

DESIGN AND ANALYSIS OF MUFFLER WITH COMPOSITE MATERIALS

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Automobile Engineering

by

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work **YASHWANT KONDAPPA (Reg. No. 37860016), PARTHIBA KRISHNA. K (Reg. No. 37860022)** who carried out the project “**DESIGN AND ANALYSIS OF MUFFLER WITH COMPOSITE MATERIALS**” under my supervision from November 2020 to March 2021.

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DECLARATION

I **YASHWANT KONDAPPA (Reg. No. 37860016), PARTHIBA KRISHNA (Reg No. 37860022)** hereby declare that the Project Report entitled **“DESIGN AND ANALYSIS OF MUFFLER WITH COMPOSITE MATERIALS”** done by me under the guidance of **Mr.R. Kumarasubramanian, M.E.**, at Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Automobile Engineering.

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ABSTRACT

The project deals with the design of a commercial automotive muffler, which is being used in current automobile vehicle Maruti Suzuki Alto 800 vxi. Initially the muffler is designed in the basic 3D modelling can be done using commercial CATIA software package and can be imported into Commercial CATIA software using a neutral file format. With the help of Computational Dynamics Flow analysis through ANSYS FLUENT package with the proper boundary conditions flow analysis is done. The propensity to this muffler relies vastly on the thermal performance of the material, impedance and the perforations. In muffler the hot gases pass through, which may affect the properties of the muffler. So, we have analysed the thermal properties of the muffler. And defines the heat transfer occurring inside the muffler. The heat flow causes the variation in the properties of the muffler. The main purpose of a muffler in an automobile is to reduce the engine noise produced by combustible the exhaust system has various attributes including vibration, acoustics, thermal distribution and durability, flow and power loss in addition to its interface with vehicle. with respect to its in-service conditions, selection of suitable materials for muffler box. The functions of automotive muffler are discussed below, highlighting how the muffler functions as a part of exhaust and lab tests are done physically in the material selection process. Tensile strength, yield strength and elongation properties and chemical compositions were used as basic criteria for the material selection. Variety of materials including Stainless steel grade 309, Nickel-chromium alloys were obtained in the material selection for automotive muffler. Stainless steel grade 309 and Nickel-chromium alloys possess suitable properties for this application. However, stainless steel grade 309 was considered as a better choice of material for automotive exhaust systems due to its considerable price and density, acceptable strength at elevated temperatures and excellent corrosion resistant it possesses as a result of the protective film of chromium oxide which forms on the surface of the metal.

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LIST OF ABBREVIATIONS

SS	STAINLESS STEEL
CAD	COMPUTER AIDED DESIGN
CFD	COMPUTATIONAL FLOW DYNAMICS
Hz	HERTZ
CES	CAMBRIDGE ENGINEERING SOFTWARE
SCC	STRESS CORROSION CRACKING
IC	INTERNAL COMBUSTION
AL ALLOY	ALUMINIUM ALLOY
SLM	SOUND LEVEL METER
UTM	UNIVERSAL TESTING MACHINE
OES	OPTICAL EMISSION SPECTROSCOPY
UTS	ULTIMATE TENSILE STRENGTH
YS	YIELD STRESS
%EL	PERCENTAGE OF ELONGATIVITY
$F_{\max}$	MAXIMUM FORCE LOAD
IL	INSERTION LOSS
FEA	FINITE ELEMENT ANALYSIS
FEM	FINITE ELEMENT METHOD
PDEs	PARTIAL DIFFERENTIAL EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 MUFFLER

Mufflers are introduced in the exhaust system in most of the combustion engines. The muffler is engineered as an acoustic tool to reduce the loudness of the sound pressure created through the engine by acoustic quieting. The noise of the burning-hot exhaust gas exiting the engine at high velocity is abated through a chain of passages and chambers lined with sequentially arranged fiberglass insulation and/or resonating chambers harmonically tuned to cause destructive interference, where the opposite sound waves cancel each other out. An unavoidable side impact of this noise reduction is restriction of the exhaust gas flow, which creates back pressure, that can decrease engine efficiency. This is due to the fact the engine exhaust must share the same complex exit pathway built within the muffler as the sound pressure that the muffler is designed to mitigate.

A few aftermarket mufflers declare to boost engine output and/or reduce fuel consumption by using slightly decreased back pressure. This typically includes much less noise reduction (i.e., more noise).

