DESIGN AND ANALYSIS OF EXHAUST MANIFOLD OF FOUR WHEELERS

Santosh Kulkarni[1], Dontula Achyuth[2], Dappu Ravi Kanth[3], Dubashi Sai Teja[4]

[1]Assistant Professor, Department of Mechanical Engineering, CMR College of Engineering & Technology, Hyderabad, India.

[2,3,4]Student, Department of Mechanical Engineering, CMR College of Engineering & Technology, Hyderabad, India

Abstract

The exhaust manifold in an internal combustion engine is a very vital component affecting the performance of an engine. The engine's volumetric efficiency is directly depended on its ability to push out the exhaust gases effectively to suck in more air for combustion. To effectively expel the exhaust gases, a good manifold is required and in cases of a turbocharged engine the manifold is even more important. The objective of this project is to analyze existing designs of exhaust manifold to establish a better understanding of the significance of various factors involved in its design process. The material and specifications are varied and results were compared in present paper. The target of this research is to design, implement and then perform experimental comparison a EXHAUST MANIFOLD under various metals such as Stainless Steel 304, Aluminium 6063, Cast Iron. In automotive engineering, an exhaust manifold 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 gas from multiple cylinders and deliver it to the exhaust pipe. Normally, ferrous alloys are used in the manufacturing of exhaust system. These include carbon steel, stainless steel, alloy steels and cast iron. The purpose of adding alloying elements is to help in solid solution strengthening of ferrite, improve the corrosion resistance and other characteristics and the cause the precipitation of alloy carbides. Mild carbon steel was extensively used for the manufacturing of exhaust systems for a considerable period of time. Although mildsteel has the properties to withstand exhaust temperature it has very poor corrosion resistance. High exposure to road salt and exhaust condensate can terribly shorten the life span of a mild steel based exhaust system.I gave the detailed report of material properties, simulation, evaluation and orthographic view.

Key words: Exhaust manifold, Volumetric efficiency, Automotive engineering.

1. INTRODUCTION

The exhaust manifold of a vehicle motor is constantly presented to hot gasses. Cast iron has been being used for the generation of exhaust systems generally. The fundamental qualities required for the exhaust manifold material incorporate warm weariness quality required to withstand the high temperature deplete gasses, oxidation resistance , great manufacture properties and low warm ability to upgrade the reactant work. Ferritic stainless steel display every one of these properties and offers huge weight lessening too. Ferritic stainless steel displays enhances warm weariness attributes when prepared by strong arrangement reinforcing with molybdenum or niobium. The exhaust manifold used in a 4-stroke IC engine is mounted on the cylinder head of an engine. The gases exhausted from the engine are collected by the exhaust manifold and it is sent to a catalyst converter. The exhaust manifold has an important role in the performance of an engine system. The exhaust manifold affects the efficiencies of emission and fuel consumption. During the process of collecting the gas from engine and exhaust to catalyst converter, the exhaust manifold experiences temperatures of800°c and the pressures varying from 100 to 500kpa. The exhaust manifold is under a thermal fatigue produced by the exhaust gases increasing and decreasing temperatures. The pressure waves of the emitted exhaust gases during particular times of the cycle subject internal pressure. These will lead to cracks in the exhaust manifold. Thermal and mechanical loadings are the major factors in the failure of the exhaust manifold. The manifold may be a casting or fabricated of relatively light material. The purpose of the exhaust manifold is to collect and carry these exhaust gases away from the cylinders with a minimum of back pressure. Exhaust Manifolds are affected by thermal stresses and deformations due the temperature distribution, heat accumulation or dissipation and other related thermal quantities. In a today scenario, there is high competition between vehicle manufacturers.

Fig 1: Exhaust Manifold

Exhaust Systems for Specific Applications:

Some engine applications confront more establishment difficulties than others. Marine establishments, for example, are managed almost no space and require impressive security from water entering the fumes framework. The data that takes after locations some of these challenges and can be relevant to marine based and in addition some land based establishments.

