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Modal and Steady State Thermal Analysis on Exhaust Manifold of an Engine Using FEA

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ABSTRACT: In the present study case we have considered the An Exhaust Manifold. In an Automotive Industry the exhaust manifold plays major role in collecting exhaust gases from multiple channels or cylinders and converts into single channel or pipe. It is connected to your vehicle's engine and collects your engine's emissions. Since it collects exhaust gases from the multiple cylinders definitely it experiences high temperature level up to 500 to 700 deg centigrade. The Design of the Exhaust manifold was carried out in the CAD Design Software i.e CATIA (Computer Aided Three-Dimensional Interactive Application) And Simulation on turbine blade was performed using ANSYS Software (Analysis of Systems). In this project Strength of materials, Design of Machine Members, and various physical and material properties.

KEYWORDS: Exhaust Manifold, CATIA, ANSYS, FEA

I. INTRODUCTION

The exhaust manifold is the first component of your vehicle's exhaust system. That is connected to your vehicle's engine exhaust and collects your engine's emissions. The exhaust manifold main function is to receive the air/fuel mixture from the multiple cylinders in your vehicle's engine. It collects the fuel/air mixture from each cylinder, whether you've got four, six, or eight cylinders. The manifold receives all of the burnt engine gases, but also it completely burns any unused or incomplete burnt gases using its very heat. The manifold also houses the primary oxygen sensor in your exhaust to examine the quantity of oxygen entering the system. The oxygen sensor always monitors the quantity of oxygen and can tell the fuel injection system to extend or decrease the quantity of oxygen utilized in the fuel/air mixture used to power the engine. Basically, the manifold acts as a funnel and is employed to gather all of the engine's emissions (from however many cylinders your vehicle has). Then once they're in one place and completely burnt, the manifold sends the emissions into the remainder of the exhaust.

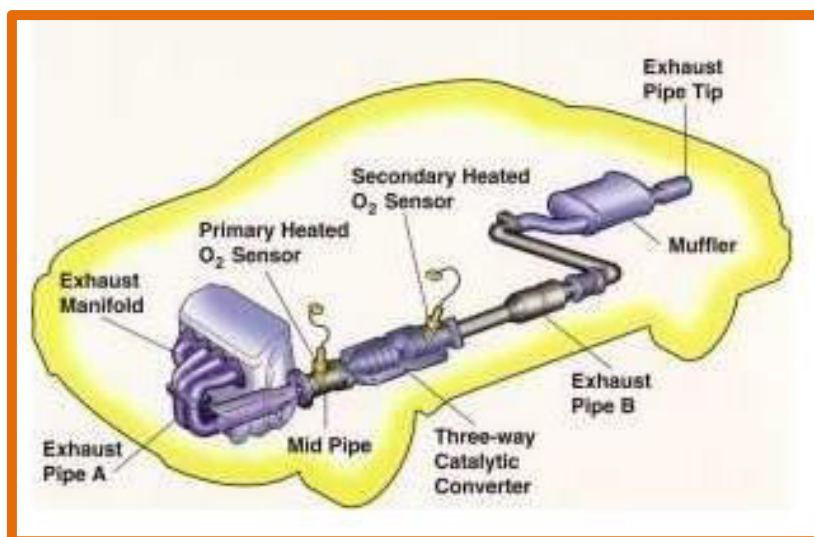


Fig 1. Represents the Schematic figure of Exhaust System



The muffler / exhaust system of your vehicle is an important part of maintaining the performance and lifespan of your vehicle. As soon as combustion process happens in your vehicle the exhaust and muffler systems take over in charge, removing the spent gasses during a clean, safe manner. Ensuring that the exhaust airflow isn't interrupted which the combustion is handled accordingly may be a main concern of ours. There is variety of components in your vehicles exhaust. Given how intense of a system handling burning hot gasses from an engine is, there's many opportunity for something to travel wrong. Here is a few basic information regarding each component function and recommended service guide.

II. MATERIAL AND MANUFACTURING PROCESSES

The size and shape of the manifold became important criterion in recent years. More particularly, the manifold must compete for the limited space within the engine compartment of the vehicle with various accessories to the engine and with required pollution control equipment.

