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# DESIGN AND OPTIMIZATION OF INTAKE MANIFOLD FOR FORMULA STUDENT VEHICLE

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## ABSTRACT

This study acquaints a notable technique with upset the plan of Equation Vehicle air consumption frameworks, leaving from customary experimentation draws near. It expects to lay out a vigorous logical and designing establishment by analyzing the admission framework into its parts and inspecting the standards overseeing every one's plan.

The cycle starts with social occasion definite motor information, including cam profiles, consumption valves, and chamber details, to fabricate a far-reaching motor recreation model. This model is carefully created to successively precisely investigate every part of the admission framework. Through exhaustive approval against reenactments of the whole motor framework, the wind current way of behaving of individual parts is examined. Actual testing utilizing a stream seat is led to approve the reproduction results, guaranteeing the unwavering quality and exactness of the proposed plan arrangements. A particular mathematical plan for a restrictor is proposed to boost wind current while limiting tension drop, in this manner upgrading the general exhibition of the Recipe Vehicle motor.

In adherence to Recipe SAE contest guidelines, a 20mm restrictor is ordered in the admission complex to guide all wind current to the motor. Nonetheless, this represents a test as it lessens the motor's admission limit, influencing wind stream and power yield, regardless of whether the motor is single or multi-chamber.

Recognizing the pivotal job of a very much planned consumption complex in enhancing gas powered motor execution, this concentrate carefully centers around the 3D reproduction of a solitary chamber KTM 390 Duke Motor. Involving ANSYS Familiar programming for both consistent and insecure investigations, it plans to uncover new bits of knowledge into admission framework improvement.

**Keywords:**

Intake Manifold, Plenum, Restrictor, Velocity Vectors, Pressure Contour, Throttle body, SolidWorks.

## 1. Introduction

Our venture centres around the improvement of a vital part known as an admission complex for Recipe SAE race vehicles. Recipe SAE, regulated by the General public of Car Specialists Worldwide, gives a stage to understudy groups to plan and build elite execution vehicles. Key with this attempt is complying to severe guidelines administering motor power. A critical component in this guideline is the usage of a 20 mm consumption restrictor, which successfully controls the motor's power yield.

Engine in Equation SAE are restricted to 610 cc limit and are fit for creating 120 drive at 15,000 cycles each moment (RPM). With the incorporation of the 20 mm restrictor, engine speed is compelled to a scope of 10,000 to 7,500 RPM. Given the high functional paces, guaranteeing ideal wind stream into the motor becomes principal for effective fuel burning.

The test lies in working with a fast wind stream while limiting tension drop inside the admission complex, especially inside the venturi-type restrictor. Studies show that in spite of the proper mass stream rate forced by the 20 mm restrictor, boosting air admission stays fundamental. Thusly, our essential goal is to plan a particular admission complex that expands air consumption while limiting strain differentials, improving motor execution inside Equation SAE guidelines.

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**2. Air Intake Manifold**

The intake manifold serves as a vital component in supplying air to the engine, playing a crucial role in crafting an effective intake system. The efficiency of the engine directly correlates with the geometry of the intake design, necessitating careful consideration of several key factors in manifold design:

1. Optimize air velocity within the engine cylinder to promote efficient combustion.
2. Reduce pressure losses to maintain engine performance and responsiveness.
3. Strive for a mass flow rate of air approaching Mach no. 1 to ensure optimal airflow dynamics.
4. Minimize the presence of sharp corners in the design to mitigate vibrations in the intake manifold, promoting smoother airflow and engine operation.

**Figure 1 Air Intake Manifold**

The affirmation complex contains major parts, which integrate the air channel, gag, restrictor (or venturi), plenum, and runner. The blueprint of these parts is according to the accompanying:

1. Air channel
2. Throttle
3. Venturi/Restrictor
4. Plenum
5. Sprinter/Runner

**2.1. Air Filter:**

An air filter/air channel is regularly made of a sinewy or permeable material, generally creased paper or fabric, encased inside a cardboard casing. Its essential capability is to work with the conveyance of new, wipe air while sifting through strong particles like residue, dust, mud, and microscopic organisms. Thusly, the air channel keeps these foreign substances from straightforwardly influencing the engine's power and execution.

The shortfall of an air channel in vehicles can prompt a few downsides:

1. Interruption of the air-fuel combination.
2. Expected hazard of engine seizure.
3. Expanded engine Wear.
4. Diminished engine Execution.
5. Higher Support Expenses.
6. Potential engine Harm.
7. Abbreviated engine Life expectancy.

