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Streamline Flow Air Intake Design For FSAE Car

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Abstract - This paper focuses on design and manufacture of an intake system for FSAE single cylinder race car engine. The rules impose the introduction of a restrictor in the intake system of the engine. The use of restrictor chokes the engine which reduces its performance and power output and hence necessitates its selection and improvisation. The objective of this paper is to optimize the Venturi to maintain a constant mass flow rate and to maximize the delta pressure after passing through the restrictor. The volume of the Plenum and the size of the Runner were determined for efficient working of the intake system. Analysis was done in iterations by changing the converging and diverging angles of the Venturi. Experimentation showed that converging and diverging angles of 12&6 prove to maximize the pressure lost due to the 20mm restrictor. Plenum and Runner were implemented to recover the pressure lost after the restriction through its way to the engine. The overall design is modelled on a 3D modeling software and the analysis is performed on a flow simulation software. Rapid prototyping being the core manufacturing process, fused deposition modelling was done followed by the process of Fiberglass reinforced lining. This overall process was considered due to the final product being light-weight, profile desired design, elimination of finishing processes and increased strength of the product.

Key Words: FSAE, Single Cylinder Engine, Intake System, Venturi, Plenum, Runner, Prototype

1. INTRODUCTION

The formula SAE is a student design competition organized by SAE international (previously known as the Society of Automotive Engineers, SAE). The concept of the event is that a fictional company has contracted a student design team to manufacture a formula type racecar which is targeted for non-professional weekend racers. Each team designs build and tests the car based on a set of rules. There are varying departments which are to be worked on for manufacturing the vehicle. The intake system for the engine is one of the important departments to be worked on. The rules for intake system state that "a singular circular restrictor of 20mm diameter must be placed in between the throttle body and engine". This rule is in order to limit the power capability from the engine and for safety consideration at which the event is held. The amendment of the restrictor causes the performance of the engine to be affected drastically. The performance of an internal combustion engine depends directly on the amount of air elaborated in every cycle during its functioning. On this basis, a way to limit the maximum power of an engine is to introduce a pressure loss along the intake manifold .Runner connects the plenum with engine and is tuned at certain rpm to optimize engine performance. The competition has a variety of engines being used ranging up to 610cc. This paper deals with design of intake system for a KTM RC 390cc engine. The engine is liquid cooled and produces 43 Bhp of power and 35 Nm of torque. The engine comes with a six speed manual gearbox and weighs 35kg.
Basically there two options available for the restriction device that can be used in the air intake system of the car.
1. Venturi
2. Orifice
The following table shows the comparison between the both-

Parameters	Venturi	Orifice
Pressure loss	Low	High
Coefficient of discharge	0.975	0.60
Manufacturing	Difficult	Easy
Cost	High	Low

Table.1 Comparison between venture and orifice From the above table it can be concluded that Venturi is more efficient as the restriction device that is used in the intake system of the car as the pressure losses are less as well of coefficient of discharge is high in the venturi [2]. This both characters of the venture are important to compensate the loss power. As we need less pressure loss and high mass flow in the engine. But the manufacturing is quite hard as it's difficult to manufacture the throat section of the venturi. Hence Venturi is selected as the restriction device for the intake system.

2. SCOPE

- To optimize design of convergent- divergent type restrictor.
- To optimize plenum shape for having least flow resistance and maximum air flow velocity.
- To obtain optimum plenum volume

3.SIMULATION METHODOLOGY

2.1 Intake System

Restrictor:

For the restrictor, we have considered the design of convergent-divergent nozzle .For 20mm throat convergent-divergent nozzle, maximum mass flow rate achieved during chocking is 0.0703kg/s

For KTM 390cc, max mass flow rate required is 0.030kg/s, so only Consideration while designing nozzle was of pressure loss.