On May 18, 1905, the state of Oregon surpassed a law that required automobiles to have "a light, a muffler, and green brakes".

The legality of changing a motor vehicle's original equipment exhaust device varies by jurisdiction; in lots of developed international locations such as the United States, Canada, and Australia, such adjustments are particularly regulated or strictly prohibited. Aftermarket mufflers normally modify the manner a car performs, because of back-pressure reduction.

The exhaust system of any automobile is exposed to excessive temperatures, corrosive exhaust gases like, Carbon dioxide, Nitrous oxides and different Hydrocarbons. The pressure is also very excessive in the exhaust system. The most critical part of the car exhaust system is the Muffler. These factors cause wearing of the inside surface of muffler and considerable deformation additionally takes place because of excessive pressure.

The materials mostly used in exhaust systems are solid iron, stainless-steel, mild metal / carbon metallic. latest developments closer to mild weight concepts, fee discount and higher overall performance, designers are progressing closer to sheet metals. In recent times, stainless steels are used in flexible bellows, catalytic converter, resonators, mufflers, pipes. mild steel / carbon steel is used for flanges, pipes, and mufflers. The addition of elements plays a vital position in finding out the performance, manufacturability and self-existence. Examples such as carbon increase the hardness, hardenability while reducing the ductility. Silicon will increase the energy, ductility and corrosion resistance. The manganese increases the ductility, weld capacity. Sulphur and phosphorous addition assist in reducing the ductility and will increase brittleness. Addition of Molybdenum increases the hardenability, hardness, strength, corrosion resistance. Chromium, nickel and titanium enhances the corrosion resistance.

1.2 WORKING OF A MUFFLER.

Vehicle's engine produces small explosions of dangerous emissions which come from the combustion chamber. those explosions produce dangerous gases which include carbon dioxide, carbon monoxide, hydrocarbons and nitrogen oxides. For protection, those dangerous gases are dispersed far from your vehicle's cabin the usage of an exhaust system, which the muffler is a key factor of. To give an explanation for how the muffler works, we need to know the different components of the muffler.

There are 4 sections in a vehicle's muffler:

- Inlet — The inlet attaches from the exhaust system. Exhaust gases and sound enters the inlet from the exhaust gadget.
- Resonator — It acts as an echo chamber by way decreasing the overall noise volume of the engine with the aid of cancelling sound waves.
- Perforated tubes — The perforated tubes are metal tubes positioned within the muffler and are accountable for how loud or quiet your automobile sounds. They reduce or suppress the sound and work to increase your automobile overall performance.
- Outlet — the opening emits both the remaining sound and exhaust gases.

The muffler carries tubes, channels, and holes which direct gases and reduce exhaust strain. It quiets the engine by decreasing the sound pressure emitted. The muffler is designed not to just dampen sound, however to combine sound waves and cause them to cancel out one another.

The muffler is likewise responsible for freeing the poisonous gases, that could harm you and your passengers if launched into the cabin of your car. Some mufflers are designed to be silent whilst others are especially designed to create what might be considered a growling sound. The muffler additionally improves the general overall performance of your car. Your engine can generate extra energy quicker if it may dispose of all the exhaust gases it produces quickly.

Keeping your exhaust maintained and functioning well will hold your vehicle from making unpleasant, loud noises and controls how your car influences the surroundings. ensuring those dangerous emissions stay outside of your vehicle, thus protect your health and the safety of your passengers.

1.3. CLASSIFICATION OF MUFFLERS ON THE BASIS OF FUNCTIONING PRINCIPLE

On the basis of functioning principal, mufflers are generally classified into two main types i.e., Active and Passive. The passive muffler can be further classified in two types: Reactive (or reflective) and absorptive (or dissipative). Amongst those passive mufflers are widely used due to their smooth and financial layout potential. In addition, reactive mufflers are maximum typically used due to their clean manufacturing and price effective.

1.3.1 ACTIVE MUFFLER

These mufflers are often used in large ducts where the external silencers are not possible. This muffler uses the principle of impedance. The noise manipulates in ducts include secondary supply of noise and an adaptive virtual manipulate gadget which produces the identical frequency noise to arise zero impedance on the junction. An active noise manipulate gadget forms a circuit, successfully suppressing the primary as well as secondary sources of sound. It is effective mostly to damp low frequencies (50 to 500 Hz).

