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Research Paper

An Investigation on the Thermal Properties of an Element of an Exhaust Manifold for Use in Automobiles

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ABSTRACT:
A sectional model of the exhaust manifold has been examined in this study in order to minimize heat loss via pipe insulation using various insulating materials. The exhaust manifold's thermal resistance was raised using four distinct insulating materials to reduce heat loss inside the manifold. The insulating material model was discretized and modeled. The discretized model has been given the thermal and structural characteristics, which have been prepared for examination. The analytical model is fed the exhaust gas heat flux as input. Temperature differential and heat loss were considered outputs. Based on the current investigation, it can be concluded that using these four materials will lessen heat loss via the exhaust manifold.
KEYWORDS: *Thermal Property, Thermal Load, Exhaust Manifold, Automobile Element.*

I. INTRODUCTION

Automotive and energy industries, such as internal combustion engine is used in various fields are an important major transport. Performance, emissions and engine durability and design, choice of material and auto parts, the fatigue life of the heat transfer effect. And the need to improve the performance of the engine is transferred to the heat of the engine cooling system. Automobile exhaust gases in the exhaust system of the engine of the temperature measurement are useful to understand the process. Empty the gas engine at a very high speed and high temperature strength. Outgoing gas silencer in the exhaust system of the automobile exhaust, exhaust system, which is thermal, vibration and fatigue caused by cracks in the muffler in the exhaust system, which led to the disruption of the high temperature of the combustion chamber, the hot parts of the exhaust system in order to study heat transfer analysis to improve the performance of the machine.
The types of insulating materials utilized in this work are listed below.

1.1. Insulation Made of Fibrous Materials
composed of air that has been carefully broken into interstices by fibers of tiny diameter, which are often mechanically or chemically linked to make hollow cylinders, boards, and blankets. For instance, mineral fiber and fiber glass

1.2. Cellular Insulation: Made of boards, blankets, or hollow cylinders, this insulation is made of air or another gas enclosed in a foam of stable tiny bubbles. Polyurethanes and elastomeric foam are two examples.

1.3. Granular Insulation: Made of blocks, boards, or hollow cylinders, this material is made up of air or another gas in the spaces between tiny grains. Calcium silicate, for instance

II. MATERIAL PROPERTIES

Table.1. Properties of Steel used.

Material	Value	Unit
Density	7.9E-09	tonne/mm^3
Young's Modulus	2.1E+05	MPa
Poisson's Ratio	0.3	
Co-efficient of thermal expansion	1.2E-05	mm/mm-K
Thermal conductivity	0.0253	W/mm-K

Table.2. Properties of Silica used

Property	Value	Unit
Density	2.42E-09	tonne/mm3
Young's Modulus	7.3E+04	MPa
Poisson's Ratio	0.165	-
Co-efficient of thermal expansion	5.5E-07	mm/mm-K
Thermal conductivity	1.7E-05	W/mm-K

Table.3. Properties of Glass wool used.

Property	Value	Unit
Density	5.1E-10	tonne/mm3
Young's Modulus	5.5E+03	MPa
Poisson's Ratio	0.3	-
Co-efficient of thermal expansion	4.8E-06	mm/mm-K
Thermal conductivity	4E-05	W/mm-K

Table.4. Properties of Plastic foam used.

Property	Value	Unit
Density	6.72E-10	tonne/mm3
Young's Modulus	3.6E3	MPa
Poisson's Ratio	0.21	-
Co-efficient of thermal expansion	7E-05	mm/mm-K
Thermal conductivity	3E-05	W/mm-K

VEHICLE SPECIFICATIONS

For the present analysis, the engine specifications of Mitsubishi Pajero have been selected. The details of the vehicle specifications are given below.

Table.5. Vehicle Specifications

Sl. No.	Brand	Mitsubishi
1.	Model	Pajero
2.	Generation	Pajero IV
3.	Engine	3.8 i V6 24V MIVEC (250) 5-doors
4.	Power	250 HP/6000 rpm.
5.	Maximum speed	200 km/h
6.	Acceleration 0 - 100 km/h	10.8 sec
7.	Seats	7
8.	Length	4900 mm.
9.	Width	1875 mm.
10.	Height	1870 mm.