The results of iterations carried out at various converging and diverging angles are as follows:

Iteration no.	Converging angle	Diverging angle	Pressure difference(pa)
1	12	6	1896.85
2	10.5	6	1852.62
3	9	5	1990.4

Table.2 converging and diverging angles

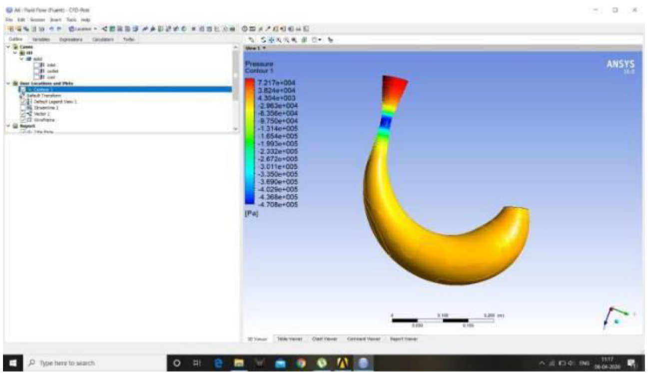
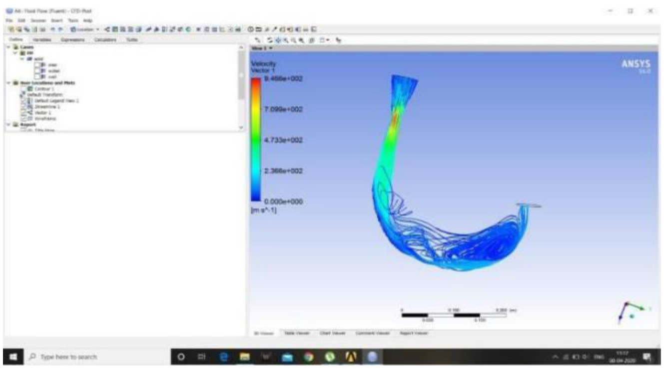


Fig.1 Pressure Analysis for iteration 1



Fi.2 Velocity Analysis of Iteration 1

Plenum:

The volume of plenum has to be such that the engine does not strive for air during its suction stroke. As the plenum has to serve the purpose of air environment it has to have a volume which is bigger than the cubic capacity of the engine. Some literature suggest it should be 2-2.5 times the cubic capacity of the engine. While some literature suggest it should be quite more than that.

The volume of plenum is an important factor for the type of performance needed from the vehicle. The less time required for air to be sucked in to the combustion chamber the more the throttle response on the other side bigger the size of plenum more time required for getting in fresh air hence reducing the throttle response. As is also the case that less the volume more work required for grabbing in fresh air and filling the plenum. Alternatively bigger the size more air being stored in the plenum at once so less work required for sucking in fresh air.

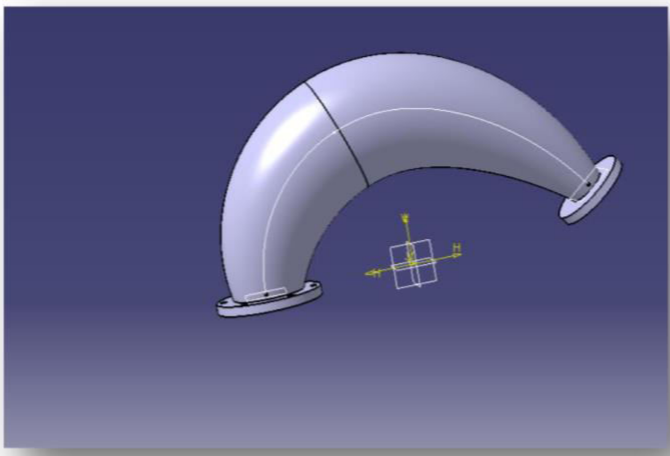


Fig.3 Catia Model of plenum

Intake Runner:

Intake runner length is the key factor to decide. The performance of whole intake system is depends on tuning of runner length. Intake runner length is designed for 5000 rpm so as to get low end torque and power based on track & driver's experience. According to Induction wave theory.

The formula for optimum intake runner length (L) is:

L=(EVCD*0.25*V*2/RPM*RF)-(0.5*runner diameter)

= (514º*0.25*1125*2/5000*7) –(0.5*1.8897)

L =494.717mm

Where:

RV = Reflective Value=7

V = Pressure Wave Speed=1125ft/s

D= Runner Duameter = 1.8897inch

D = Runner Diameter = 1.8897

EVCD = 720-(ECD)

EVCD = 720-226+20=514°

EVCD = 514°

According to induction wave tuning theory, intake system was tuned at 5000 RPM, resulting in total runner length of 494.717mm.

Runner Diameter is selected as 48 mm same as throttle body.

Fig.4 proototyped plenum

4. CONCLUSION

Thus we designed an air intake system for SUPRA SAE INDIA race car. We have achieved the purpose of compensating the pressure losses because of restrictor of 20 mm according to SAE rulebook and ultimately the Power losses of the engine.

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