CFD ANALYSIS OF INTAKE MANIFOLD OF DIESEL ENGINE

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Abstract

It is quite well known that a properly designed Intake Manifold is vital for the optimalperformance of an IC engine. The power and torque output of an engine can be dramaticallyimproved throughgood intake design. For example, performance can be improved by reducingpressure losses in the intake system. Simulation is a very powerful tool for cutting productdevelopment cycle. It significantly reduces time required for optimization and also gives thedesigner flexibility of going for wide variety of design options, which is not feasible otherwisethrough experimentation. Simulation also helps in detailed understanding of the physicalphenomenon of the respective system. engine intake manifold was experimentally tested, toexamine the variation of velocity of air flow at outlet of four runners and variation of pressure on the manifold. To modify the intake manifold material to increase the volumetric efficiency, first a 3-D model of existing manifold is made indesign software CATIA and ANALYSIS is carried by Ansys.

1. INTRODUCTION

The primary function of an Intake manifold system is to transfer the air fuel mixture from carburetor to the intake port; in addition, intake manifolds have the potential to change the flow characteristics of the charge, which controls the engine performance. The length and diameter of an intake manifold helps in shifting the peak torque point in the engine operating speed range. The volumetric efficiency of an engine can be increased by the principle of dynamic charge boosting. The sum of kinetic energy and potential energy remains constant, thus an increase in the velocity of the Fluid occurs proportionately with an increase in both its dynamic pressure and kinetic energy, and a decrease in its static pressure and potential energy. By making the charge flow through a longer manifold with smaller diameter the velocity of the charge increases which imparts higher momentum to the charge and increases the turbulence of the charge in the combustion chamber.Helmholtz resonance method can also be utilized to achieve peak volumetric efficiency at a desired engine speed, when the intake valve closes, the charge which is in motion hits the valve face and bounce back, this causes a rare-fraction wave to travel down the intake pipe to the open end and it is rejected as a compression wave. A positive tuning effect occurs when the compression wave arrives at the inlet valve as the valve is closing; this can be achieved by proper design of intake manifold length. The tuning peak depends on the engine operating speed During various operating conditions of the vehicle, the torque requirement from an engine is highly variable. Good torque at lower engine speeds improves drivability at city driving conditions and better torque at higher engine speeds improves highway cruising. Conventionally an engine produces peak torque at one particular engine speed usually at the mid-range of the engine operating speed. Shifting of peak torque to lower engine speed by using a longer manifold, improves drivability at city driving condition but leaves poor acceleration at higher engine speeds, and also Peak torque point can be shifted to higher engine speeds by using a shorter manifold which improves highway cruising but leaves poor drivability at city driving conditions. So it is a compromise between low speed drivability and high speed cruising. In order to achieve both low speed drivability and high-speed cruising, the torque should be higher at both lower and higher engine speeds. Dual intake manifolds have the ability to produce better torque at both lower and higher engine speeds by directing the flow of charge through longer manifolds at lower engine speeds and by directing the flow of charge through shorter manifolds at higher engine speeds. Conventionally dual intake manifolds have two manifolds of different length with same entry and exit points, a valve is provided at the manifold junction where it operates in directing the flow of charge through longer or shorter manifolds based on the engine operating speed. However, usage of Dual Intake manifold system in production vehicles is very limited due to packaging constraints, complexity in operation, need for an external actuation mechanism to actuate the valve and increased number of moving parts in the manifold makes it unreliable and incurs additional cost. This research presents a novel Dual Intake Manifold system where it precisely functions in diverting the charge through longer and shorter manifolds. The intake manifold is shown in the fig

Regular Intake manifold and Dual Intake manifold differs in the following:

1. Valve less:- no flow diverting valves are used, which reduces the complexity of the system.
2. No external pneumatic or hydraulic actuation system is required.
3. No moving parts are present in the system thus increased reliability and reduced complexity in operation.
4. Highly compact and packaging is effective.
5. Functions based on Throttle position, partially open throttle condition (POT) and Wide-open throttle condition (WOT).

2. PROBLEM SOLVING AND SOLUTION

Problem Formulation and Gap:

Intake manifold is a device used to distribute the air/air fuel mixture evenly into all cylinders of the engine. Intake manifold is found in each and every engine. Evenly distribution of air/airfuel mixture has made the designing of intake manifold complex. Because if air is not distributed evenly to all cylinders, then power generated in all cylinders vary and show effect on crank shaft and the engine may work roughly. The inlet air temperature is also a major factor affecting the engine performance, the low the temp of inlet air the high the performance of the engine. At present intake manifolds do not reject heat so fast. Our aim is to design a intake manifold with a material which rejects heat fastly and withstand to all the pressure generated inside the manifold and Increase velocity of air entering the engine. Different cross sections of manifold are designed using 3D designing software CATIA.