Marine Dry Exhaust System:

The marine dry fumes framework, as a rule, is like a run of the mill arrive based fumes framework and will be liable to a similar fumes framework plan contemplations as of now talked about in this area.

Fig 2: Marine Dry Exhaust sysytem

Marine Exhaust Ejector Automatic Ventilation System:

A moderately basic framework using a motor's fumes for ventilating a motor room can be organized with most dry fumes frameworks. Ventilation work can be introduced around the motor fumes channeling in a manner that the fumes stream makes a vacuum that is used to draw the hot freshen up of the upper part of the motor room. This strategy has been utilized effectively in marine applications with little motor rooms and negligible ventilation prerequisites. A fumes ejector framework may draw out an amount of ventilating air around equivalent to the stream of fumes gas.

2. DESIGN CONSIDERATIONS AND CRITERIONS

Present day engines are required to have more engine power and are also required to meet the strict pollution standards. To improve exhaust system performance, many design specifications are required. The Exhaust Manifold of an automobile engine is always exposed to hot gases. The main characteristics required for the exhaust manifold material include thermal fatigue strength required to withstand the high temperature exhaust gases, oxidation resistance, good fabrication properties and low thermal capacity to enhance the catalytic function. Proper material section for components exposed to elevated temperature service is complex. Although operating temperature and peak skin temperatures are the major factors limiting materials that can be used, many other variables contribute to the proper selection. In addition to operating working temperatures, mechanical and thermal loading conditions in the component's working environment are also considered.As the operating temperature of a component exceeds 600 F, the range of service limitations begins, such as degradation of mechanical properties. The higher the temperature, the greater the number of degradation mechanisms at work, but alloying additions can be effective in sustaining many material properties

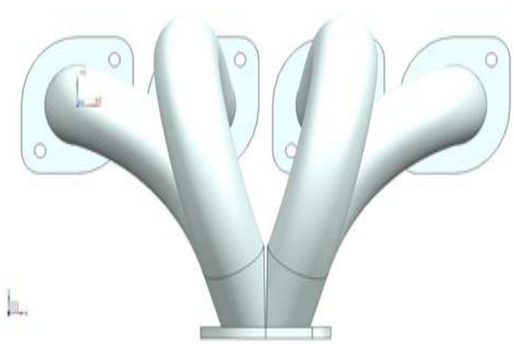


Fig 3: Top view of the exhaust manifold

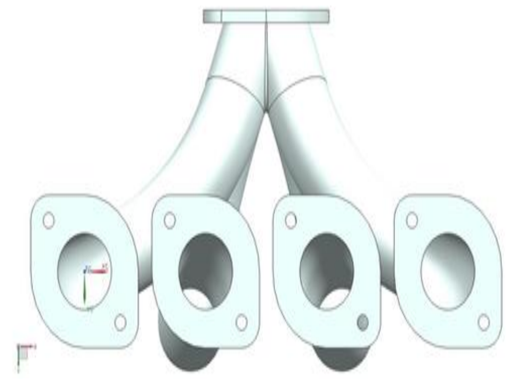
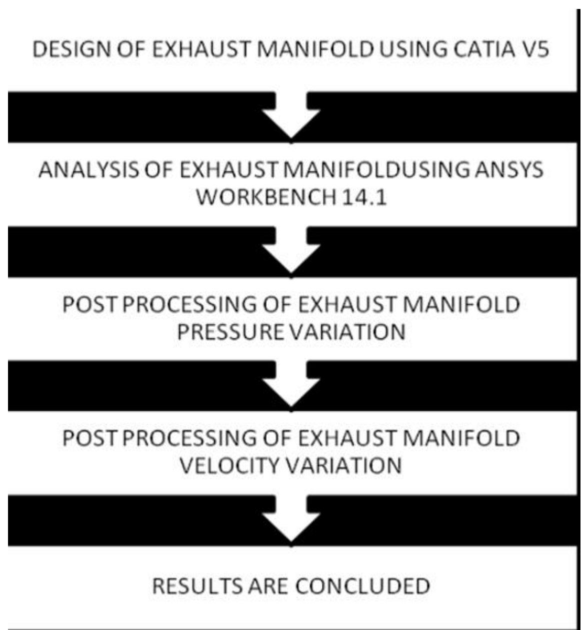


