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Design and Thermal Analysis of Intake Manifold Using Cae Tools

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I INTRODUCTION

In contrast, an exhaust manifold collects the exhaust gases from multiple cylinders into a smaller number of pipes – often down to one pipe. Even distribution is important to optimize the efficiency and performance of the engine. It may also serve as a mount for the carburetor, throttle body, fuel injectors and other components of the engine. Due to the downward movement of the pistons and the restriction caused by the throttle valve, in a reciprocating spark ignition pistion engine , a partial vacuum (lower than atmosphere pressure) exists in the intake manifold. This manifold vacuum can be substantial, and can be used as a source of automobile ancillary power to drive auxiliary systems: power assisted break, emission control devices, cruise control ,ignition advance, winshield wiper ,power windows, ventilation system valves.

The carburetor or the fuel injector spray fuel droplets into the air in the manifold. Due to electrostatic forces some of the fuel will form into pools along the walls of the manifold, or may converge into larger droplets in the air. Both actions are undesirable because they create inconsistencies in the air-fuel ratio. Turbulence in the intake causes forces of uneven proportions in varying vectors to be applied to the fuel, aiding in atomization. Better atomization allows for a more complete burn of all the fuel and helps reduce engine knock by enlarging the flame front. To achieve this turbulence it is a common practice to leave the surfaces of the intake and intake ports in the cylinder head rough and unpolished.

Modern intake manifolds usually employ runners, individual tubes extending to each intake port on the cylinder head which emanate from a central volume or "plenum" beneath the carburetor. The purpose of the runner is to take advantage of the Helmho;tz resonance property of air. Air flows at considerable speed through the open valve. When the valve closes, the air that has not yet entered the valve still has a lot of momentum and compresses against the valve, creating a pocket of high pressure. This high-pressure air begins to equalize with lower-pressure air in the manifold. Due to the air's inertia, the equalization will tend to oscillate: At first the air in the runner will be at a lower pressure than the manifold. The air in the manifold then tries to equalize back into the runner, and the oscillation repeats. This process occurs at the speed of sound, and in most manifolds travels up and down the runner many times before the valve opens again.

The smaller the cross-sectional area of the runner, the higher the pressure changes on resonance for a given airflow. This aspect of Helmholtz resonance reproduces one result of the venture effect. When the piston accelerates downwards, the pressure at the output of the intake runner is reduced. This low pressure pulse runs to the input end, where it is converted into an over-pressure pulse. This pulse travels back through the runner and rams air through the valve. The valve then closes.

1.1 Effects on Intake Manifold

Variable-Length Intake Manifold (VLIM) is an inertnal combustoin engine manifold technology. Four common implementations exist. First, two discrete intake runners with different length are employed, and a butterfly valve can close the short path. Second the intake runners can be bent around a common plenum, and a sliding valve separates them from the plenum with a variable length. Straight high-speed runners can receive plugs, which contain small long runner extensions. The plenum of a 6- or 8-cylinder engine can be parted into halves, with the even firing cylinders in one half and the odd firing cylinders in the other part. Both sub-plenums and the air intake are connected to an Y (sort of main plenum). The air oscillates between both sub-plenums, with a large pressure oscillation there, but a constant pressure at the main plenum. Each runner from a sub

CHAPTER – II

LITERATURE SURVEY

The literature reviews presented in the work are classified into five major domains. Engine performances, breathing of engine, characteristics of volumetric efficiency are reviewed in this chapter. Engine simulation modeling techniques and design methodologies in transient runs are also reviewed. Research works carried out with GT Power code simulations are also reviewed.

2.1. ENGINE PERFORMANCE

Payri et al (1990) discussed the processes of P-V diagram and T-S diagram of a diesel engine in detail. The experimental tests were conducted in a single cylinder, indirect injection Ricardo E6-MS/128/76 type diesel engine with variable loads and different engine speeds of 1000 rpm to 2200 rpm. Payri et al (1990) developed the methodologies for intake system design. Klein (1991) studied the effect of heat transfer through a cylinder wall on the work output of Otto and Diesel cycles. The maximum work or power and the corresponding efficiency bounds are derived. Chen (1996) derived the relations between net power output and the efficiency of the Diesel and Otto cycles with considerations of heat transfer through a cylinder wall.