11.	Wheelbase	2780 mm.
12.	Model Engine	Mitsubishi 6G75
13.	Position of engine	Front, longitudinal
14.	Engine displacement	3828 cm^3
15.	Torque	329 Nm/2750 rpm.
16.	Fuel System	Multi-point injection
17.	Position of cylinders	V engine
18.	Number of cylinders	6
19.	Bore	95 mm.
20.	Stroke	90 mm.
21.	Compression ratio	9.8
22.	Number of valves per cylinder	4
23.	Fuel Type	Petrol (Gasoline)

III. CAD AND MESHED MODEL

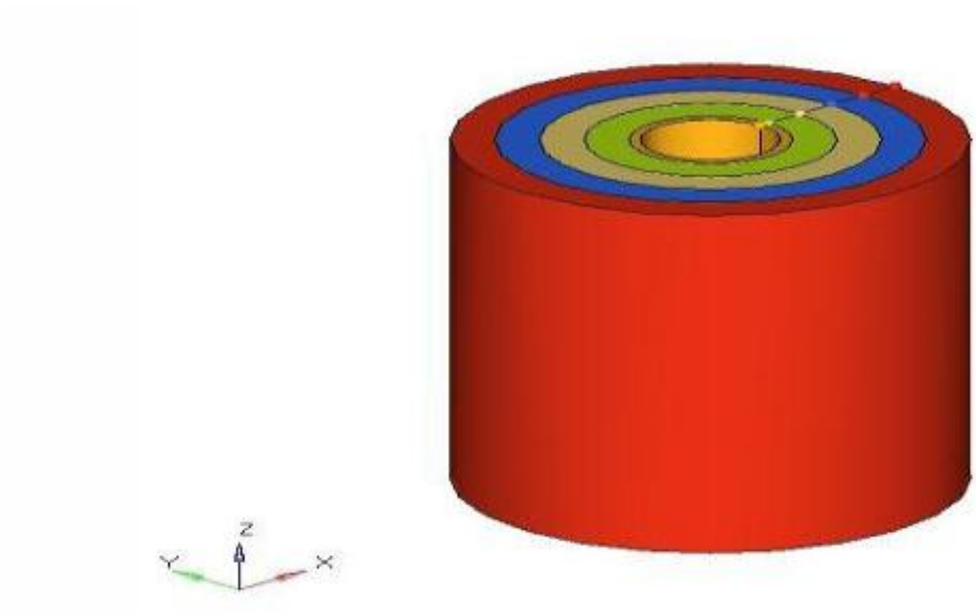

Fig.1. CAD Model of the exhaust manifold section

This CAD model was created using CATIA version 5, as seen in the figure. The dimensions that were chosen in the stage before this one have been used for the modeling process. It demonstrates that a steel pipe is located in the middle of the model, and that four different types of insulating materials—namely, silica, glass wool, polyurethane foam, and plastic foam—have been modeled around the steel pipe. All of the measurements that are utilized are in millimeters.

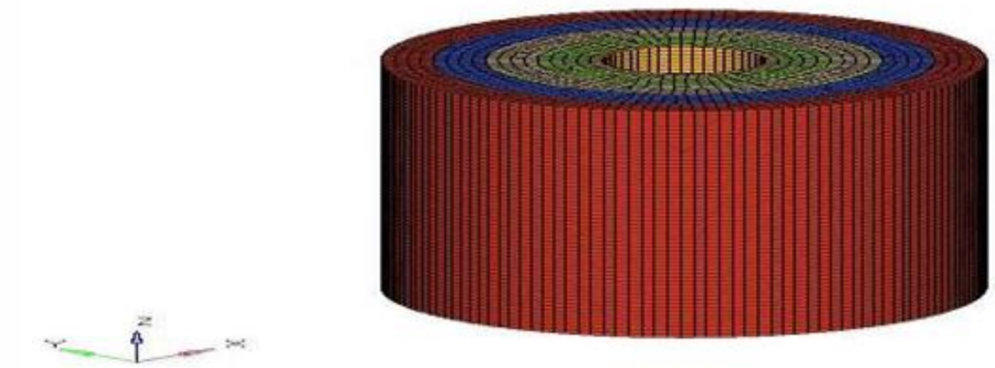

Fig.2. FE Model of the Exhaust manifold section

Meshed result of Exhaust Manifold section.
Total No of Nodes- 444081, Total No of Elements -439200

