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Review of Model Analysis of Intake Manifold of a Carburetor

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ABSTRACT

The efficiency of an internal combustion engine depends heavily on the intake manifold and its associated parts. Breathing in an engine, according to many studies conducted all over the globe, is directly tied to the shape of its air intake. The volumetric efficiency of an engine is affected by the design of its intake manifold. Traditional intake manifolds have a set geometry and cannot meet the needs of a broad variety of engine speeds. In this study, we take a look back at the research of some notable scholars who have focused on intake tuning and variable intake manifolds. From this, one can readily deduce that the intake shape must be modified in order to achieve optimal volumetric efficiency over the whole engine speed range. In order to get the most out of your engine's air intake, you want to keep the length of the intake tube long at lower speeds and short at higher speeds. Using a manifold that allows for a range of intake lengths yields noticeable improvements in both torque and fuel efficiency.

Keywords: Intake Manifold, Intake Tuning, Plenum, Torque Characteristics, Engine Performance, Charging.

Introduction:

A vehicle's engine's inlet manifold is made up of the air filter, the intake pipe, the plenum, and the intake runners, and it is responsible for delivering the fuel/air mixture to the cylinders. The intake manifold's job is to evenly distribute the air-fuel mixture (or simply air in a CI or Direct Injection engines) to each intake port in the cylinder head. A well-balanced distribution is crucial for the engine's optimal performance. Carburetor, throttle body, and fuel injectors are only some of the engine parts that might fit there.

Engineers have been examining different engine components to see whether there is room for improvement in their design and arrangement in response to the rising need for more engine power, torque, and decreased emissions. This inspiration brought us to the intake manifold, a crucial part of the engine. It's common knowledge that a well-thought-out intake manifold can do wonders for an engine's output. To optimise the in-cylinder movements and pressure effects, an engine's intake manifold may be "tuned" by altering its geometry. The conventional method for designing and optimising intake manifolds relies on test bench experiments with many geometry. The engine manifolds were manufactured, installed, and tested. This approach, although potentially fruitful, is time-consuming and costly. Furthermore, the real flow characteristics within the intake manifold cannot be determined using this approach. With the help of an Intake Manifold. [3]

The design philosophy relies heavily on symmetrical geometry. These days, to generate better and more accurate outcomes, engineers often aim to mimic real-world working settings. Many years have been spent perfecting a variety of test-based and numerical simulation-based methods for achieving this goal. Time and money may be saved, and the best possible optimization can be achieved, with the help of 1D engine simulations (1D CFD simulation tools that are commercially accessible in market). [2]

Tuning intake for improved volumetric efficiency and engine performance may be calculated theoretically using the Chrysler Ram theory, acoustic tuning (using a Helmholtz resonator), and other similar techniques.

Literature Review

The purpose of the CFD Study is to boost engine performance while reducing emissions. For optimal engine performance, it is essential to maximise both the mass flow rate and the output velocity, and to distribute both uniformly throughout all cylinders. A number of variables, including compression ratio, fuel injection pressure and quality, combustion rate, air fuel ratio, intake temperature and pressure, inlet manifold and combustion chamber designs, etc., affect engine performance. One such technique for enhancing engine performance is the use of an intake manifold with a geometrical design that has been optimised for maximum efficiency. Improved airflow into the combustion chamber is the result of revised intake manifolds. In this study, we apply a k- model for Computational Fluid Dynamics (CFD) analysis on two distinct Manifold Designs to determine which one maximises mass flow and output velocity, and hence how best to boost an engine's efficiency. [4]

In this case, CATIA is used to create a digital replica of a carburetor. The use of fully associative engineering drawings and revision control systems allows for an accurate moulding of a product and its whole bill of materials. Using Pro/associative E's features, users may make changes to the and have subsequent outputs recalculated and updated instantly. This permits simultaneous efforts by design, analytical, and manufacturing engineers, speeding up and improving the development process.

