Comparison of Heat Flux by using Different Geometry and Temperature of Exhaust Manifold

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***Abstract* — *An exhaust manifold or header collects the exhaust gases from multiple cylinders into one pipe. Exhaust manifolds are generally simple cast iron or stainless steel units which collect engine exhaust gases from multiple cylinders and deliver it to the exhaust pipe. The goal of performance exhaust headers is mainly to decrease flow resistance, and to increase the volumetric efficiency of an engine, resulting in a gain in power output. The exhaust manifold has to withstand the pressure of exhaust gases and amount of heat generated in the engine. A parametric model of exhaust manifold has been developed to predict the transient thermal behavior. The parametric model is created in 3D modeling software Pro/Engineer. Present used materials for exhaust manifold are cast iron or stainless steel. Steady thermal analysis is done on the exhaust manifold to determine variation temperature distribution over time. The analysis is to be done using Stainless Steel are present used materials. We compare the results to verify the best material for exhaust manifold .Steady thermal analysis determines temperatures and other thermal quantities that vary over time. The variation of temperature distribution over time is of interest in many applications such as with cooling. The accurate thermal simulation could permit critical design parameters to be identified for improved life. The analysis is done using ANSYS on workbench of Steady state thermal analysis performed for calculating the heat flux and thermal difference or analytically heat flux is also calculated in this analysis. Select the optimum design and its behavior of physical properties.*

Keywords-*Exhaust Manifold, Heat flux, Heat flux per unit length, Design optimization, FE Analysis.*

I. INTRODUCTION

Research paper on studying different aspects of exhaust manifold shapes and design .In automotive engineering, exhaust manifold collect the exhaust gases from multiple cylinders into one pipe. Exhaust manifolds are generally simple cast iron or stainless steel unit which collect engine exhaust gas from multiple cylinders and deliver to the exhaust pipe. These consist of individual exhaust head pipe for each cylinder, which then usually converge into 1 tube called a collector The exhaust manifold pressure is a crucial variable for turbocharger Diesel engines, affecting the torque production & the emissions through variations in the EGR mass flow in the residual mass fraction in the cylinder. This variable is therefore considered very relevance for closed-loop EGR and turbocharger control.

Figure 1: Exhaust Manifold Model

II LITERATURE REVIEW

Air intake and exhaust system of an engine plays very important role in engine performance in such competitions where even a slight less performance increases chances of failure. So, designing those needs special attention and lots of study. In market there are various manufacturer like - Eurojet MK6 Exhaust System, SFX, Donaldson, and Silex, which provides wide range of these system according to performance requirements. [1]

Investigated different types of general intake configuration used in such competitive events. The Conical-Spline Intake system was found to give less variation of volumetric efficiency when compared to every cylinder and engine performance out of all the three types of intake concepts that were evaluated. [2]

Suggested different ways of optimization technique used for air intake and exhaust system. Orthogonal Array Testing was implemented which is common these days for designing air intake of such competitions. It was assumed that the air in the system due to its inertia is sloshing back and forth and bouncing in the resonant cavities as a result expansion and compression waves are passing through the pipeline, which gets reflected due to collision with open and closed ends and also due to variation in cross sectional area of the pipeline, [3]

The engine performance of a JIALING JH600 motorcycle was optimized by applying energy balance equation for the whole system and mass balance in different section of the engine. Also, it was found that the solution for simulation of 1D flow in the approximated direction considering average of flow, requires the conservation of mass, momentum and energy equations,[4]

Provided a brief interpretation of the dynamics of exhaust system of an internal combustion engine which makes it requisite field for improving performance of the engine by both theoretically and practically. Dynamic analysis of exhaust system, theoretical modelling and simulation, experimental investigation product development and virtual prototypes were studied. And a distinctive exhaust configuration was modelled, simulated and experimentally investigated for realizing the fact and to appraise modelling ideas. In this investigation prime attention was to observe the effect of the bellows-type flexible joint. [5]

He had designed exhaust and intake system for a car which has 600cc Suzuki GXR engine. This was designed to meet the criterion to satisfy the rule of 20mm restrictor on the intake flow of air to the engine. A new engine mapping was done for better performance of the engine. It also compared the air flow simulation using CFD analyses and looked at various alternate air intake configuration. It discussed use of rapid prototype technique for creating a prototype. And presented designing and manufacturing of a new throttle body. The whole process for engine ECU tuning and dyno test results were also introduced. This presented an approach for the designing and analysing of various exhaust configuration and measuring sound level.[6]

III. *PROBLEM DEFINITION*:

Engine exhaust manifolds are the metal components that are responsible for collecting exhaust gases and transporting them to the exhaust for expulsion from the tailpipe. They are bolted to the engine cylinder head(s) and are sealed using a gasket known as the exhaust manifold gasket. The exhaust manifold gasket is usually a multi-layered gasket that contains metal and other materials that are designed to provide the best seal possible. As the exhaust manifold gasket is the first in the exhaust system, it is a very important seal that should be inspected if any problems arise. When it fails or has any issues, it can cause all sorts of problems for the vehicle. Usually a bad or failing exhaust manifold gasket will produce a few symptoms that can alert the driver of a potential issue.