**Figure 2 Air Filter**

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**2.2. Throttle Body:**

The KTM RC390 highlights a choke body that assumes a urgent part in the motor's exhibition and responsiveness. The choke body fills in as the door for the air consumption into the motor, controlling how much air entering the burning chamber in view of the rider's choke input. Key highlights of the KTM RC390 choke body include:

1. Size and Diameter: The choke body on the KTM RC390 is designed to upgrade wind current and fuel conveyance to the motor. It is planned with a particular size and width to match the motor's prerequisites and execution qualities.
2. Electronic Choke Control (ETC): The KTM RC390 uses electronic choke control innovation, otherwise called ride-by-wire. This framework replaces the customary choke link with electronic sensors that impart choke position to the motor control unit (ECU). And so on considers exact control of choke reaction, working on generally execution and rider experience.
3. Integrated Sensors: The choke body is outfitted with sensors to screen different boundaries, for example, choke position, air temperature, and motor burden. These sensors give constant information to the ECU, empowering the motor administration framework to change fuel infusion and start timing for ideal execution and ecofriendliness.
4. Fuel Infusion System: The choke body houses the fuel injectors, which are answerable for conveying the exact measure of fuel into the admission air stream. This guarantees productive burning and power conveyance all through the motor's working reach.
5. Integrated Design: The choke body is consistently coordinated into the KTM RC390's general motor and fuel the executive’s framework. It is intended to endure the afflictions of elite execution riding while at the same time giving smooth and unsurprising choke reaction.
6. Maintenance and Serviceability: Like different parts of the cruiser, the choke body requires intermittent upkeep and review to guarantee ideal execution. This might incorporate cleaning the choke body, investigating for any indications of wear or harm, and recalibrating the electronic choke framework if important.

By and large, the choke body on the KTM RC390 is a complex part that adds to the bike's dynamic presentation and rider experience. Its reconciliation of cutting-edge innovation, exact designing, and electronic control frameworks mirrors KTM's obligation to conveying superior execution cruisers for devotees and racers the same.

**Figure 3 Throttle body.**

2.3. **Venturi/ Restrictor:**

A restrictor fills in as a component situated at the motor admission to manage its power yield. In Recipe SAE rivalries, severe guidelines direct the greatest permissible breadth for the restrictor, set at 20mm. The mass stream rate can be resolved utilizing the formula: **m=r.V.A**

For an ideal compressible gas, the mass stream rate can be determined utilizing the accompanying information:

M= 1

A = 0.001256 m2 (20 mm restriction)

R = 0.286 KJ/Kg-K

$\gamma$ = 1.4 Pt=
101325 Pa Tt =
300 K Max.

**Mass flow rate = 0.0703 kg/sec**

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The greatest mass stream not entirely settled to be 0.0703 kg/sec. In our examination, reenactments were led at different joined and disparate points. The restrictor works on the guideline of limiting tension contrasts. Through SolidWorks reproduction, results demonstrated an ideal focalized point of 10.5 degrees and a dissimilar point of 6 degrees, as they brought about the base tension drop.

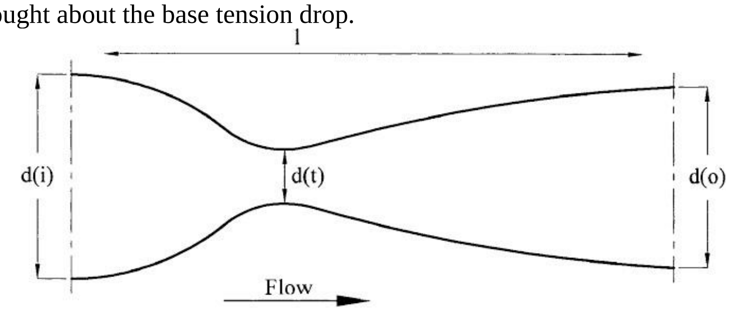


**Figure 4 Convergent-Divergent Nozzle**

$$\text{Mass Flow Rate, } \dot{m} = \sqrt{k \rho P \left(\frac{2}{k+1}\right)^{\frac{(k+1)}{(k-1)}}}$$

C= discharge coefficient
A=discharge hole cross-sectional area, $m^2$ K= $c_p / c_v$ of the gas $c_p$ = specific heat of the gas at constant pressure $c_v$ = specific heat of the gas at constant volume
ρ = real gas density at P and T, $kg/m^3$
P = absolute upstream pressure of gas, Pa