One sort of prior art manifold has been cast from an appropriate metallic material. These cast manifolds may result in cost efficiencies for very large manufacturing runs and may be cast into a good range of possible shapes. However, the casted metal exhaust manifolds typically are relatively heavy with a rigid structure that has capability of receiving high temperature gases and thus impose an associated penalty on operational performance. Additionally, the cast metal manifolds function as a conductor which absorbs the warmth of combustion and causes the converter to light-off more slowly.

Material selection of specified components plays a major role. Basically the material Selection for a component was selected based upon the various mechanical experienced forces and we need to distinguish all the mechanical failures. The Exhaust Manifold is a component that undergoes up to a peak temperature of 500 to 700deg centigrade to the super racing cars. The Selected material must possess good strength and Life and it should be resistance to damage when it experienced the loads. Secondly Cost Effective is the concern of choosing the material according the usage and it should be readily available in the market for various manufacturing sites.

Stainless steel features a great sort of surface finishes, from matt to bright and including brushed and engraved. It are often embossed or tinted, making stainless a singular and aesthetic material. It is often employed by architects for building envelopes, interior design and street furniture.

Compared to other materials after casting, chrome steel alloys has strong mechanical properties at ambient temperatures – it's steel after all! In particular, it combines ductility, elasticity and hardness, enabling it to be utilized in difficult metal forming modes (deep stamping, flat bending, extrusion, etc.) while offering resistance to heavy wear (friction, abrasion, impact, elasticity, etc.). And moreover it offers good mechanical behaviour at both low and high temperatures.

FeCrAl alloys are high-strength and resistance typical materials that have capability of withstanding high temperature utilized in applications with maximum operating temperatures up to 1,400°C (2,550°F). The upper maximum operating temperatures also can cause longer element life.

Nickel alloys are one the best alloys are combination of material with nickel as principal element. with a Complete solid solubility material that exists between nickel and copper. The amount of Wide solubility percentage ranges between iron, chromium, and nickel change many alloy combinations.

Material	Thermal Conductivity W/moC	Young's Modulus Pa	Density Kg/m ³	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
Stainless Steel	15.1	1.93e+11	7750	0.13	1.693e+10	7.3664e+10
FeCrAl	17.1	2.1e+11	2120	0.35	2.333e+11	7.888e+10
Nickel Alloy	90.9	6.9e+10	8990	0.31	175.44e+10	2.594e+10

Table 1: shows the material properties of the of Stainless steel, FeCrAl Alloy, Nickel Alloy

III. MODELLING AND ANALYSIS PROCEDURE

For the Modelling of Exhaust manifold we have chosen the CATIAV5 R21 which is really a good user interactive and friendly software has different modulus like part, Surface and Assembly Design. The procedure of creating the blades is as follows initially take plane and positioned sketch here we have created an 2D Sketch as a Geometrical element which need to be constrained and then converted into a part by inserting a body. The Major Tool bars used are pad, revolve, pattern, slot etc and

