Air Intake System for SAE SUPRA, Formula Bharat

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Abstract: - *This paper is based on design, calculations and manufacture of an air intake system for SAE SUPRA and Formula Bharat events. This paper deals with air flow optimization for KTM RC 390 single cylinder 4 stroke engine. Design and flow simulation was done using Solid works and various results were observed.*

***Key Words*: Air Intake System, Throttle body, Restrictor, Plenum, Runner, Solid works, SAE SUPRA, Formula Bharat**

1. INTRODUCTION

SAE SUPRA and Formula Bharat are the two main student Formula events taking place in India every year. These competitions have their different rulebooks set up by the organizing committees which they provide to the participating teams. One rule is common in both the rulebooks that is an air intake system and an engine capacity which is limited to 610 cc. For our SAE SUPRA 2018 competition KTM RC 390 engine was used.

Table -1: Engine specification

Displacement	373.2cc
Maximum Power	43.5 bhp@9000 rpm
Maximum Torque	36 Nm@7000 rpm
Cooling	Water cooled
Valves	4
No. of Cylinders	1
Stroke	69mm
Bore	89mm

2. RESEARCH METHODOLOGY

Air Intake System for SAE SUPRA and Formula Bharat is divided into 4 main parts:

1. Throttle Body
2. Intake System Restrictor
3. Plenum
4. Runner

According to the student formula rules a single circular restrictor is to be placed in the intake system between throttle body and the engine. The maximum length of restrictor can be 132.0 mm and maximum throat diameter of restrictor can be 20.0 mm.

1. Throttle Body:

Throttle body is a part of air intake system that controls the amount of air flowing into engine. Throttle body is fixed between air filter box and intake manifold. Inside throttle body there is a butterfly valve that regulates the air flow. For normal part throttle operation a lean mixture about 14.6:1 air fuel ratio will suffice that is 14.6 parts of air and 1 part of petrol would give complete combustion.

Fig -1: Throttle body of KTM RC 390

2. Restrictor:

There are generally two types of instruments that are used as an intake restrictor in SAE SUPRA and Formula Bharat. Two types are:

a. Orifice plate
b. Convergent-Divergent Nozzle

When both the types are compared it is found that convergent – divergent nozzle type restrictor is best for use. For the design of restrictor in solid works first we fixed the convergent part of the restrictor with convergent diameter as 47mm, throat diameter as 20mm, and total length of restrictor as 130mm. Now flow simulation was done on solid works with inlet pressure at 1 bar and mass flow rate at outlet at 0.0703 kg/sec.

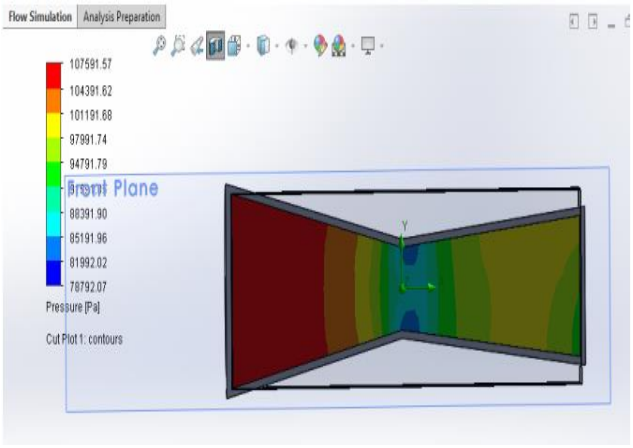

Fig -2: Flow Simulation of Restrictor

Our simulation was carried on different convergent and divergent angles. Restrictor is based on the principle of minimum pressure difference. After simulation in solid works result was obtained with convergent angle 12 degrees, divergent angle 6 degrees, divergent diameter 33.97mm.

3. Plenum:

It is a storage container for charge. It is attached to the restrictor and the intake runner. Plenum provides extra charge during intake. One main function of plenum is to equalize pressure for even and fine distribution. Generally volume of plenum is kept between 2 to 2.5 times to capacity of engine. For our vehicle volume of plenum was 0.78 L. We can have plenum of 2 different shapes:

1. Log shaped plenum
2. Streamlined

For the best results we kept our plenum chamber in top facing and shape was log shaped kept in vertical.

Fig -3: Log Shaped Plenum

4. Runner:

Runner connects plenum with engine. We can find effective runner length using two theories:

1. Helmholtz Resonator Theory

$$Fp = \frac{162}{K} c \sqrt{\frac{A}{LV}} \sqrt{\frac{R-1}{R+1}}$$

Where:
Fp = Engine rpm
K = 2.0 to 2.5
C = speed of sound, ft/s
V = Displacement of cylinder
L = Inlet pipe length, in
A = Inlet pipe cross-sectional area
R = compression ratio
162 constant incorporating units

2. Induction Wave Theory

L = (EVCD*0.25*V*2) / (rpm*RV) – 0.5*D

Where:
EVCD = Effective valve closed duration
V = speed of sound, ft/s
Rpm = Revolutions per minute
RV = Reflective value
D = Runner Diameter

Our engine was tuned at 4000 rpm and calculations were done by Induction wave theory.

Cam specification:

Intake opens 2 degrees Before Top Dead Centre (BTDC)
Intake closes 44 degrees After Top Dead Centre (ATDC)

Effective cam duration, ECD = 180°+2°+44°
= 226°
4 stroke = 720°

Effective valve closed duration, EVCD = 720°-ECD-20°
= 720°-226°-20°
= 474°
Diameter of runner = 47mm = 1.85 inches

Length of runner =
(474*0.25*1125*2) / (4000*4) – 0.5*1.85
= 399.54 mm
= 15.7 inches

3. CONCLUSION

Air Intake system for SAE SUPRA and Formula Bharat are very important during the event and we can't neglect it. Thus we designed our Air Intake System according to the rules. We designed a restrictor with 20 mm throat diameter and convergent angle as 12 degrees and divergent angle as 6 degrees. Our plenum had a volume of 0.78 L. Runner was of length 399.54mm and diameter 47mm. Our intake system

was made up of aluminium because of light weight and it provided more stability.

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