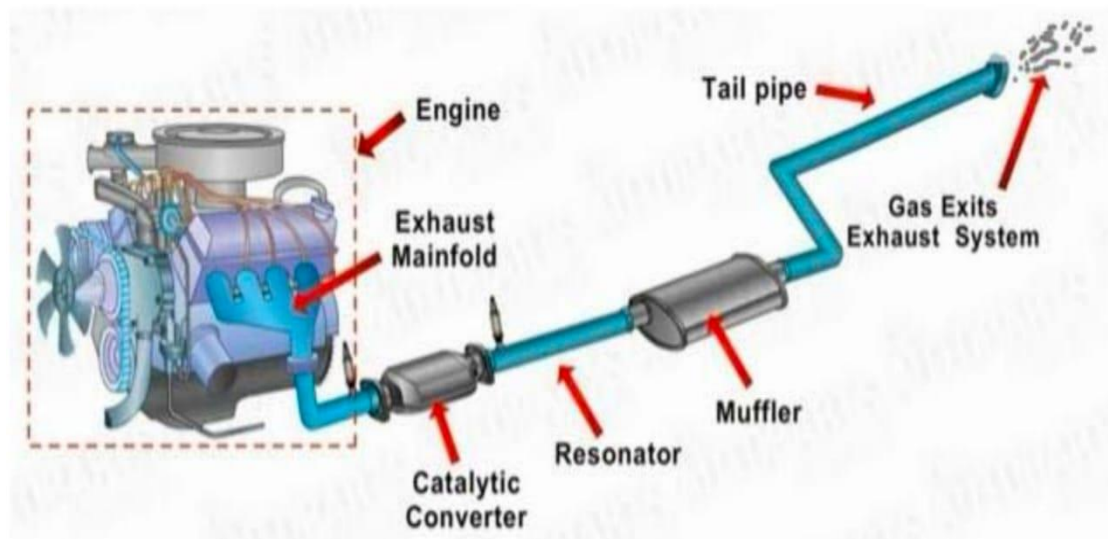


Fig 1.1: PARTS OF EXHAUST SYSTEM

1.3.2 PASSIVE MUFFLERS

Passive mufflers are the mufflers which do not use any secondary noise sources. Passive mufflers use reflection and absorption of noise as their principle. They are classified into two different types:

1.3.2.1 REACTIVE MUFFLERS



Fig 1.2: REACTIVE MUFFLER

Reactive (Reflective) mufflers are the types of muffler that reduce noise by the phenomenon of destructive interference. This is proceeded by making sudden changes in cross sectional area of the shell, incorporating perforated tubes and resonators. The sound pulses generated from engine partially cancel themselves in the expansion chamber.

1.3.2.2 ABSORPTIVE MUFFLERS

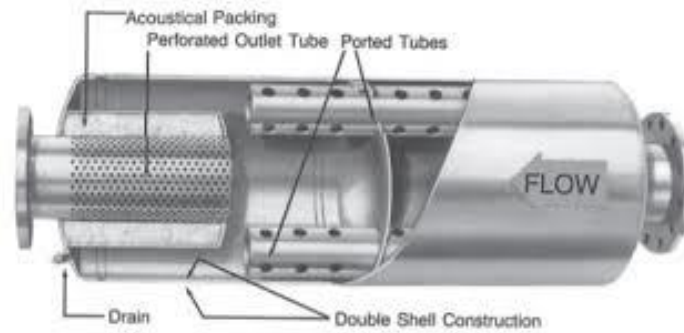


Fig 1.3: ABSORPTIVE MUFFLER

Dissipative(absorptive) mufflers are the types of muffler that makes use of a valid absorbing material to lessen noise instead of reflecting the noise like reactive mufflers. The sound absorbing material absorbs the sound strength and converts that energy into warmth energy.

CHAPTER 2

LITERATURE SURVEY

1. Ikpe Aniekan E., Orhorhoro Ejiroghene Kelly, Gobir Abdulsamad “did Engineering Material Selection for Automotive Exhaust Systems Using CES Software.