Objective:

The material used for manufacturing a inlet manifold of diesel engine which offers higher engine performance by increasing the air velocity and reducing the temperature of the air entering the engine from intake manifold. And it should also increase the durability life of component.

The main objective of this project are:

- To compare the heat flux of standard intake manifold and proposed material.
- To compare the air flow velocity at outlet of the manifold for different materials.
- To compare the pressure on intake manifold for different materials.

Materials used:

- Previously the "Intake manifold" was made of Cast Iron and Aluminum.
- The development change in our project would be manifold completely made up of "CERAMIC" material.
- Ceramic has a property of rapid Heat Dissipation, which helps to maintain the temperature of air inside the manifold cooler.
- The Surface Roughness of Ceramic is also very low which helps the air in the manifold to flow with high velocity.
- The properties of the material used is shown in the table 3.1

MATERIALPROPERTIES:

Table 3.1 Material Properties of AL_2O_3 (ALUMINA (CERAMIC))

Parameters	Units	Values
Density	g/cm^3	3.82
Theoretical Conductivity	W/m-k	25-35
Specific Heat	J/Kg K	770
Young's modulus	Gpa	300-400
Surface Roughness	m	$3x10^{-6}$

The values above in Table1 Shows the various values of the Ceramic material used in this project.

Table 1 Material Properties of Cast Iron Used

Parameters	Units	Values
Density	g/cm^3	7.2
Theoretical Conductivity	W/m-k	40-60
Specific Heat	J/Kg K	447
Young's modulus	Gpa	80-110
Surface Roughness	m	$3x10^{-4}$

- The values above in Table 2 Shows the various values of the Cast Iron material used in this project.

3. METHDOLOGY

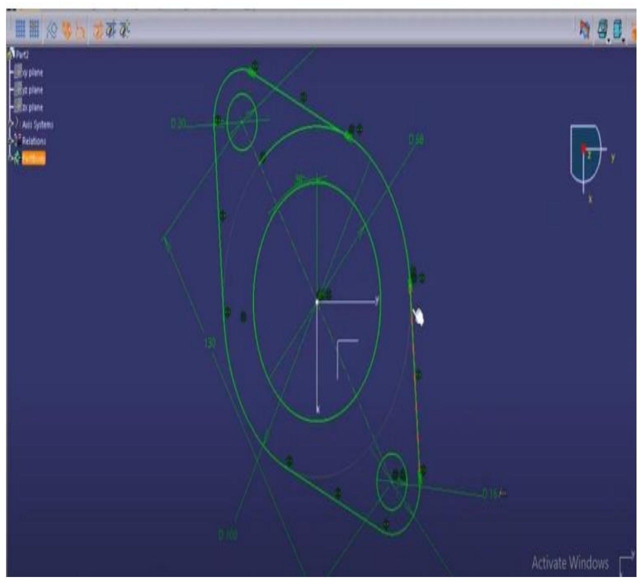

FIG 1 Final part the fits on the head of the engine

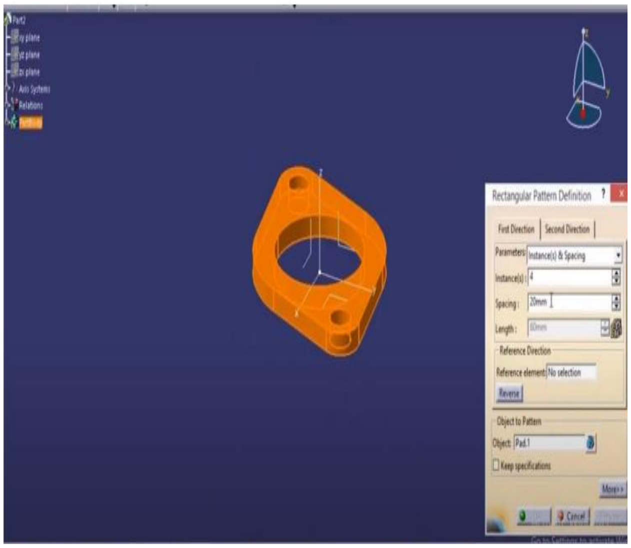

FIG 2 Using pad command to pad the part

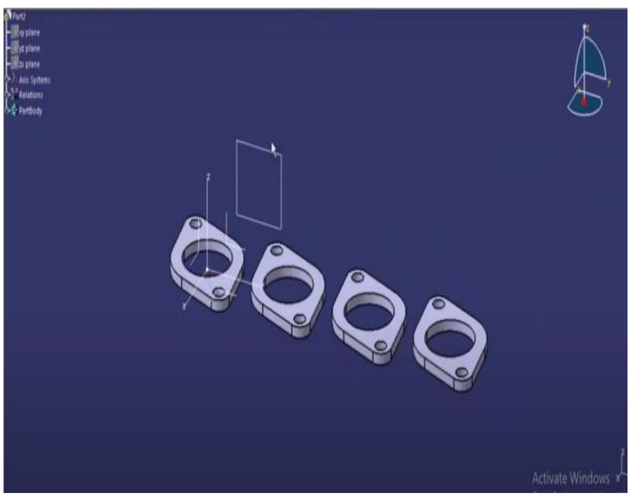

FIG 3 Making four parts using Rectangular Pattern tool.