Fig 4: Bottom view of the exhaust manifold

BLOCK DIAGRAM



3. METHODOLOGY

The Dimensions and Exhaust temperature are noted using experimental studies on the manifold. The geometric model of exhaust manifold created using Creo Parametric 2.0 is saved with STEP (.stp) format so that it can be imported and accessed in ANSYS Workbench 14.5. Steady State Static Structural and Transient Thermal Module are coupled. Fine Mesh model is created using Model wizard. Materials are assigned using the Engineering Data Wizard. Structural forces and exhaust thermal conditions are applied in the set up wizard. Results of the analysis are obtained in the form of Total Deformation, Equivalent (von-Mises) Stress and Temperature Distribution, Maximum Deflection and Stresses are obtained for the results. Reports are generated for three different materials and these results are analyzed

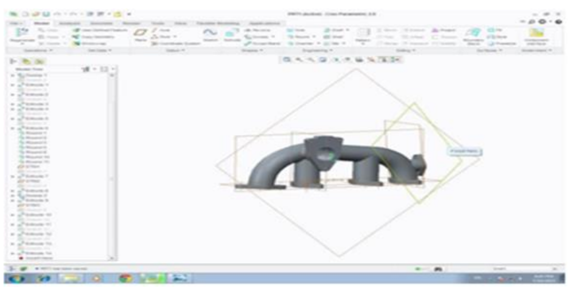


Fig 5 Ansys software

Table 1: Properties of materials

Material Properties	Unit of Measurement	Manganese	Stainless steel	Copper
Density	kg m^3	7200	7750	4430
Isotropic thermal Conductivity	w m^-1 k^-1	46	22.5	6.7
Coefficient of thermal expansion	c^-1	1.1e-005	1.7e-005	9.4e-006
Young's modulus	mpa	97000	19900	96000
Poisson's ratio	-	0.26	0.31	0.34
Ultimate tensile Strength	mpa	150	1500	950
Yield tensile strength	mpa	98	310	880
Brinell hardness	hb	440	269	334
Melting	°C	2210	1510	3020

4. ANALYSIS & RESULT

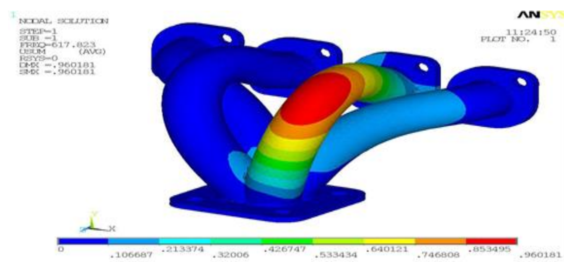
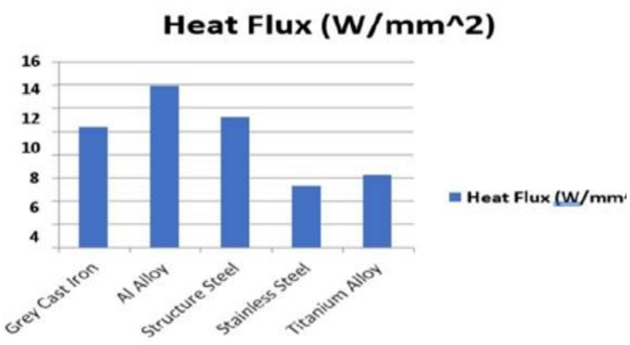
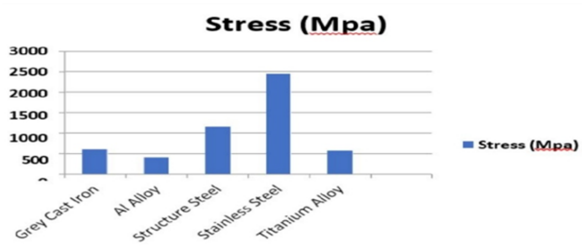