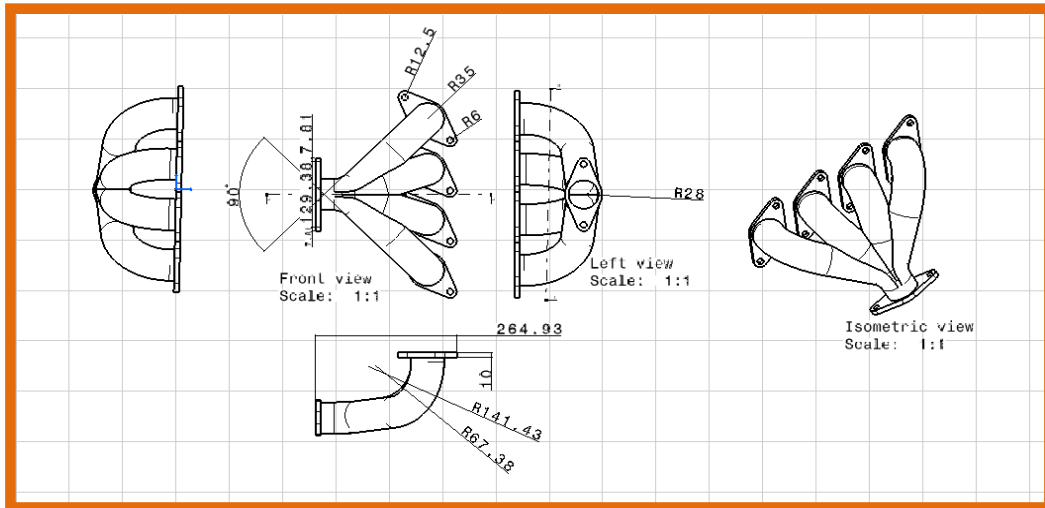


Fig 2. Shows the specifications of the exhaust manifold

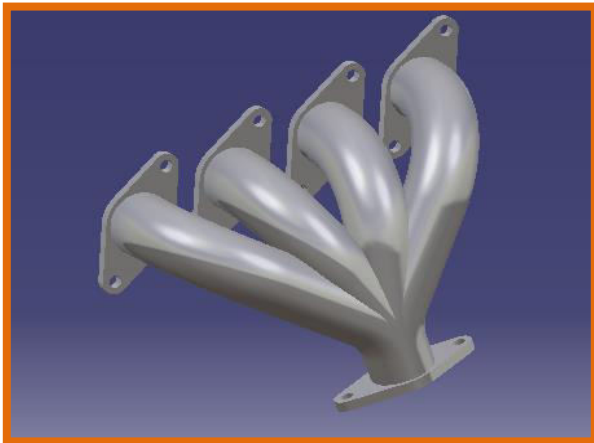


Fig3. Shows the manifold after modelling

After Designing the Turbine blade it was saved in an STP format (step File) which can be easily uploaded in ANSYS Workbench ANSYS is a Finite element Analysis Software package. Different types of analysis can be carried out using Ansys like Structural, Model, and Thermal etc. Ansys is performed with an internal sequence of steps i.e Pre-processing, Meshing, Loading Boundary Conditions Post processing, solve and finally the results.

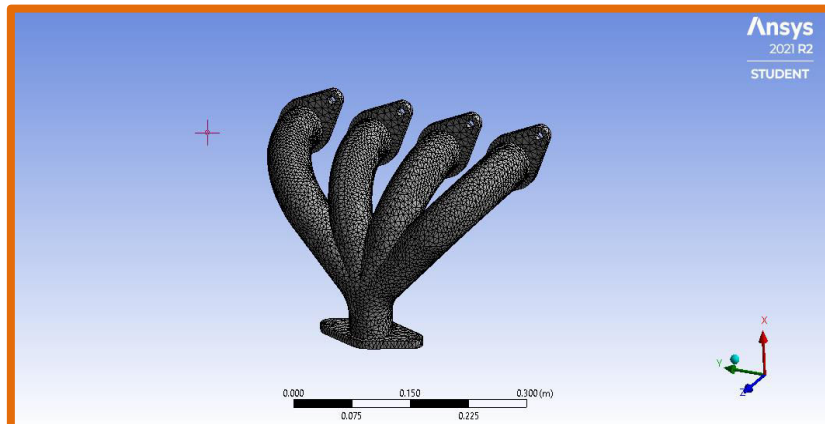


Fig4.shows the mesh presentation

Meshing is an internal most important Simulation process in ANSYS. What happens is it divides or segregates the solid into tiny number of elements to make the speedup of solution and mostly high accuracy. Here we have created meshing with Tetrahedrons element shape with program controlled type and 1mm at the corner and 5mm normal size

IV. LOADING AND BOUNDARY CONDITIONS

As per the Functioning point view the Exhaust Manifold constitute heat up to 500 to 700degree and load of gases after the combustion process