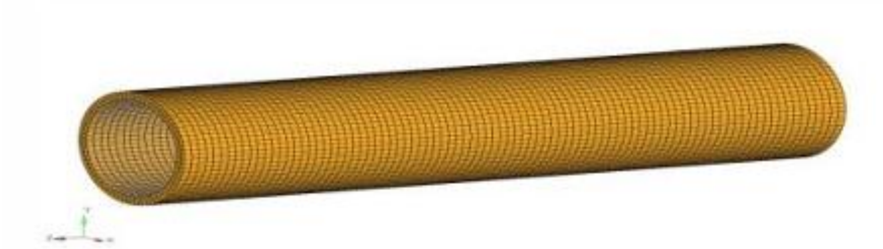

Fig.3. FE Model of the steel pipe

Meshed result of STEEL section
Total No of Nodes- 20748, Total No of Elements -20520.

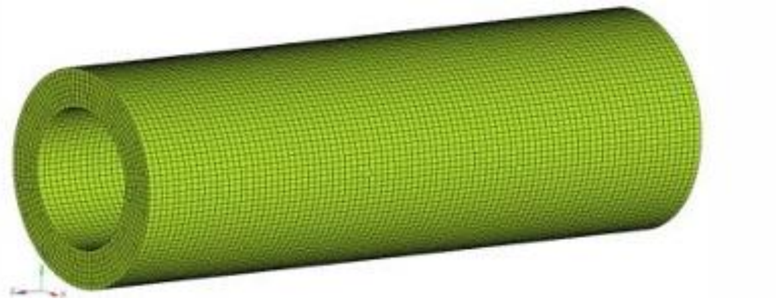

Fig.4: FE Model of Silica insulation

Meshed result of SILICA section
Total No of Nodes – 71890, Total No of Elements – 64260

Fig.5: FE Model of Glass Wool Insulation

Meshed result of Exhaust Manifold section
Total No of Nodes- 104468, Total No of Elements – 92700

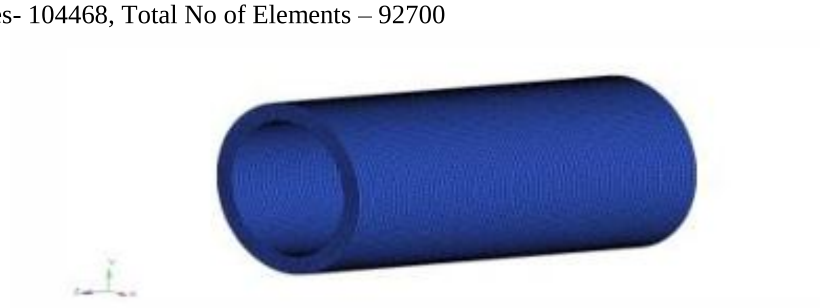

Fig.6: FE Model of PUF insulation

Total No of Nodes-133770, Total No of Elements -117900

IV. THERMAL LOADING AND BOUNDARY CONDITIONS

Both the thermal boundary conditions and the load that was applied to the model are shown in the figure below. The heat flux that was computed in the previous section has been applied to the inner radius of the steel pipe, and the BCs have been applied to the edges of the model that are on the outside. A close simulation of the action of the exhaust gases passing through the steel exhaust manifold portion is provided by this example.