2.3 ENGINE SIMULATION AND MODELING TECHNIQUES

Until recently, the most common solution techniques used by both industry and the academic institutions were based upon the numerical solution method of Characteristics as proposed by Benson et al (1964 a). Although these algorithms were sufficiently accurate for most practical purposes, they carried a number of limitations within their formulation. The primary drawback was the non-conservative implementation of the source terms in the one dimensional equation set. This meant that geometrical discontinuities such as sudden enlargements and contractions had to be handled using iterative boundary solutions that were computationally time-consuming. Also the first order quasi-linear solution of the characteristic equations caused unavoidable smearing of pressure and contact discontinuities. A major breakthrough in solution accuracy and computational efficiency was application of finite difference/finite volume solutions for one dimensional unsteady flow. The validated model was used as a virtual engine in order to develop an in-cylinder mass observer for engine control, allowing access to relevant internal variables such as air and residual gas mass trapped in the cylinder. Since Matlab and Simulink was the corner stone tool for current engine control designer.

CHAPTER – III

PROBLEM STATEMENT AND OBJECTIVES

The objective of this project work is to successfully develop a design of an Intake Manifold to have the better alignment towards the in ports of the combustion chamber for the ignition process. The mechanism is to be reliable, simple, cost-effective and feasible.

The aim of this paper is to provide and to perform a numerical study on a compact Intake Manifold at different intake flow rates., so as to enable added by modifying chosen geometrical and flow parameters. This system is also supposed to enhance engines efficiency as the side force felt by a engine

The methodology adopted to use standard and presently used component in design rather than to design all supportive components from ground up. The advantage of this method is that, you do not have to spend ridiculous amount and time in testing the integrity of each part as they have already proved their worth in real world applications.

Initially the Intake Manifold design was adopted from already existing Engine Manifold and minor changes were made to suite our purpose, the Engine Manifold mechanism first devised was based on using power by DC Motor and lowering each area of the inlet of the Manifold.

3.1 WORKING MECHANISM

An intake manifold is a component that delivers either air or an air/fuel mixture to the cylinders. The design of these components varies widely from one application to another, but they all perform that same basic function and they all have a single input and multiple outputs. In carbureted engines, the intake manifold connects the carburetor to the intake ports. In fuel-injected engines, the intake manifold connects the throttle body to the intake ports.

In addition to the basic functionality of connecting intake ports to the rest of the intake system, an intake manifold will often serve as the mounting point for other components. These manifolds sometimes also form an integral part of the cylinder head, in that they may serve to “seal” the top of an engine, particularly on internal combustion engines that have a V configuration. In addition to air (and fuel), intake manifolds sometimes also have coolant pass through them.

CHAPTER – IV

DESIGN METHODLOGY OF INTAKE MANIFOLD

4.1 Introduction to CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).

Sets of workbenches can be composed according to the user’s preferences. Therefore Dassault Systems offers three different software installation versions. The platform P1 contains the basic features and is used for training courses or when reduced functionality is needed. For process orientated work the platform P2 is the appropriate one. It enables, apart from the basic design features, analysis tools and production related functions. P3 comprises specific advanced scopes such as the implementation of external software packages.