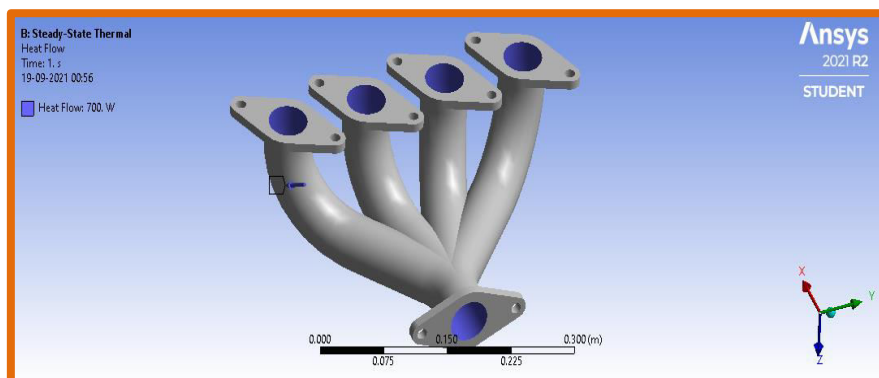
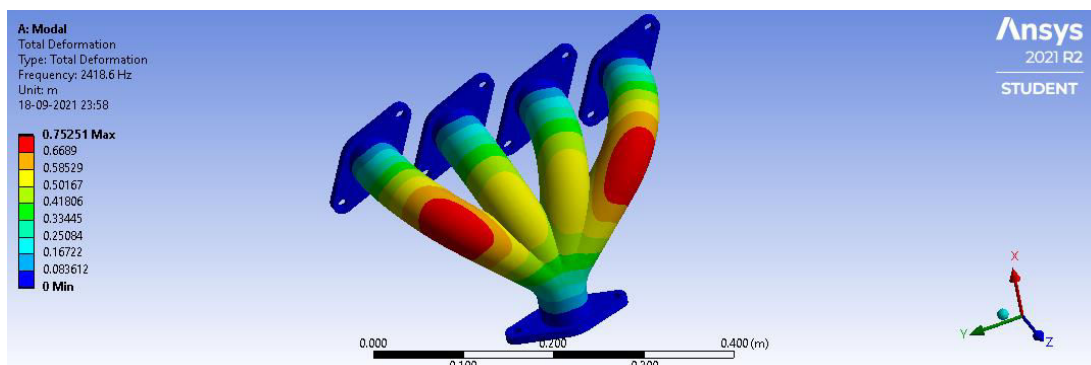