Fig 6 Model shape @Hz for exhaust manifold



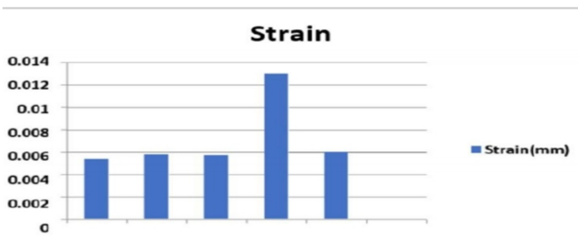
Graph 1: Total heat flux comparison

In the total heat flux comparison, we can see that the maximum heat flux occurred in Aluminum Alloy material and minimum heat flux occurred in stainless steel.



Graph 2: Stress Comparison

In the stress comparison we can see that the maximum stress generates in Stainless Steel material and minimum stress generate in aluminum Alloy.



Graph 3:Strain Comparison

In the strain comparison we can see that the maximum strain generates in Stainless Steel material and minimum strain generate in grey cast Iron.

5. PARAMETERS

Table 2 : Parameters

Parameters	Manganese	Stainless steel	Copper
Total Deformation	1.5507e-006 m	7.563e-007 m	1.0073e-006 m
Total Heat Flux	7.8333e+006 W/m²	6.3174e+006 W/m²	1.3067e+005 W/m²
Equivalent(von-Mises) Stress	1.2081e+005 Pa	1.1901e+005 Pa	1.1728e+005 Pa
Manifold Weight	15.43 Kg	17.34 Kg	8.87 Kg

6. CONCLUSION

In this study we design an exhaust manifold with different high temperature resistant materials and we test it with Finite Element Methodology, both temperature distribution and thermal stress concentrations are calculated using Finite Element Methodology .Here after design we have imported it into the Ansys and first Thermal analysis is done on it using the materials-cast iron, silicon nitride, zinc oxide. By using these materials the results are obtained and when they are compared with each other we can conclude that cast iron has the best ability to dissipate heat but it will get effected by the heat very soon, even though silicon nitride and zincoxide are poor conductors, we should consider there insulation property's as when manifold gets heated up it will act as a heat source to the cylinder head on which it is mounted. More over these materials won’t chip in course of time so clogging of exhaust system is also avoided, which also prevents back pressure conditions.Now even CFD analysis is done to the best output material here and the results obtained are plotted in a tubular form. As per the results obtained totally we can conclude that the exhaust manifold with and zinc oxide are the best suited materials with better life.Basic examination and Thermal investigation has been performed on the ventilation system to discover the deformities in the arrangement of ventilation system. Examination was finished by considering the two unique materials structural steel and gray cast iron. gray cast iron has observed to have more twisting while contrasted with others. structural steel is great material for this design. We can also reduce the cost of the manifold if we use these materials as coatings on the manifold. By using these materials the results are obtained and when they are compared with each other we can conclude that cast iron has the best ability to dissipate heat but it will get effected by the heat very soon, even though silicon nitride and zinc oxide are poor conductors, we should consider there insulation property’s as when manifold gets

heated up it will act as a heat source to the cylinder head on which it is mounted. More over these materials won’t chip in course of time so clogging of exhaust system is also avoided, which also prevents back pressure
conditions.With the Reference of FEA Result we are concluded that titanium alloy shows the better result than grey cast iron which is our existing material.The amount of weight reduced by titanium alloy is 21% compared to the existing material also in thermal consideration heat flux reduced 25% compared to the existing material.In structure parameter also titanium alloy deformed 20% less deformed compared to the existing material.