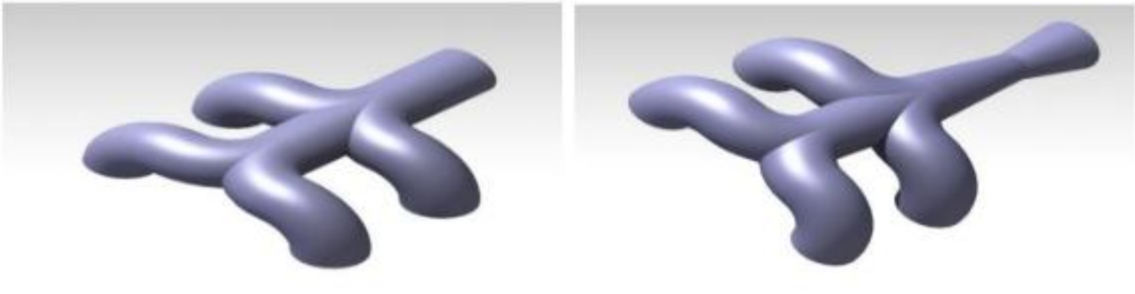


Figure 1: Geometry of (a) Carburettor without C-D Nozzle (b) Carburettor without C-D Nozzle [4]

We used CFD software to do the simulations. In CFD, we performed the necessary pre-processing steps, such as geometry clean-up, meshing, and setting boundary conditions, to run our simulations. In order to efficiently mesh the computational volume of the Intake manifold, the polyhedral mesh element type was used for.

Flow losses were analysed in both an experimental setting and a computational fluid dynamics model. All ten possible setups were executed. The following visuals depict the outcomes of the analysis.

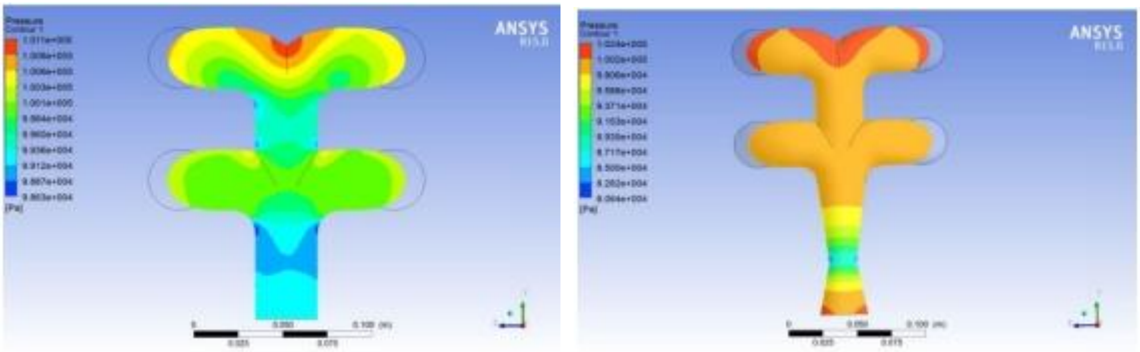


Figure 2: Geometry of (a) Pressure Plot without C-D Nozzle (b) Pressure Plot with C-D Nozzle [4]

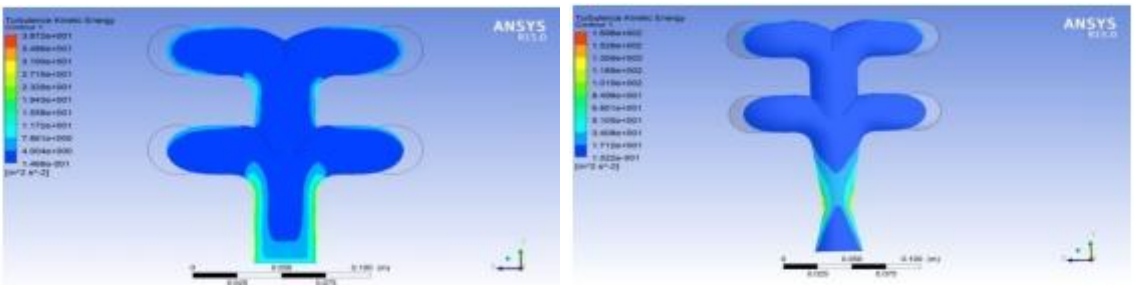


Figure 6: Dimensions of test Specimen: (a) Pressure Plot without C-D Nozzle (b) Pressure Plot with C-D Nozzle