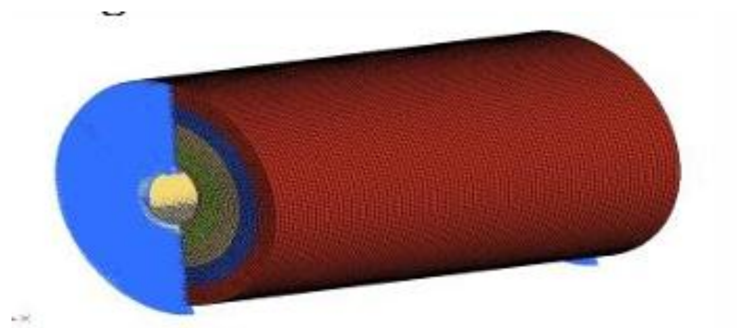

Fig.8: Thermal Loads and Boundary conditions of the exhaust manifold section

V. RESULTS AND DISCUSSION

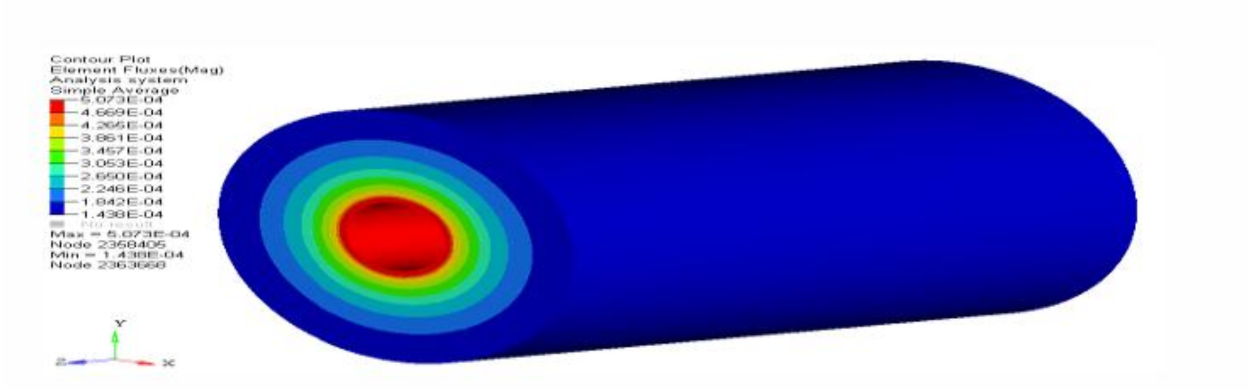

Fig.11: Variation of heat flux in the exhaust manifold section

The heat flux distribution in the exhaust manifold portion is seen in the figure positioned above. Observation reveals that the highest heat flow occurs inside the steel pipe due to the presence of exhaust gasses, and that this flux diminishes as the pipe gets closer to the atmosphere. The outer surface of the pipe segment exhibits the lowest heat flux of any part of the pipe. As a result of the fact that the thermal conductivity of the insulating materials is changing, this demonstrates that the heat flow is decreasing.

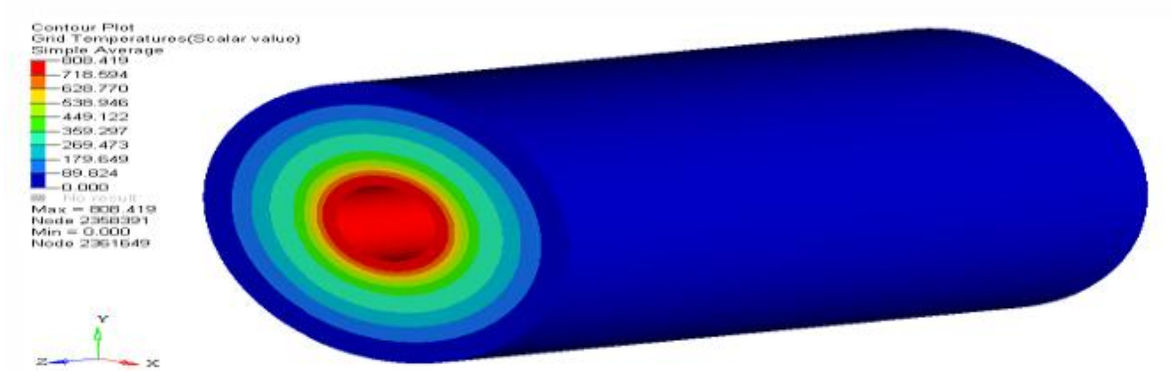

Fig.12: Temperature distribution in the exhaust manifold section

A temperature distribution in the exhaust manifold portion is shown in the figure that can be seen above. The exhaust gases that are passing through the steel pipe force the inner wall to reach its highest temperature. This is due of the structure of the steel pipe. With a high value of 808.4 degrees Celsius near the steel pipe and a low value of around 35 degrees Celsius on the outside surface of the insulation, the temperature ranges from high to low.

VI. CONCLUSIONS

The following findings may be drawn from the current study.

The thermal loads imposed on the manifold section indicate that the temperature distribution is consistent and remains within the parameters of the insulating materials. The heat flux generated in the model owing to thermal loads is seen to diminish, exhibiting a high value at the core and a low value at the periphery of the insulation. The pressure exerted on the steel pipe indicates that the displacement is minimal and does not impact the pipe's performance. The stress in the pipe segment is under the yield limit of the materials and is safe for operation under the specified circumstances.

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