Fig.5.shows the boundary conditions

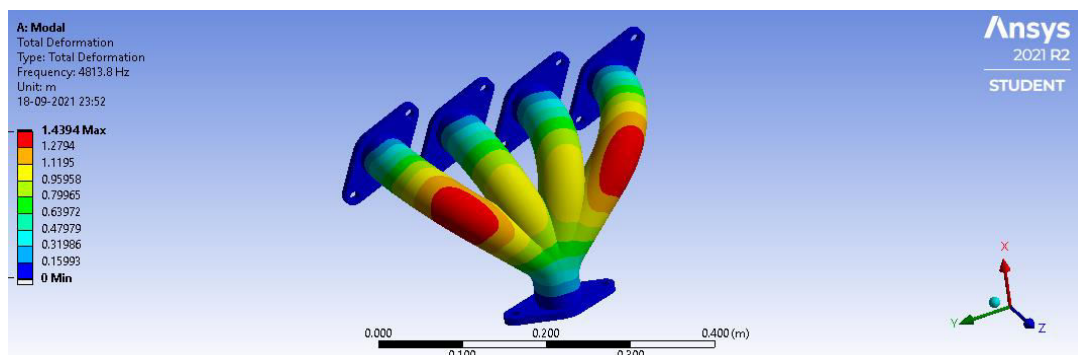
V. EXPERIMENTAL RESULTS

The Modal Analysis is been carried upto 10natural frequencies

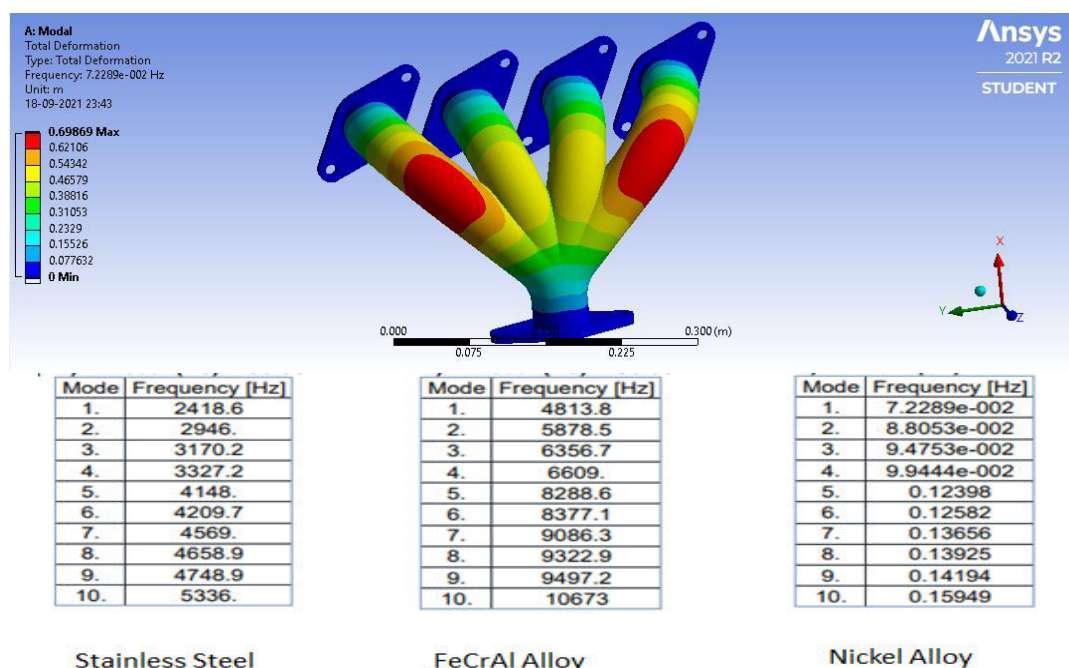
For Stainless steel



For FeCrAl Alloy



For Nickel Alloy

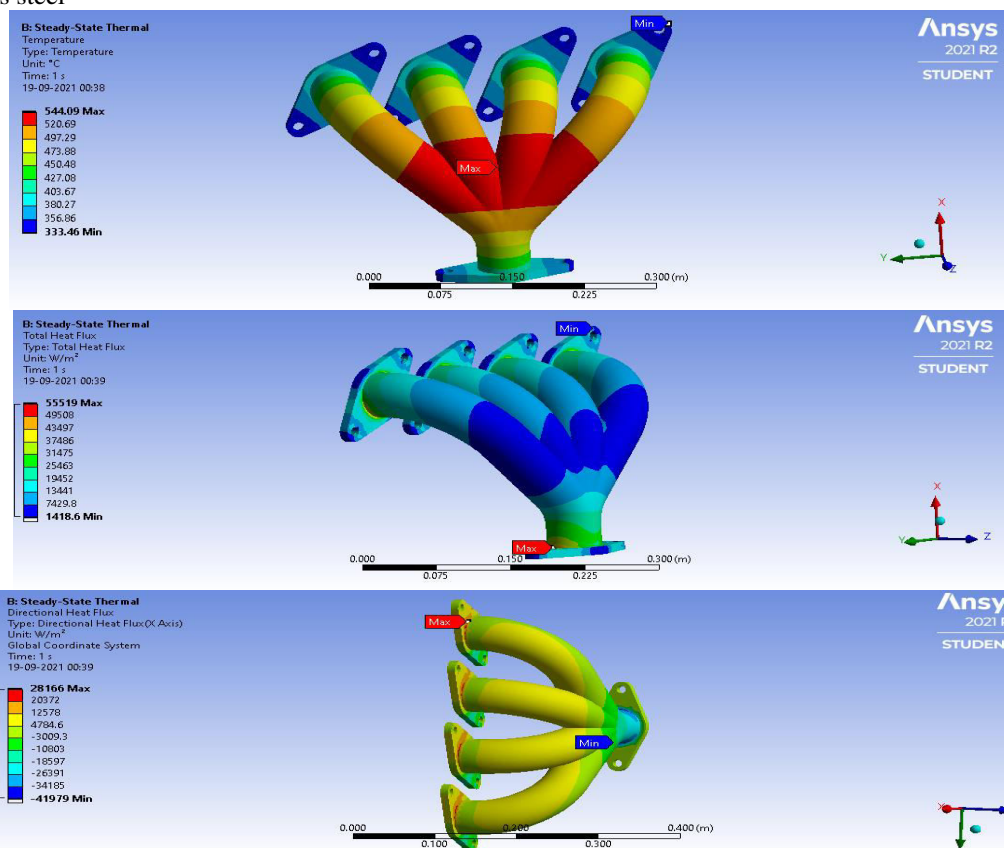


Material	Directional Deformation X-Axis	Directional Deformation y-Axis	Directional Deformation z-Axis
Stainless Steel	0.4244	0.63148	0.16366
FeCrAl Alloy	0.80429	1.2098	0.3121
Nickel Alloy	0.9313	0.58665	0.15168