In this paper they have discussed about the criteria for the selection of the materials for the different parts of the exhaust system which contains exhaust manifold, downpipe silencer/ muffler box and tail pipe and comprises the exhaust system. They have chosen different materials like Stainless Steel 304, Nickel-chromium alloy for different part of exhaust system like for exhaust manifold which collect gases from the engine outlet manifold and channel them into common exhaust pipe as a result of the pressure and velocity in which exhaust gases are emitted by the engine through

exhaust manifold, the exhaust material gas possess high temperature and therefore consideration of all factors the material selected for the component should withstand high temperature and material chosen should not react with the chemical gases as it will not only corrode the material but also reduce its durability drastically. materials selected for manufacturing of exhaust system must possess not only sufficient strength and fatigue resistance but also excellent corrosion resistance against varieties of operational conditions, Therefore, it is important to look inward for materials that possess high fracture toughness to resist crack propagation from existing cracks and to reduce the effect of residual stresses caused by vibrations and other loading effects. Material index to optimise fracture toughness and resistance to Stress Corrosion Cracking (SCC) for the exhaust system components. The choice of the material is governed by very many factors as shown in the study above in its increasing of service life to obtain better results.

2.A.S. MATE and V. KUMBHAKAR did “ THERMAL ANALYSIS OF SILENCER PIPE.

In this paper they have reviewed the heat transfer analysis of automotive exhaust System By measuring temperatures at the points using experimental set up on the silencer, then stress distribution for those temperatures is found out by software. Temperatures are recorded at critical locations of silencer. Muffler section are critical as real-time temperatures are difficult to get. They are obtained by remote probe of temperature recorder, with thermocouple at each of section of the silencer, approximately 4 locations are fixed for temperatures and temperatures recorded. The temperatures are recorded at exhaust manifolds, at middle of the silencer, before the muffler, at the muffler and at the exhaust of silencer. The experimental data is then used with FEM package for creation of temperature field for the silencer pipe, muffler pipe and muffler assembly. The analysis software used is ABAQUS. Analysis is done for silencer pipe, muffler pipe and muffler assembly. From the analysis it is observed that the stress concentration is at the periphery of the holes of the muffler. So, we can say that stress raising sections are dominant over muffler region because of holes, which are mandatory now days due to which stress distributions are fluctuating and unsteady. To have more life span of silencer stress concentration across the holes

has to be minimized. Corrugated construction of pipe with baffles should be used to prevent stress raisers.

3. Nagisetty Lokhesh Kumar and K Veladri did “Modification of Maruti Suzuki Alto 800 vxi Muffler design to increase exit velocity”.

In this paper they discussed about the modification of muffler to increase the exit velocity, A Maruti Alto 800cc muffler was taken for this project. The outer wrapping of the muffler was removed and required dimensions were noted down. A 3D model was developed in UG NX 11.0 with proper dimensions and alternate designs were proposed and with the help of ANSYS fluent package velocity volume rendering was obtained for every design which were of total four designs excluding the existing model in which inlet velocity boundary condition for every model was give 10m/s and outlet velocity was observed in every model which was 13.873 m/s for the existing model and 13.49 m/s for the first design and 16.15 m/s for second design and 15.86 m/s for the third design and 16.29 m/s for the fourth design, The proposed designs were modelled and analysed. This was done in order to choose the best proposed design. And accordingly design 4 was selected to be the best design as it gives an increase of exit velocity by 17.42% when compared with the existing model.

4. Priyam Maheshwari, Pradeep Khanna did “Cost and Weight Analysis of Automobile Mufflers using Computational Fluid Dynamics”

This paper aims at finding the appropriate material and alloying elements which can be used to obviate such consequences. The flow analysis is done using Ansys Fluent. Various materials have been compared based on their mechanical properties to withstand high temperature and high pressure, the aim is to reduce the weight of the muffler and also reduce its price. The weight and cost analysis presented in this paper is aimed to solve such problems. The materials used in the fabrication of mufflers include mainly stainless steels and cast steels. Earlier, cast steels were used for manufacturing mufflers, but now the trend has shifted to stainless steels with better corrosion and wear resistance, with the addition of alloying elements. The muffler discussed in this paper is of the “Combined resonance and absorptive type”. Usually, every IC engine is fitted with a muffler in order to cancel the pressure pulses with the

purpose of both noise reduction and pollution control. This paper uses ANSYS Fluent Package to do numerical simulations and obtain results of CFD analysis. The focus was also to reduce the weight and cost of the muffler to make it more efficient and cost effective, without compromising the mechanical properties like, strength of the material and its wear resistance. While selecting the material the weight and the cost analysis of the inner and outer core of the muffler to select the most suitable material for its manufacturing. the muffler has been developed and simulated with practical boundary conditions to find the pressure, velocity and shear stress distributions in the muffler. The comparison of different stainless steels has been done. From the results, clearly, the Mild steel is the least costly material and the Al alloy material is the lightest. But Aluminium and Mild steel has higher thermal conductivity than Stainless steel. This leads to elevated temperature of the muffler body and easy deformation. Stainless steel can be used at much higher temperatures than Aluminium (which can become very soft above 400 degrees). Stainless steel is highly corrosion resistant unlike Mild steel and has higher strength to weight ratio. Hence Stainless steel is more preferred for automotive industry even though it is available at a higher cost.

