Variables:

Since the aim is to optimize the intake restrictor, the mass flow rate calculation is to be done. Maximum flow rate is:

$$m = r \times V \times A$$

For an ideal compressible gas:

$$m_{max} = A \times p_0 \sqrt{\frac{k}{RT_0}} \left(\frac{2}{K+1}\right)^{(k+1)/[2(k-1)]}$$

Where A = cross-sectional area at which the flow is sonic, P0 is the stagnation pressure,T0 is the stagnation temperature, R is the specific gas constant, and k = cp/cv is the specific heat ratio of the gas.

The maximum flow rate can be expressed in terms of inlet temperature Ti and inlet pressure Pi by expressing the stagnation temperature and stagnation pressure as[3]

$$T_0 = T_i + \frac{v_i^2}{2c_p}$$

$$p_0 = p_i \left(\frac{T_0}{T_i}\right)^{k/(k-1)}$$

Where,
Vi is the inlet velocity.
Mass flow rate is maximum when M = 1. At these conditions, flow is choked. The mass flow rate from above equation is calculated using the following data values:
M = 1
A = 0.001256 m2 (20 mm restriction)
R = 0.286 KJ/Kg-K ϒ = 1.4
P0= 101325 Pa
T = 300 K

Mass flow rate = 0.0703 kg/sec

Parts and Assembly of Intake System

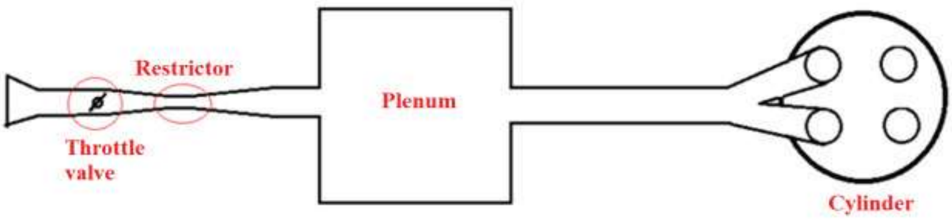

Fig.(3)Assembly of intake system[9]

Parts: 1.Air Filter, 2. Throttle Valve, 3. Intake Restrictor, 4. Plenum, 5. Cylinder

Plenum:

In order to reduce the influence of the restrictor, it is necessary to minimize the maximum instantaneous flow velocity through it.A way to obtain this objective is to place a plenum chamber between the restrictor and the engine. The plenum allows one to minimize the pulsating flow through the restrictor. As a consequence the pressure drop at the restrictor decreases and the mass flow rate elaborated by the engine raises allowing growth of engine performance.[4]

Discussions & Conclusion

FSAE is all about speed, acceleration and economy. In this competition, all the teams are busy trying to utilize almost a single horse power available even with the restrictor attached. This gives rise to the increase in research and optimization of intake system designs. The optimum solution is to achieve the maximum mass flow rate of air through the flow restriction device. Venture serves the best design for this objective. It allows a maximum flow rate of 0.0703 kg /sec of air flow to the engine.[5]

III. Acknowledgement

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