Dassault Systems has begun serving shipbuilders with CATIA V5 release 8, which includes special features useful to shipbuilders. GD Electric Boat used CATIA to design the latest fast attack submarine class for the United States Navy, the Virginia class. Newport News Shipbuilding also used CATIA to design the Gerald R. Ford class of super carriers for the US Navy

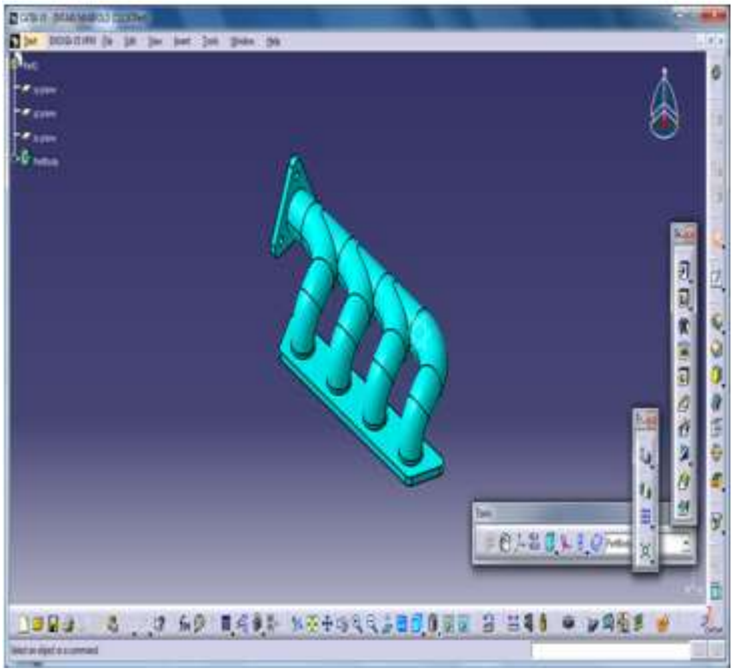

Fig: 4.1: Model design of Intake Manifold in CATIA-V5

CHAPTER-V

ANALYSIS OF INTAKE MANIFOLD

5.1 Procedure for FE Analysis Using ANSYS

The analysis of the Intake Manifold is done using ANSYS. For compete assembly is not required, is to carried out by applying moments at the rotation location along which axis we need to mention. Fixing location is bottom legs of rod assembly machine.

5.2 Meshing

Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain. The term "grid generation" is often used interchangeably. Typical uses are for rendering to a computer screen as finite element analysis or computational fluid dynamics. The input model form can vary greatly but common sources are CAD, NURBS, B-rep and STL (file format). The field is highly interdisciplinary, with contributions found in mathematics, computer science, and engineering.

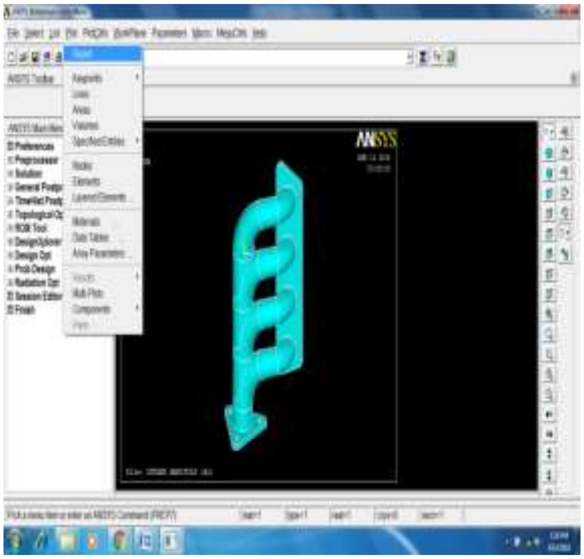

Fig.5.1: Replotting (Refresh) the component from the menu bar.

Three-dimensional meshes created for finite element analysis need to consist of tetrahedral, pyramids, prisms or hexahedra. Those used for the finite volume method can consist of arbitrary polyhedral. Those used for finite difference methods usually need to consist of piecewise structured arrays of hexahedra known as multi-block structured meshes.