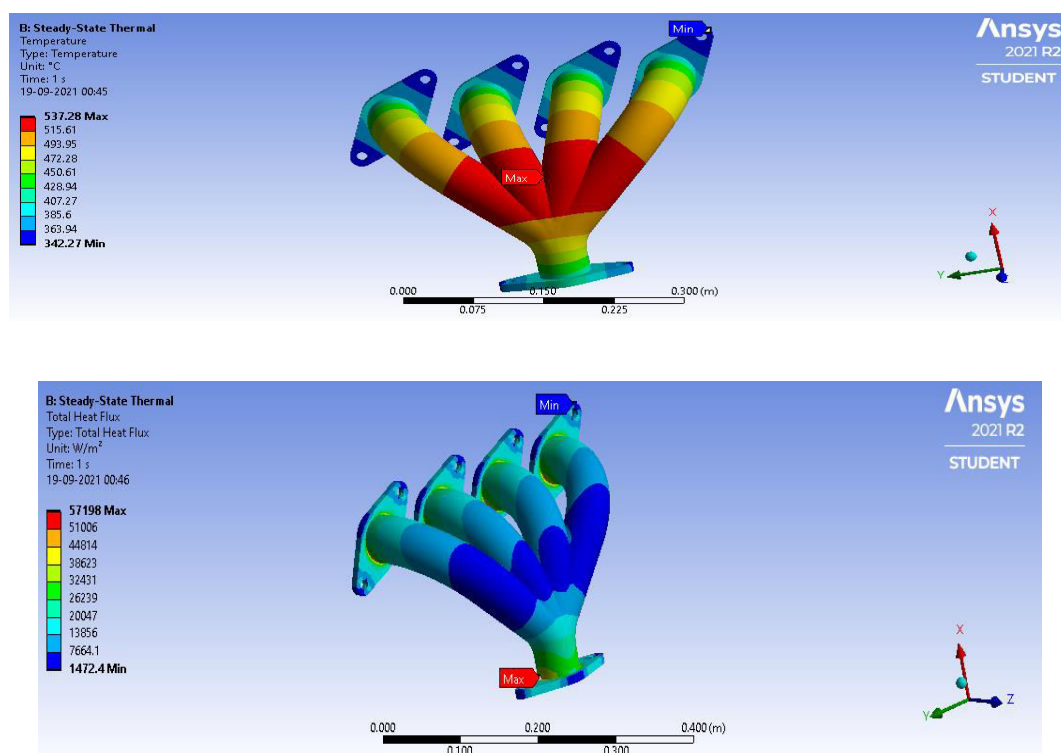
Table 1: shows the Deformation in X,Y,Z Axis

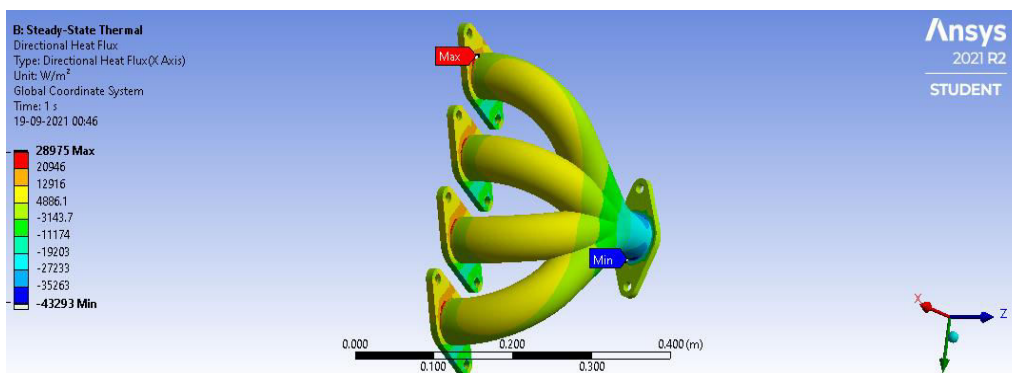
The steady state thermal analysis is been carried to the maximum temperature of 700deg centigrade.