5.Vaibhav D. Prajapati, Ankit J. Desai did “Design and Analysis of Automotive Muffler”

This Paper summarizes that Muffler is a very important part of the vehicle exhaust system to reduce the noise produced by engine combustible products when passing through the exhaust system. To achieve maximum noise reduction with the minimum pressure drop is very difficult. A conventional muffler of Maruti-Suzuki WagonR is taken as reference and depending upon parameters new muffler is designed and modelled in software and analysis will be done numerical codes. Comparison of conventional muffler and proposed designed muffler is based on amount of noise reduction, pressure drop and muffler life. In experimental setup pressure drop calculated by the water manometer tube and sound intensity measured by Sound Level Meter (SLM) device. From the simulation it is concluded that Modified design is far better in pressure loss so with higher pressure loss there is more noise reduction. But merit and demerit are always together increase in pressure loss will increase back pressure which is not good for engine.

CHAPTER 3

AIM AND OBJECTIVE OF PRESENT INVESTIGATION

3.1 AIM

Aim of this project is to increase the factor of safety of the existing Maruti Suzuki Alto 800 muffler by replacing existing material with composite materials.

3.2 OBJECTIVE

- To design 3D models of Muffler using CATIA V5.
- To import 3D model in Ansys Workbench for CFD Fluent to find the flow, velocity, pressure and temperature contour.
- Then Thermal Analysis is done after completing CFD analysis.
- Then the thermal load from CFD is imported into Structure Analysis for obtaining Thermal stress and Thermal Deformation.
- Done for 3 different Materials.
- Concluding the best of three materials.

CHAPTER 4

EXPERIMENT AND METHOD

4.1 SELECTION OF MATERIAL

Generally, the mufflers are made from mild galvanized steel to stainless steel or mild steel, depending upon different heating temperatures in different types of vehicles. In this project we are using stainless steels and an alloy to compare their properties and suitably select the proper material for muffler.

Principally, the muffler of an exhaust system is exposed to chemical attacks that must be accounted for while designing the muffler. At the same time, it is also subjected to vibrations and unwanted knockings. The particulate matter of the unburned exhaust gases sticks on the walls of the muffler and this is known as condensate corrosion. The condensate usually consists of salts of various compounds like Cl^- , NO_3^- , and other inorganic as well as inorganic compounds. To account for these factors, stress corrosion cracking (SCC) and inter-granular cracking, it is advisable to use stainless steel as a base material. It has good wear resistance and thermal resistance to high temperatures. Stainless steels along with other alloying materials yield good results. Two varieties of stainless steels are commonly used; Austenitic and Ferritic. The two most important constituents of stainless steels are Nickel and Chromium. Nickel stabilizes the austenitic phase and also shifts the eutectoid point towards the left. Nickel gives toughness and increased ductility to the material, while Chromium gives good wear and corrosion resistance and hardness. One of the most common and lower cost austenitic stainless steel used for exhaust systems is SS (304), but the residual stresses in the material and poor resistance to corrosion to road salts make it susceptible to SCC. Contrasting to this, SS (309) gives more resistance to stress corrosion cracking due to its higher Ni and Cr contents. Inconel 800 surpasses SS 304 and SS 309 when it comes to general corrosion resistance at elevated temperatures.

Moreover, fracture toughness is one of the most important factors that determine the life of the exhaust system under such severe condition. Therefore, the materials are chosen to compare the thermal stress and thermal expansion with suitable graphs and

analysis. The main objective of the material selection process is to minimise cost and mass and maximize thermal Strength.