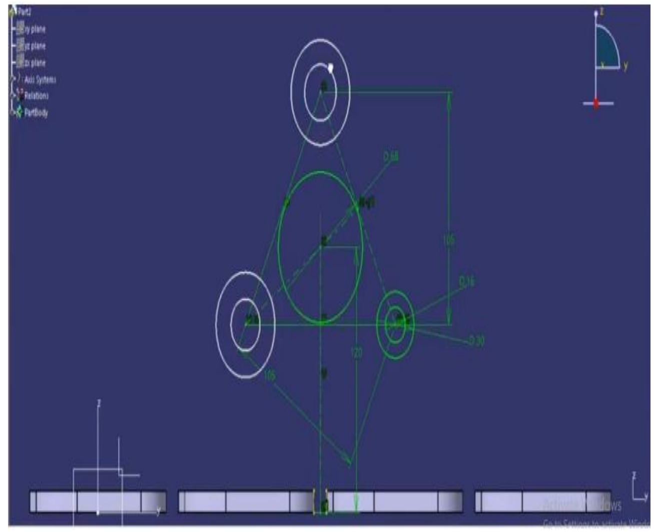

FIG 4 Adding constrains for inlet part

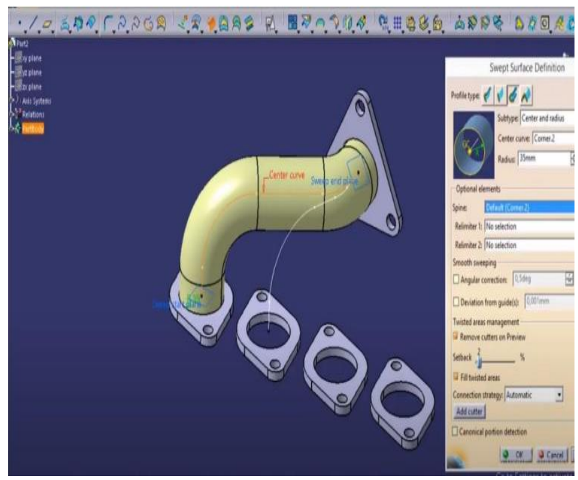

FIG 5Using Swept Surface Definition tool to create runner

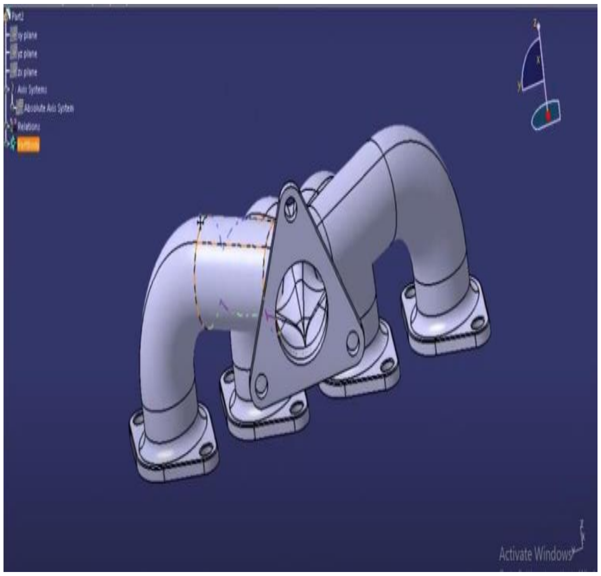

FIG 5 Final intake manifold design

Solving the Analysis

After specifying the boundary conditions in the mechanical window, you need to set the variables to define the results and solve the analysis.