5.3Analysis Procedure of Intake Manifold

Tetrahedral element that has a quadratic displacement behavior and is well suited to model irregular meshes (such as produced from various CAD/CAM systems). The element is defined by ten nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element also has plasticity, creep, swelling,

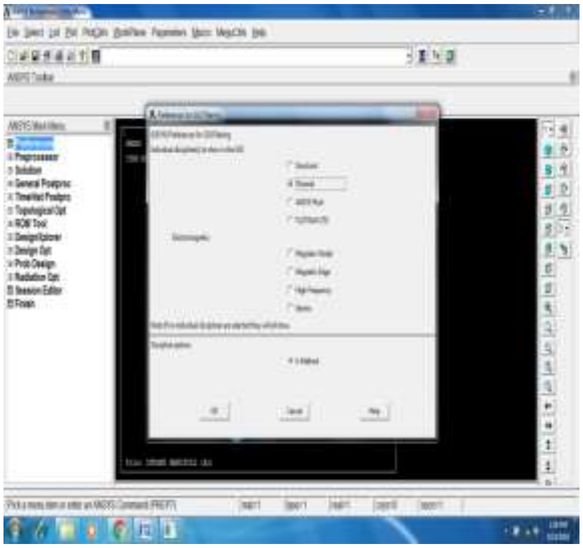

Fig.5.2: Giving Preferences to the solid component – Thermal – ok

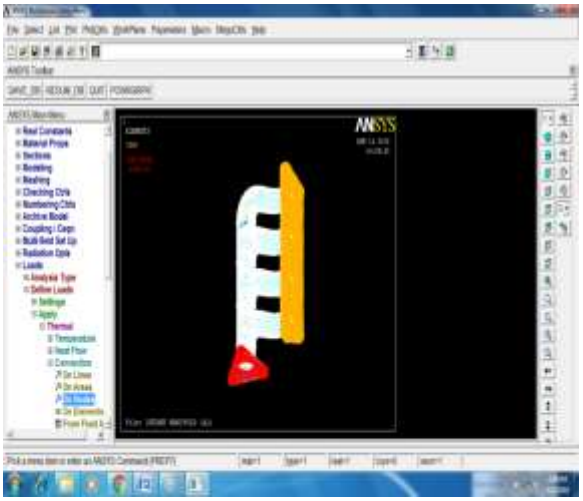

Fig.5.3: Image of Element where Loads are applied

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DISCUSSION ON ANALYSYS RESULT