### 2.4. Plenum:

The plenum serves as a critical component for introducing an air and fuel mixture into the cylinder, ensuring that the pressure within the manifold exceeds that in the cylinders. It operates based on the RAM theory, which posits that a ram air intake utilizes dynamic air pressure generated by vehicle motion. This design strategy aims to raise the static air pressure within the intake manifold of an internal combustion engine, thereby facilitating a greater mass flow through the engine and ultimately enhancing engine power.
The plenum volume is typically designed to be 1.5 to 3 times the engine displacement. For instance, with an engine capacity of 373.2 cc, the plenum volume is calculated as follows:
**Engine Capacity = 373.2cc**
**Engine Capacity times 3 = 1119.690 cc**
**1119.690cc approx. 1.11969 L**
Thus, the volume of the plenum is approximately 1.119 Liters, which is nearly three times the engine displacement.

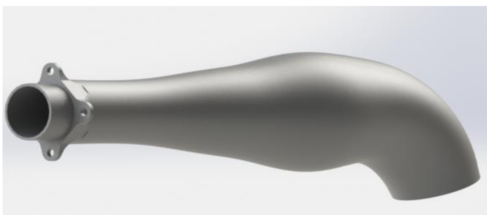

**Figure 5 Plenum.**

### 2.5. Runner:

The runner, which connects the plenum and restrictor to the engine, plays a crucial role in the intake system. The determination of the runner length can be based on either, The Induction Wave theory or the Helmholtz Resonator theory.

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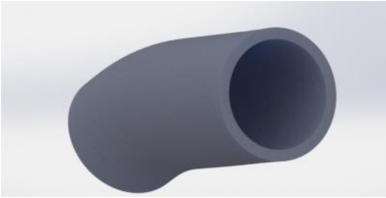

**Figure 6 Runner.**

**2.5.1. Induction Wave Theory:**

According to the induction wave theory, the length of the runner relies on factors such as EVCD, RPM, the speed of sound, RV, and the runner diameter. The formula for calculating the length is as follows:

**Length = (EVCD*0.25*V*2) / (RPM*RV) - (0.5D)** Where:

- EVCD = Effective valve close duration.
- V = Speed of Sound in feet per second.
- RPM = Revolutions per Minute.
- RV = Reflective Valve. - D = Runner diameter.

The cam specifications for the 390cc engine are:

- IVO: 2 degrees Before Top Dead Centre (BTDC)
- IVC: 44 degrees After Top Dead Centre (ATDC)
- EVCD = 720° – ECD - 20° - ECD = 180° + 2° BTDC + 44° ATDC - ECD = Effective Cam Duration.

Given:

- ECD = 226°
- EVCD = 474°
- Diameter of Runner = 56mm = 2.2047 inches

Length = (474°*0.25*1125*2) / (4500 * 4) – (0.5*2.2047) = 348.23 mm

Length = 13.71015 inches

**2.5.2 Helmholtz Resonator Theory:**

Where,

Fp= Engine rpm

K=2.0 to 2.5

C= Speed of sound, ft/s.

V= Displacement of cylinder

L= Inlet pipe length

A= Inlet pipe cross-sectional area

R= compression ratio SO, 162 constant incorporating units.

**2.6. Analysis of Air Intake Manifold:**

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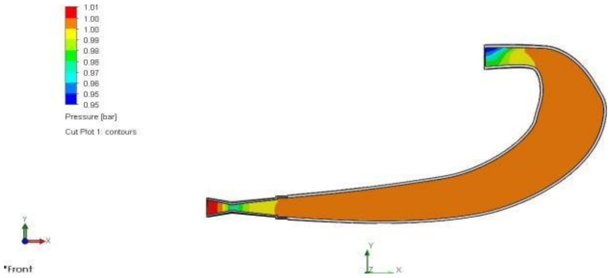

**Figure 8 Pressure Contour of walls of Entire Intake Manifold consisting of:**
1. Venturi
2. Plenum
3. Runner

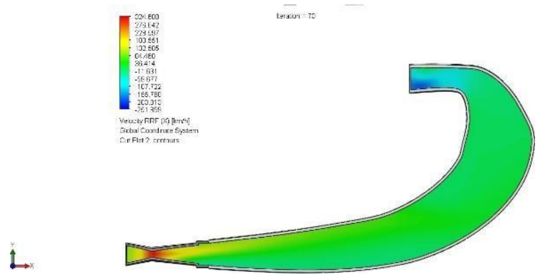

**Figure 7 Velocity Streamline for Air Flow in Entire Intake system consisting of:**
1. Venturi
2. Plenum
3. Runner

**2.7. Fabricated Air Intake Manifold:**

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