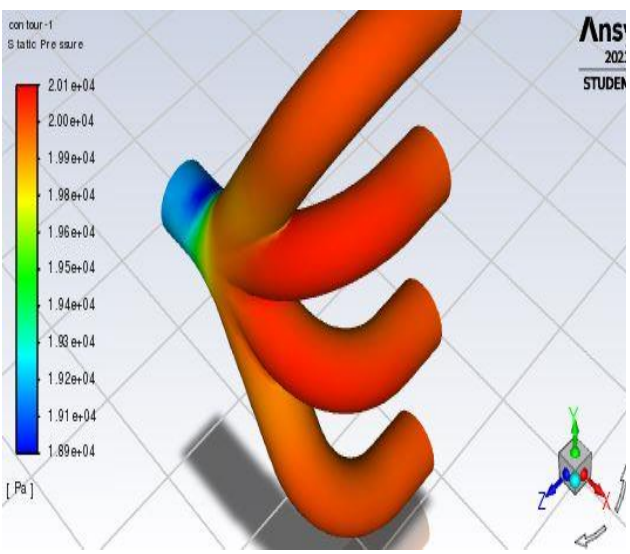

Fig 6 Pressure on Ceramic manifold

The Fig 6 shows the Pressure on Ceramic Intake Manifold at one of the boundary conditions (ie Inlet Velocity at 40m/s, Inlet Air Temperature at 523K). The pressure on the Manifold is high on 2nd and 3rd runners as most of the air flows through through those two runners in our design.

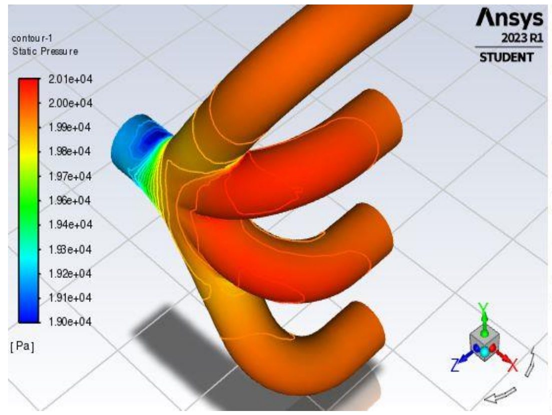

Fig 7 Pressure on Cast Iron Manifold

The Fig7.5 shows the Pressure on Cast Iron Intake Manifold at one of the boundary conditions (ie Inlet Velocity at 40m/s, Inlet Air Temperature at 523K). The pressure on the Manifold is high on 2nd and 3rd runners as most of the air flows through through those two runners in our design.

4. RESULT

Table 3 Values of Heat flux for Ceramic and Cast Iron

Temperature (°C)	CeramicManifold (W/m^2)	Cast Iron Manifold(W/m^2)
100	8.58×10^5	6.63×10^5
150	1.41×10^6	1.09×10^6
200	1.65×10^6	1.51×10^6
250	2.06×10^6	1.94×10^6

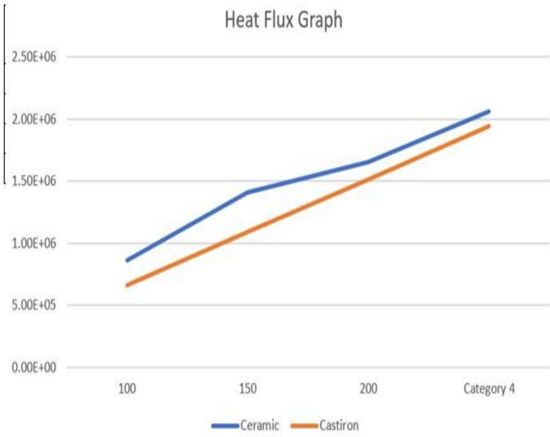

FIG 8Temperature of air at Outlet Vs Heat flux for Ceramic manifold and Cast Iron manifold

The Fig 8 is drawn for Outlet Air Temperature Vs Heat flux for Ceramic manifold and Cast Iron manifold.Heat flux is a term used to describe the amount of thermal energy or heat energy that flows through a unit area per unit time. It is usually denoted by the symbol "q" and has units of watts per square meter (W/m²).

8.2Inlet velocity Vs Outlet velocity values

Table 8.2 Values of Velocity of air at Inlet and Outlet for manifolds of different materials

Velocity of air at inlet of Manifold	Velocity in Ceramic Manifold	Velocity in Cast Iron Manifold
25	25.81974	25.78288
30	30.9917	30.94077
35	36.16541	36.09735
40	41.33816	41.25402

5. CONCLUSION

Heat flux on the Ceramic manifold is comparatively higher than the Heat Flux of the Cast Iron manifold which means dissipation of the heat generated in IntakeManifold is higher in ceramic manifold which makes cooler air to enter the engine which improves the performance of the engine.The velocity of air at outlet of the manifold which is connected to the engine is higher in ceramic manifold when compared to cast Iron manifold, which increases the engine volumetric efficiency because, the faster the air stream velocity, the more air enters the engine cylinder. This will enhance volumetric efficiency.Pressure on intake manifold is lower in Ceramic manifold when compared to Cast Iron which increases the life of the manifold.

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