7. REFERNCES:

1.Swathi Satish, Mani Prithiviraj and Sridhar Hari, “Comparison of predictions obtained on an exhaust manifold analysis using conformal and indirect mapped interface”, International Congress on Computational Mechanics and Simulation, IIT Hyderabad, 10 – 12 December 2012.

2.J.DavidRathnaraj, “Thermo mechanical fatigue analysis of stainless steel exhaust manifolds”, IRACST – Engineering Science and Technolgy, Vol 2, No. 2, April 2012, PP 265 – 267.

3. M.Rajasekhar Reddy, DrK.Madhava Reddy, “Design And Optimization Of

Exhaust Muffler In Automobiles", International Journal of Engineering Research and Applications, Vol 2, Issue 5, Sept-Oct 2012, PP 395 – 398.

4.Sweta Jain, AlkaBani Agrawal, "Coupled Thermal – Structural Finite Element Analysis for Exhaust Manifold of an Off-road Vehicle Diesel Engine", International Journal of Soft Computing and Engineering, Vol 3, Issue 4, September 2013, PP 226-230.

5.BinZou, Yaqian Hu, ZhienLiu,Fuwu Yan and Chao Wang, "The Impact of Temperature Effect on Exhaust Manifold Thermal Modal Analysis", Research Journal of Applied Sciences Engineering and Technology, August 20, 2013, PP 2824-2829.

6.A.K.M. Mohiuddin, AtaurRahamn and Mohd. Dzaidin, "Optimal design of automobile exhaust system using gt-power", International Journal of Mechanical and Materials Engineering, Vol 2 No. 1, 2007, PP 40 – 47.

7.Modelling and Design of Exhaust Manifold Under Thermo mechanical Loading by K.H. Park, B.L. Choi, K.W. Lee, K.-S. Kim and Y.Y. Earmme.

8.MasahiroKanazaki, Masashi Morikawa, "Multiobjective Design Optimization of Merging Configuration for an Exhaust Manifold of a Car Engine", Parallel Computational Fluid Dynamics, International Conference Parallel, Kyoto, Japan, May 2002.

9.Exhaust Manifold Pressure Estimation Diesel Equipped with a VGT Turbocharger by Felipe Castillo and Emmanuel Witrant, Luc Dugard.

10.Practical Finite Element Analysis by Nitin S Gokhale, Sanjay S Deshpande, Sanjeev

11 Chandramouli, B., Vijayaprabhu, A., Arun Prasad, D., Kathiravan, K., Udhayaraj, N., Vijayasanthi, M., 2022, Design of single switch-boosted voltage current suppressor converter for uninterrupted power supply using green resources integration, Electrical Engineering and Electromechanics, 10.20998/2074-272X.2022.5.05

12 Wang, J., Wei, K., Ansari, M.D., Al. Ansari, M.S., Verma, A., 2022, Photovoltaic Power Generation Systems and Applications Using Particle Swarm optimization Algorithms, Electrica, 10.5152/electrica.2022.22086

13 Prasanna Moorthy, V., Siva Subramanian, S., Tamilselvan, V., Muthubalaji, S., Rajesh, P., Shajin, F.H., 2022, A hybrid technique based energy management in hybrid electric vehicle system, International Journal of Energy Research, 10.1002/er.8248

14 Nayak, S.C., 2022, Bitcoin closing price movement prediction with optimal functional link neural networks, Evolutionary Intelligence, 10.1007/s12065-021-00592-z

15 Rajashekhar, K., Vinod, G., Mahesh Kumar, K., Naik, J.L., 2022, Impact of erbium (Er) doping on the structural and magnetic properties of Ni-Cu ($Ni_{0.1}Cu_{0.9}Fe_2O_4$) nanoferrites, Journal of Magnetism and Magnetic Materials, 10.1016/j.jmmm.2022.169323