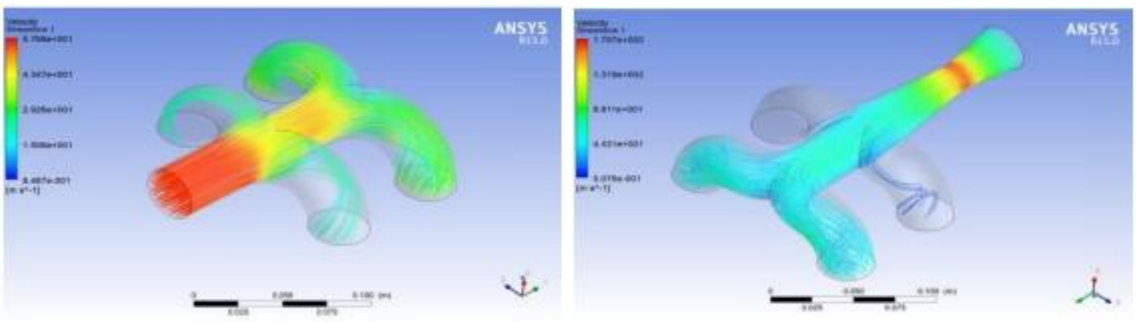


Figure 6: Dimensions of test Specimen: (a) Streamline Velocity without C-D Nozzle (b) Streamline Velocity with C-D Nozzle

The primary objective is to comprehend the flow dynamics inside an intake manifold that has been outfitted with an intake restrictor. The efficiency of an internal combustion engine (IC) relies heavily on the geometric design of the intake manifold. The inefficiency of the intake manifold may be traced to the fact that the air coming in from the runner outputs does not all move at the same speed. The goal of the described research is to achieve this more uniform velocity distribution by increasing the velocity at the outlet without significantly altering the intake manifold design. To find out where the pressure and velocity losses are coming from, two more digital models of the identical intake manifold are created with alternate design configurations and compared to the original model. After examining the models, it was discovered that the pressure losses caused by the concealed projections of the nut, the projected stiffeners, and the depth cuts at the plenum's extremes result in an unequal distribution of airflow at the runners' outputs.

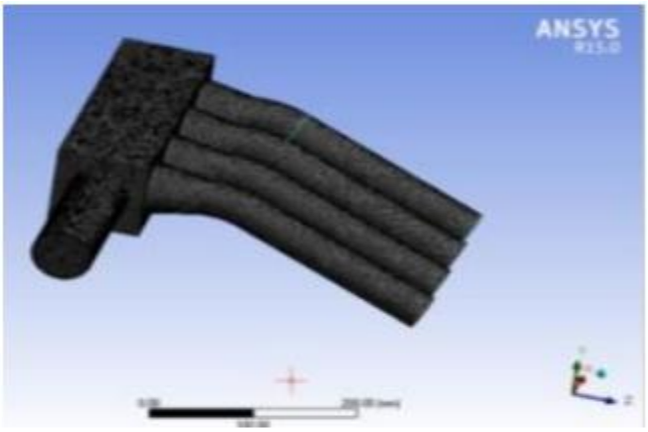


Figure 11: mesh of intake manifold [5]

It is impossible to run a simulation without setting boundary conditions. Since the intake in this case is exposed to atmospheric pressure, the exit will experience suction pressure as a result of the falling piston. Therefore, we will use inlet for pressure in and exit for pressure out. The entire pressure at the intake is required by the pressure inlet boundary condition. Therefore, the total pressure at the inlet is 0 Pa if we assume one atmosphere (gauge pressure). Under normal conditions of use, the reference pressure is set at 101325 as a default. Calculating Absolute Pressure (10,1325) - Reference Pressure (0) (101325).