1. Excessively noisy engine

One of the first symptoms of a problem with an exhaust manifold gasket is an excessively noisy engine. A faulty exhaust manifold gasket will produce an exhaust leak that will sound like a hissing or tapping sound coming from the engine. The sound may be especially pronounced during a cold start or during acceleration.

2. Decrease in power, acceleration, and fuel efficiency

Engine performance issues are another common symptom of a problem with an exhaust manifold gasket. If the exhaust manifold gasket fails, the exhaust leak can result in engine performance issues such as a decrease in power, acceleration, and even fuel efficiency. The performance decrease may be minor at first, but will worsen over time if not addressed.

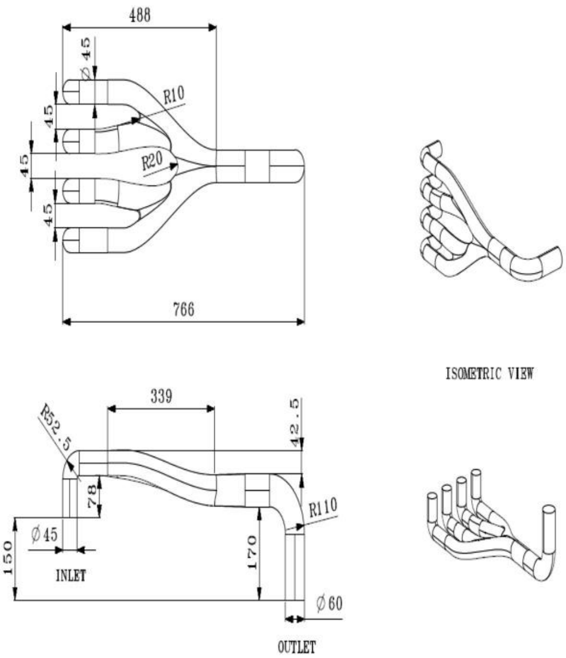


Figure 2: Dimension Of Manifold

Material Properties

Material properties	Value
Density	2770 Kg/m^3
Young's modulus	71 GPa
Poisson's ratio	0.33
Shear modulus	2.6692E+10 Pa
Tensile yield strength	280 MPa
Tensile ultimate strength	310 MPa

Table 1: Material Properties

IV *FE ANALYSIS ON THERMAL ANALYSIS*

Apply boundary condition for different geometry is Rectangular Fins, Circular Fins and Curved Fins.
Internal temperature = 600C, 800C, 1000C
Thermal Conductivity = 25W/m2C
Surrounding temperature = 25C

Temperature Distribution-

In this figures we can calculate the temperature gradient of exhaust manifold for all geometries. Value of exhaust manifold 1324 at 1000°C is give the optimum solution which give the high rate of heat dissipation.