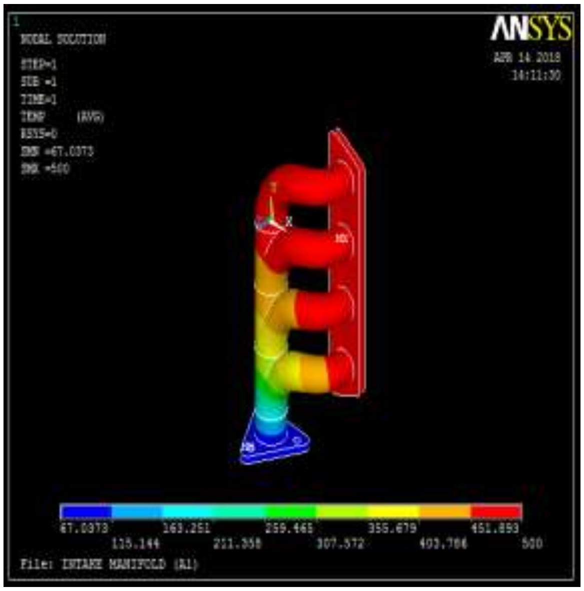

Fig: 6.1: Nodal Temperature of **Intake Manifold (Al)**

6.1 Results of Thermal Gradient analysis

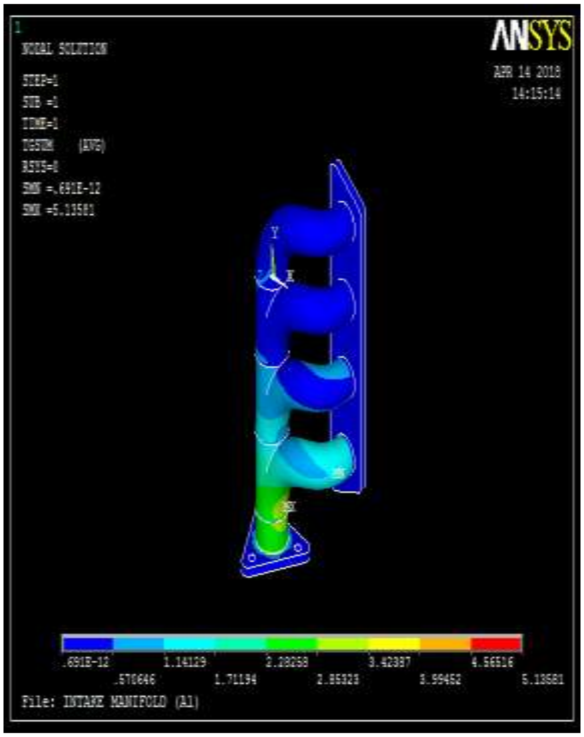

Fig: 6.2: Thermal Gradient of **Intake Manifold (Al)**

6.2 Results of Thermal Flux analysis

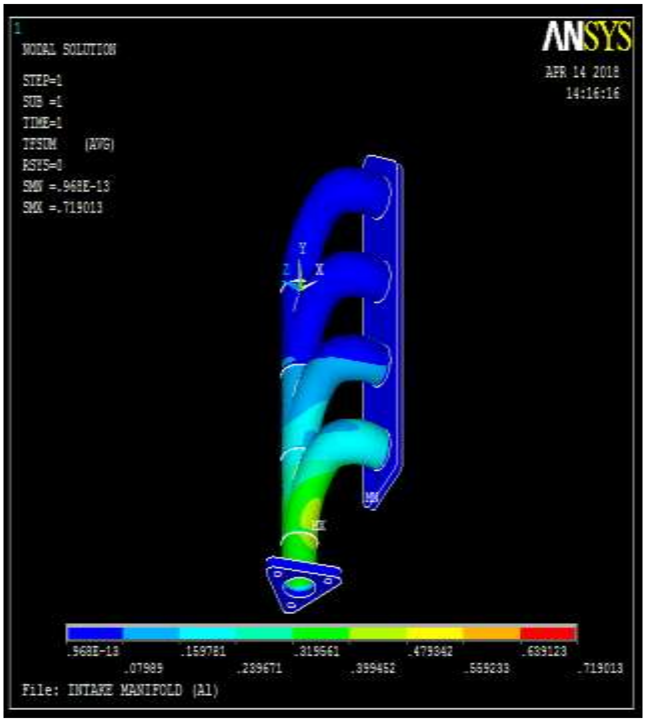

Fig:6.3 :Thermal Flux of **Intake Manifold (Al)**

CHAPTER – VII

CONCLUSION

In this project an Intake Manifold is designed, it has been compared by specifying with two different materials of Aluminum and Cast Iron. These 3D models are designed in Catia.

The analysis tool Ansys is used to perform thermal analysis of Intake Manifold at different areas. By observing the analysis results, the nodal temperature is increased by 67.03 and 88.96; temperature gradient is increased by 5.13 and 4.89 for the comparison model of the Intake Manifold.

Heat transfer analysis is performed to analyze the heat transfer rate to determine the thermal flux. The material taken is Aluminum and Cast Iron for thermal analysis. By observing the thermal analysis results, and thermal flux rate is 0.71 and 0.68; the Heat flow rate is 0.21 and 0.17 on the surface medium for the modified model of Intake Manifold.

TABLE FOR RESULTS

S.No	Intake Manifold (Al)	Intake Manifold (CI)
Nodal Temperature	67.03	88.96
Temperature Gradient	5.13	4.89
Thermal Flux	0.71	0.68
Heat Flow	0.21	0.17

FUTURE 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
- To obtain optimum runner diameter
- This design was based on taking consideration of manufacturing issue and was cost efficient. But designed could have been better if sufficient resources.

CHAPTER – VIII

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