The following findings are shown at different runners exit of the intake manifold, based on the aforementioned experimental and CFD study.

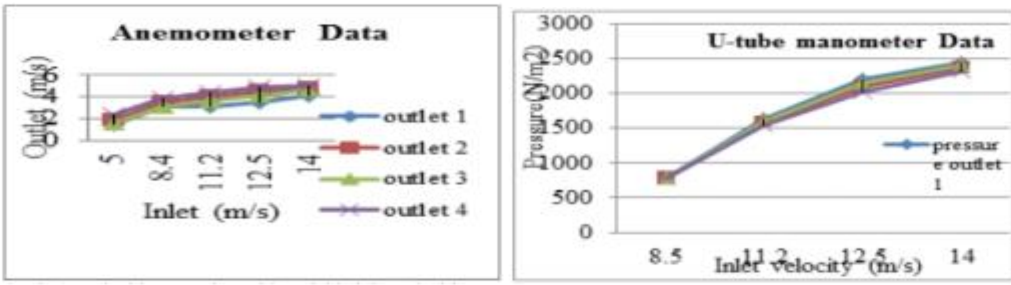


Figure 6: Dimensions of test Specimen: (a) Velocities at outlets with variable inlet velocities (b) Pressure at outlets on variable inlet velocities [5]

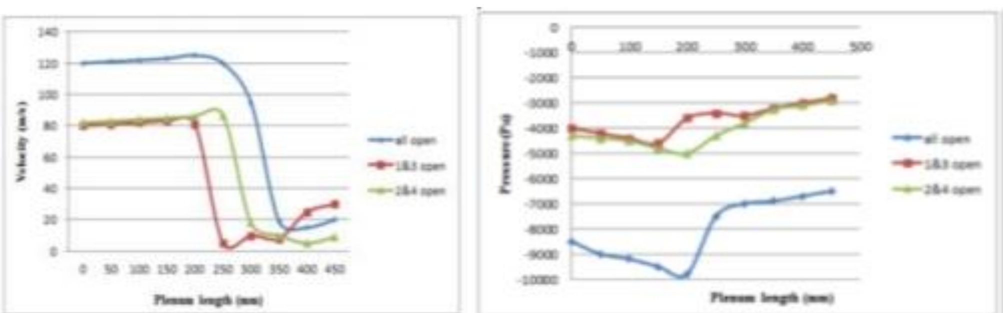


Figure 6: Dimensions of test Specimen: (a) Velocities at outlets with variable inlet velocities (b) Pressure at outlets on variable inlet velocities

The best results are seen in geometries where nuts, stiffeners, and depth cuts at the plenum's extremities have been removed. Not only is there a 16% increase in air flow velocity at runner-1, but there is also an improvement of 5% to 7% approx. at each of the other runners' exits. All around, speeds are almost same.

It has long been understood that an IC engine's performance can only be maximised by carefully crafting its intake manifold. Common components of an IM include a plenum, throttle body, and runners that lead to the engine cylinders. The designer has more leeway in choosing the intake manifold shape since air is the sole fluid in the IM of an internal combustion engine. Equal airflow to each cylinder is essential for a well-functioning engine, and this is the primary responsibility of an IM. The inefficiency of the air being sucked into each cylinder, the subsequent loss of power and higher fuel consumption, all result from an air distribution that is not uniform. A significant portion of an IC engine's volumetric efficiency is determined by the shape of its IMs. Because of the pressure decrease in the cylinders during the intake strokes of an IC engine, pressure waves are generated during operation. The rate at which cylinders are filled is impacted both by the amplitude and the phase of the pressure waves passing through them. These pressure waves are affected by IM geometry, engine speed, and valve timing, which determine their amplitude and phase.