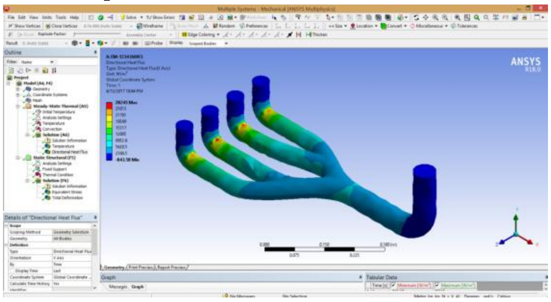


Figure 3 A Thermal Analysis Of Exhaust Manifold At 600°c 1234

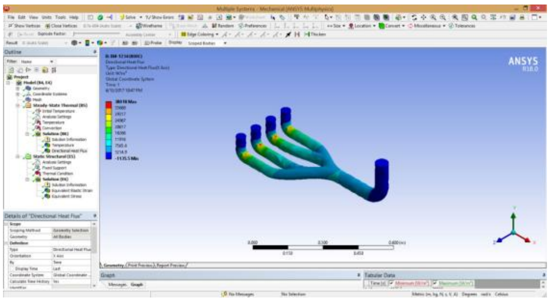


Figure 3 B Thermal Analysis Of Exhaust Manifold At 800°c 1234

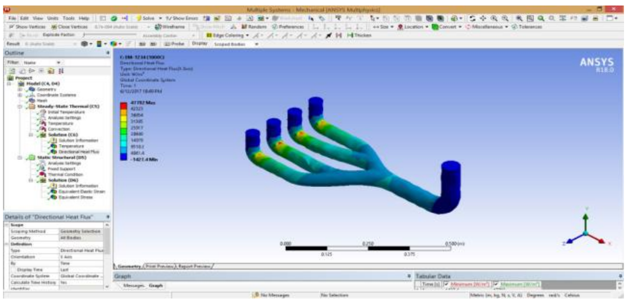


Figure 3 C Thermal Analysis Of Exhaust Manifold At 1000°c 1234

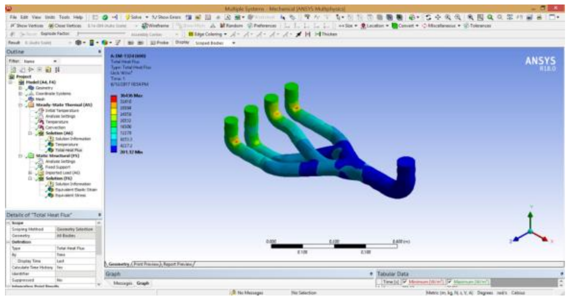


Figure 4 A Thermal Analysis Of Exhaust Manifold At 600°c in 1324

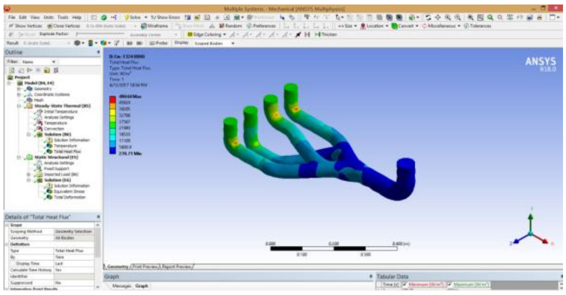


Figure 4 B Thermal Analysis Of Exhaust Manifold At 600°c in 1324

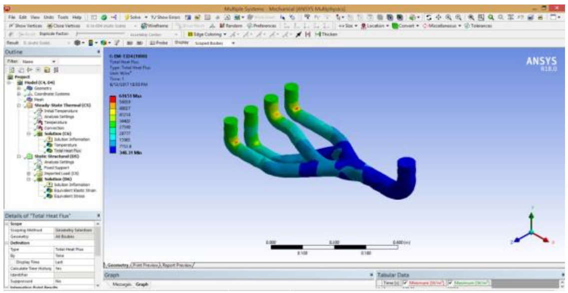


Figure 4 C Thermal Analysis Of Exhaust Manifold At 600°c 1324

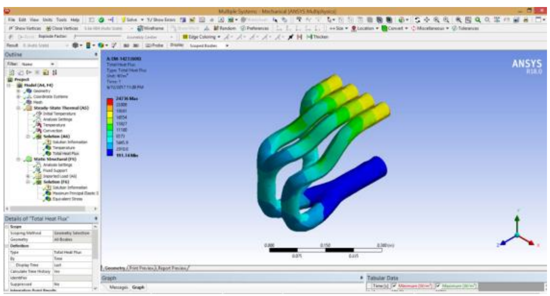


Figure 3 A Thermal Analysis Of Exhaust Manifold At 600°c

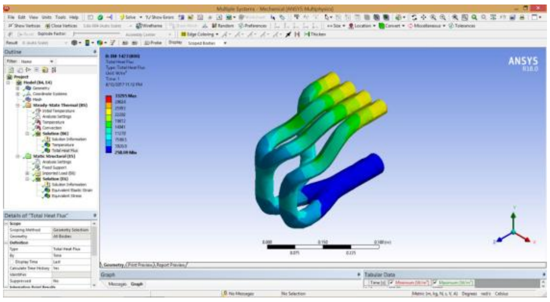


Figure 5 B Thermal Analysis Of Exhaust Manifold At 800°c in 1423

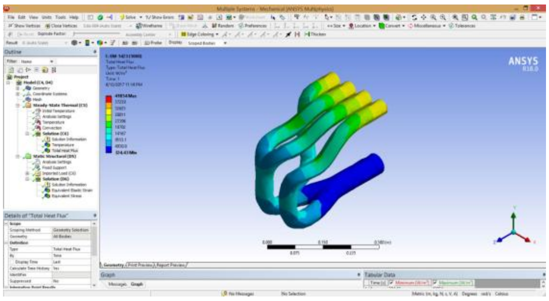
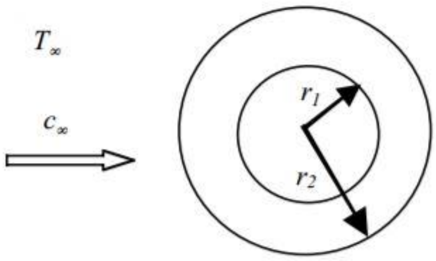


Figure 5 C Thermal Analysis Of Exhaust Manifold At 1000°c

V MATHEMATHICAL CALCULATION

A second example of combined conduction and convection is given by a cylinder exposed to a flowing fluid.

Shown in below figure-



Basic formula of heat flux are

$$Q=\frac{2\pi(T_0-T_A)}{K/hr2+\ln(r2/r1)}$$

Where,

h=Co-efficient heat transfer

T_o=Nodal Temperature

T_a=Surrounding Temperature

K=Thermal Conductivity

r2 and r1=Outer and inner radius of pipe

h=25w/m^2

T_o=600°C ,800°C and 1000°C

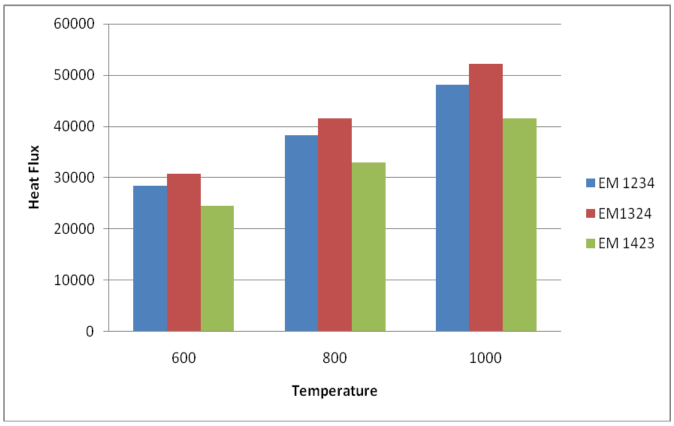
T_a=25°C

K=50W/m k

r1=.045m

r2=.040m

Analytical Graph-



Bar Graph.1 Compare All Exhaust Manifold Analytical Result-

VI RESULT

Comparison between Analytical Result and FE Analysis Result of Heat Flux

Table 1 Comparison of Exhaust Manifold 1234

Temperature	Analytical	FE Analysis	Error
600	28245	28379	4.7%
800	38018	38250	6.0%
1000	47792	48121	6.8%

Table 2 Comparison of Exhaust Manifold 1324