For Stainless steel

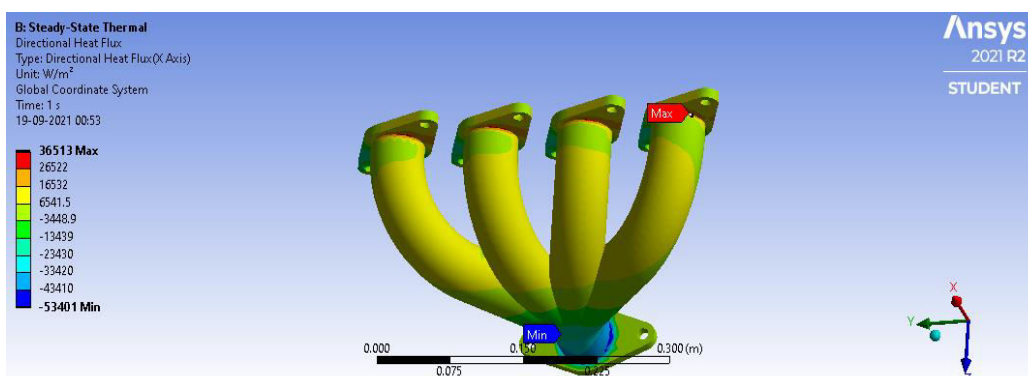
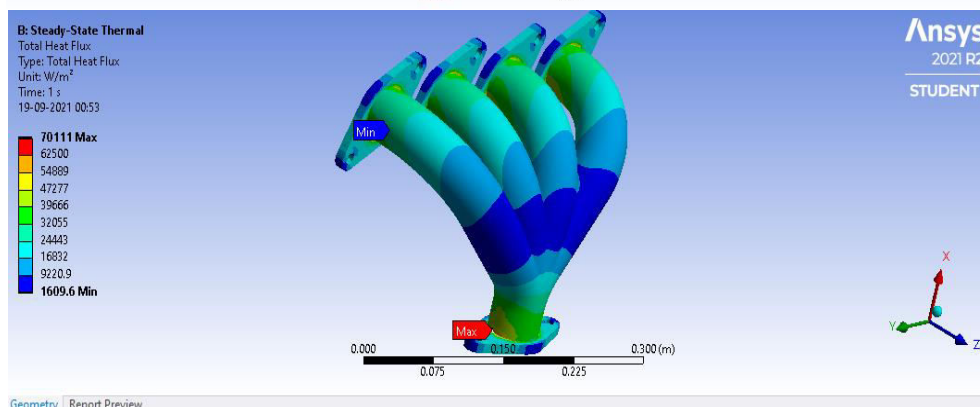
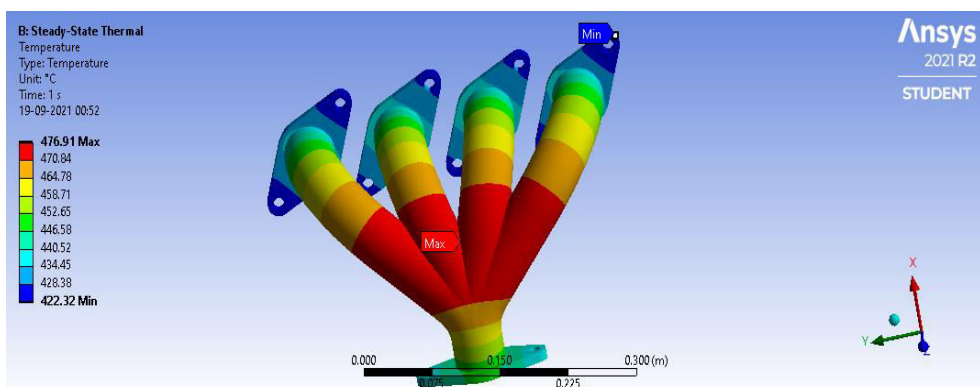


For FeCrAl Alloy





For Nickel Alloy





VI. CONCLUSION

The Modal Analysis is been Carried out Up to 10 Natural Frequencies. Simulation is done with three materials that is Stainless Steel, FeCrAl Alloy And Nickel Alloy. The Total Deformation is Found Less in Nickel Alloy that is 0.69869 because of its density value. The Steady State Thermal Analysis carried out to the maximum temperature 700 degree centigrade. The Maximum Temperature effect was observed in manifold with Stainless steel and less with Nickel Alloy. The Rate of Heat Transfer Per unit Area was found more in Nickel Alloy this is Because of High thermal Conductivity Value. Stainless Steel material is Common material from the other two materials and cost also less. The Results views that the thermal and modal Analysis experimental results suggesting that the nickel possess the better results and best suited for higher version cars.

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