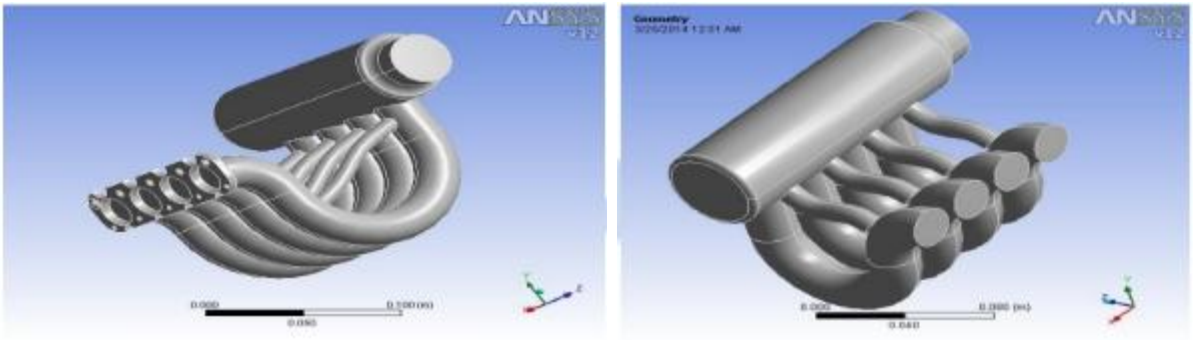


Figure 14: (a) Model of Modification 1 (b) Model of Modification 2 [7]

As the major purpose of stress analysis is to ensure that the intake manifold is sufficiently thick and made of suitable material to withstand bursting pressure under adverse circumstances, we focused on only one runner of the manifold rather than analysing the whole design.

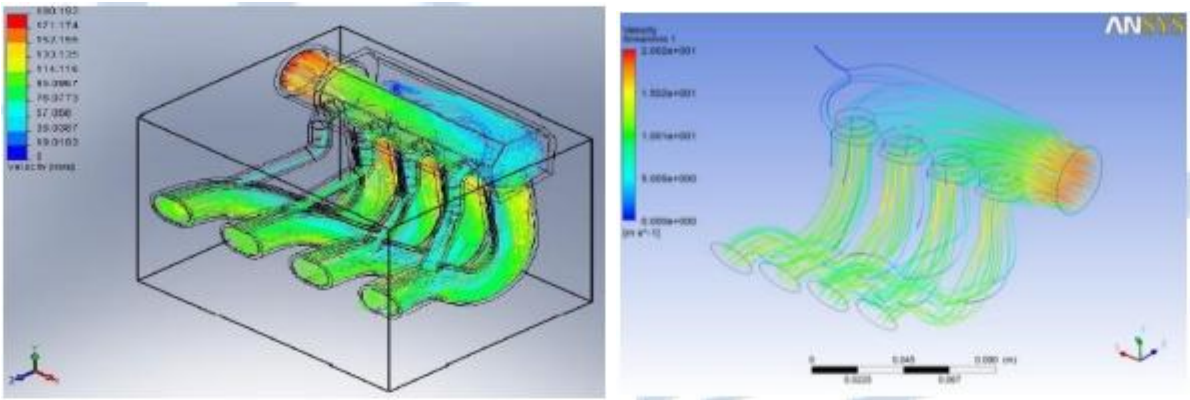


Figure 14: (a) simulation of Modification 1 (b) simulation of Modification 2

Table 1: (a) Result for Model 1 (b) Result for model 2 [7]

Inlet (m/s)	Outlet 1 (m/s)	Outlet 2 (m/s)	Outlet 3 (m/s)	Outlet 4 (m/s)
18	12.1811	14.93	14.83	15.05
15	10.81	12.4499	12.4934	12.7307
13	9.59	10.85	10.55	11.4114
11	8.17	9.15	9.0194	10.4

Inlet (m/s)	Outlet 1 (m/s)	Outlet 2 (m/s)	Outlet 3 (m/s)	Outlet 4 (m/s)
18	14.47	15.7486	15.0876	14.8862
15	11.823	13.21	12.85	12.03
13	10.095	11.4714	11.29	10.82
11	8.443	10.136	9.794	8.7458