Temperature	Analytical	FE Analysis	Error
600	30456	30804	1.1%
800	49044	41519	15.3%
1000	61651	52234	15.2%

Table 3 Comparison of Exhaust Manifold 1423

Temperature	Analytical	FE Analysis	Error
600	24736	24518	0.8%
800	33295	33046	0.7%
1000	41854	41574	0.6%

Here We Compare All The Data Related To Heat Flux Which We Collected From Mathematical Calculation And From The Software Also And We Are Very Close In Error This Will Show Our Calculation And Software Cole To Equal And That All The Related Data Taken From Research Paper Of Previous Year .

VII CONCULSION

In this thesis, a Exhaust Manifold is designed and analyzed for LCV. The Exhaust Manifold is designed for the thermal condition. Theoretical calculations have been calculated for Exhaust Manifold dimensions at different cases like varying thickness and this dissertation, analysis has been done by taking various geometry. Static and thermal analysis are conducted on exhaust manifold.

A comparative study has been made between Exhaust Manifold for thermal analysis we observed that the Exhaust Manifold is lighter and more economical than the others manifolds with similar design specifications.

This study will help to understand more the behavior of the Exhaust Manifold and give information to improve the thermal condition of the exhaust manifold using CAE tools. It can help to reduce cost and times in research and development of new product. Finite element method using CAE tool like ANSYS-18 Workbench prove the reliability of the validation methods based only on simulation, thereby saving time, This work will help to understand linear static behavior of the composite Exhaust Manifold and simulation data for the researcher's to improve the fatigue life of the Exhaust Manifold using Computer Aided Engineering tool.

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