4.1.1 MATERIAL SELECTION BASED ON

Material selected must possess certain characteristics that meets the following requirements:

- Melting point should be due to high temperature gases passing through the exhaust system. High Service temperature above 800°C for exhaust manifold and above 400°C for Muffle box and tailpipe.
- Corrosion resistance should be high with respect to different internal and external environments.
- Oxidation considering hot water vapour of exhaust gas.
- Young modulus should be high to withstand vibration from the engine.
- Low density which can improve fuel economy.
- Thermal conductivity should be high for even spreading of heat along the whole component.
- Higher fracture toughness to resist crack propagation from an existing crack.
- High resistance to thermal fatigue considering high temperature of above 800°C for exhaust manifold and above 400°C for Muffle box and tailpipe.
- High yield strength to withstand the thermal stresses.

4.1.2 MATERIALS SELECTED

The following are the three materials selected based on the above material selection process:

- 1. STAINLESS STEEL 304
- 2. STAINLESS STEEL 309
- 3. INCONEL 800

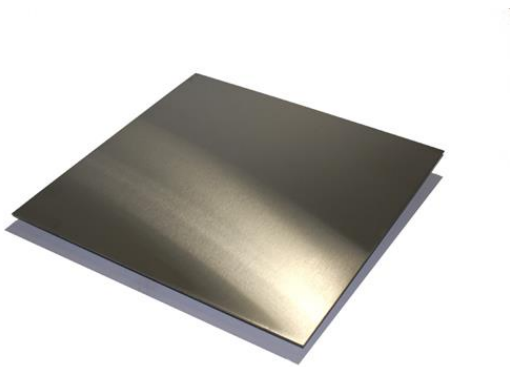


Fig 4.1: SS 304



Fig 4.2: SS 309



Fig 4.3: INCONEL 800

4.2 PROPERTIES OF MATERIAL

The following are the two main properties we have considered in our project to select materials and with through this we are going to find the thermal nature of the material through analysis.

- PHYSICAL PROPERTIES
- CHEMICAL PROPERTIES

4.2.1 PHYSICAL PROPERTIES

A physical property is any property that is measurable, whose value describes a state of a physical system. The changes inside the physical properties of a system can be used to explain its modifications between momentary states. Physical properties are also called as observables and they might be not modal properties. A Quantifiable physical property is referred to as physical quantity.

Physical properties are usually characterised as extensive and intensive properties. An intensive property does no longer rely on the size or extent of the system, nor on the quantity of matter within the object, while an extensive property shows an additive relationship. These classifications are valid only when smaller subdivisions of the sample do not have interaction in some chemical or physical process while combined.

Properties are also categorized with respect to the directionality of their nature. for example, anisotropic properties do have spatial variance and isotropic properties do not change with the direction of observation.

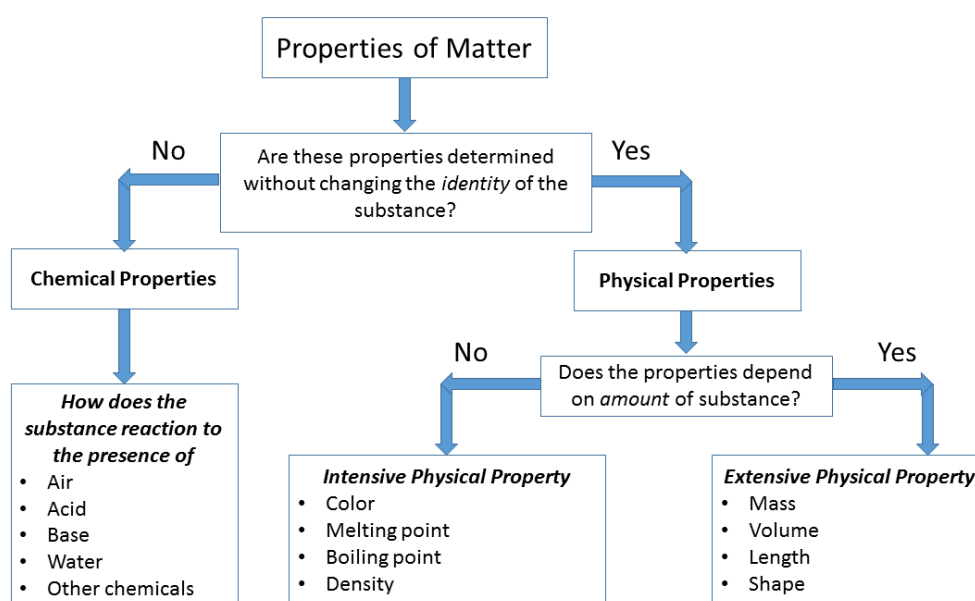
It is difficult to decide whether a given property is a material property or not. Colour, for instance, can be visible and measured; however, one perceives colour has an interpretation of the reflective properties of a surface and the light illuminates it. In this experience, many ostensibly physical properties are referred to as supervenient. A supervenient property is one which is actual, but is secondary to some underlying truth. That is much like the way wherein objects are supervenient on atomic structure. A cup would possibly have the physical properties of mass, shape, colour, temperature, and so on., however these properties are supervenient on the underlying

atomic structure, which may in turn be supervenient on an underlying quantum structure.