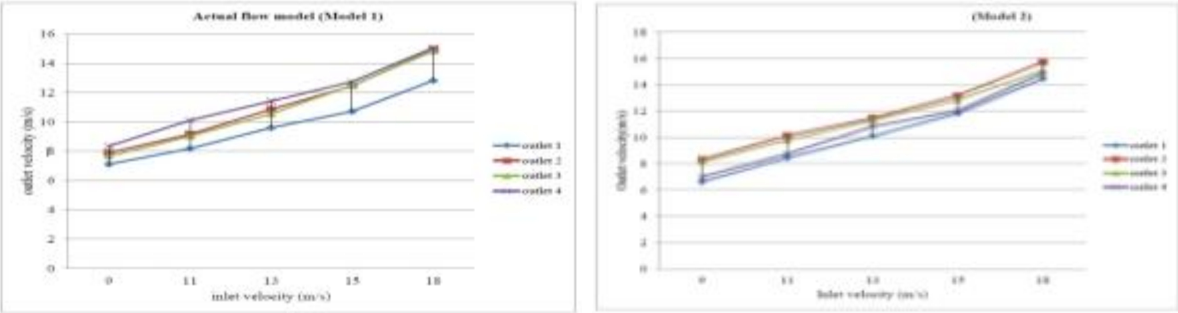
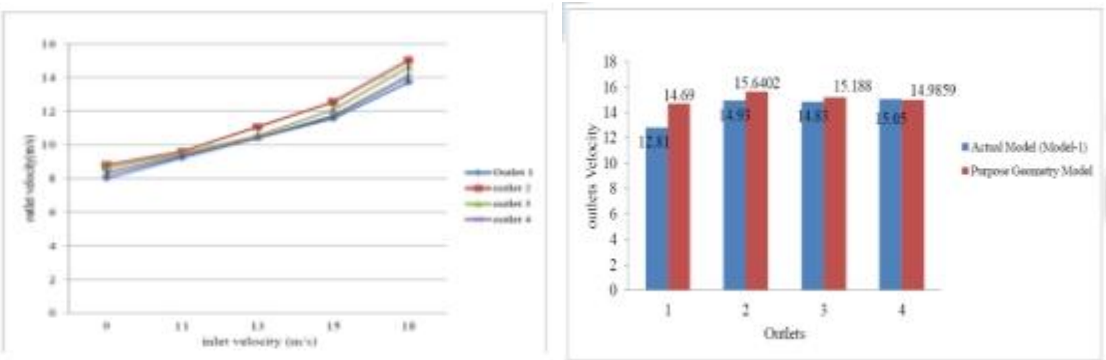


Figure 14: (a) Result of Modification 1 (b) Result of Modification 2



(c) Result of modification 3 (d) Comparison of result

This paper reports the results of a computational fluid dynamics (CFD) investigation of a diesel engine intake manifold.

1) Runners may finish in a curve, and their overall design is satisfactory for the specified intake manifold.

2) Flaws in the plenum chamber's design cause the velocities to fluctuate.

3) There are flaws in the design and casting of the plenum.

4) Since velocity is lowest at outlet-1, more pressure is lost in the plenum chamber on the runner-1 side.

5) The deep cut on runner-1's side and the inwardly protruding bolts prevent airflow.

6) Nuts, stiffeners, and depth cuts at the plenum's extremities should not protrude into the geometry. Not only does the air flow speed rise by 16% in runner-1, but it also improves by about 5% to 7% in the outputs of the other runners. When compared to the original intake manifold, all of the outputs from the runners now have about the same velocity.

Conclusion

Intake geometry has a large effect on engine performance, as is evident from a survey of the aforementioned writers' work. The engine's volumetric efficiency is primarily affected, and as a result, the torque and power output at varying engine speeds. One of the primary determining factors of where in the engine's speed range maximal volumetric efficiency is achieved is the length of the intake manifold. Torque is maximised at lower engine speeds with longer intake manifolds, whereas peak torque is achieved with shorter intake manifolds at higher engine speeds. The goal of this work is to investigate the phenomena of int ake tuning using theoretical and simulation approaches, with experimental verification of the conclusions.

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