Physical properties are contrasted with chemical properties which decide the manner a material behaves in a chemical reaction.

The physical properties of a material are the ones which can be discovered without any change of the identification of material. some of these common properties of a material are listed below-

- Density
- Specific gravity
- State Change temperatures
- Coefficients of thermal expansion
- Specific Heat
- Latent heat
- Fluidity
- Weld ability
- Elasticity
- Plasticity
- Porosity
- Thermal conductivity
- Electrical Conductivity



Graph 4.1 PROPERTIES

4.2.2 CHEMICAL PROPERTIES

Chemical properties are characteristics of a material that become evident when the material undergoes a chemical reaction or chemical exchange. Human beings can't examine chemical properties by simply viewing or touching a sample of the material; the real structure of the material should be changed so as for humans to take a look at the chemical properties.

The inner qualities of a substance must be altered to decide its chemical properties. For example:

- Flammability - How effortlessly something will burn or ignite, is a chemical property because you can't tell just by way of looking at something how easily it'll burn. Fire testing is made to determine how easy or difficult it will be to burn certain material.
- heat of Combustion - This chemical property refers to the amount of energy that is released as heat when a substance is burned with oxygen.
- Toxicity – The rate at which the substance can damage an animal, plant, cell, organ, or different organism refers toxicity. Toxicity material include lead, chlorine gasoline, hydrofluoric acid, and mercury. Toxicity is measured by how the lead, chlorine gas, mercury, or different substance impacts the organism – basically, by how much damage it does to the organism and the way fast that damage happens.
- ability to oxidize – Oxidation of material by gaining oxygen, losing hydrogen, or losing electrons. For example, rust is formed due to oxidation of material. Over time, iron and steel (that's made of iron) will rust. But they may rust greater fast if they will be mixed with blend oxygen.

- Radioactivity - The emission of radiation from an atom with a volatile nucleus, is a chemical belonging. On the periodic table of factors, the factors that haven't any stable isotopes are considered radioactive.
- Chemical stability - This chemical property in a given environment, also called thermodynamic stability of a chemical machine, refers to the stability that takes area while a chemical system is in its lowest energy state – a state of chemical equilibrium, or stability, with its environment.
- half-life - This chemical property is the amount of time it'll take for 1/2 of the original substance to decay.

4.2.3 HOW TO MEASURE TENSILE PROPERTIES?

To determine the load-carrying ability and the quantity of deformation before fracture, a sample of material is normally tested through a Tensile test. This includes applying a regularly growing pressure of tension at one cease of a sample length of the material. the other end is anchored in a rigid guide so that the sample is slowly pulled apart. The testing machine is ready with a device to suggest, and probably file, the value of the force at some stage in the test. Simultaneous measurements are made from the growing duration of a specific detail on the centre of the specimen, known as the gage length. The measurements of each load and elongation are generally discontinued quick after plastic deformation starts off evolved; but the maximum load reached is continuously recorded. Fracture factor is the issue in which the material fractures because of plastic deformation. After the specimen has been pulled apart and removed from the machine, the fractured ends are prepared collectively and measurements are fabricated from the now extended gage length and of the common diameter of the minimal cross section. The average diameter of the minimum cross section is measured only for cylindrical specimen.

The tabulated results on the cease of the test consist of the following.

1. designation of the material under test

2. original cross section dimensions of the specimen inside the gage length
3. authentic gage length
4. a link of frequent readings identifying the load and the corresponding gage length dimension
5. final average diameter of the minimal cross section
6. final gage length
7. description of the appearance of the fracture surfaces (as an instance, cup-cone, wolf's ear, diagonal, start)

A graph of the results is made from the tabulated statistics. Some testing machines are fitted up with an automatic attachment that attracts the graph during the test. (The operator wont no longer report any load or elongation readings except the most for each.). The axes of the graph are strain for the x-axis or scale of abscissae, and stress for the y-axis or scale of ordinates. The ordinate for each factor plotted on the graph is found via dividing each of the tabulated loads by means of the original cross-sectional area of the sample; the corresponding abscissa of each factor is found by dividing the increase in gage length by means of the original gage length. These two calculations are done by the following formulas,

$$\text{Stress} = \text{load} / \text{area of original cross section}$$

$$= P/A_o = \text{psi or lb/in}^2$$

$$\text{Strain} = \text{instantaneous gage length} - \text{original} / \text{original gage length}$$

$$= \text{elongation} / \text{original gage length}$$

$$= (L - L_o) / L_o = \text{inches per inch} \times 100 = \text{percent elongation}$$

Stress and strain, as computed here, are sometimes referred to as "engineering stress and strain.". They may be not actual stress and pressure, which can be computed on the basis of the region and the gage duration that exist for every increment of load and

deformation. For example, true stress is the natural log of the elongation ($\ln(L/L_0)$), and true stress is P/A , where A is area. The latter values are typically used for scientific investigations, but the engineering values are useful for figuring out the load-carrying values of a material. Below the elastic limit, engineering stress and true strain are almost same.



Fig 4.4: UNIVERSAL TESTING MACHINE

4.2.3.1 STRESS STRAIN CURVE

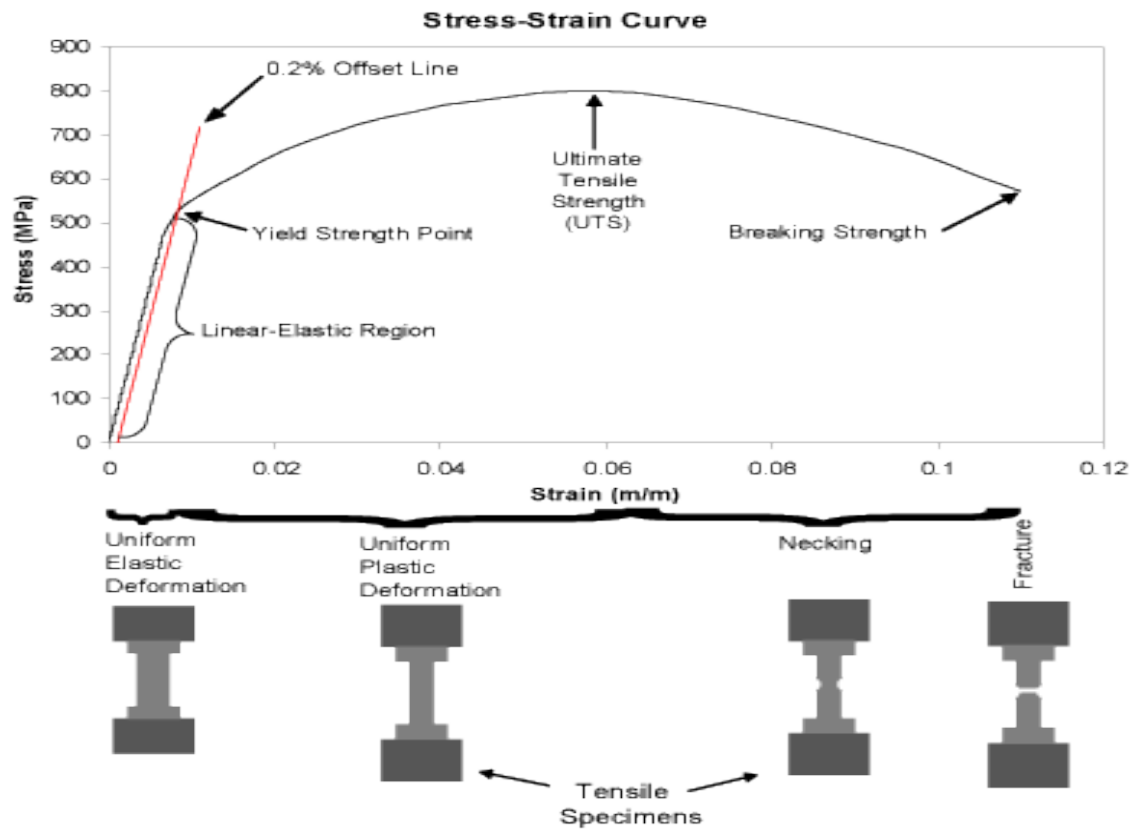


Fig 4.5: STRESS STRAIN CURVE

4.2.3.2 SPECIMEN SIZE

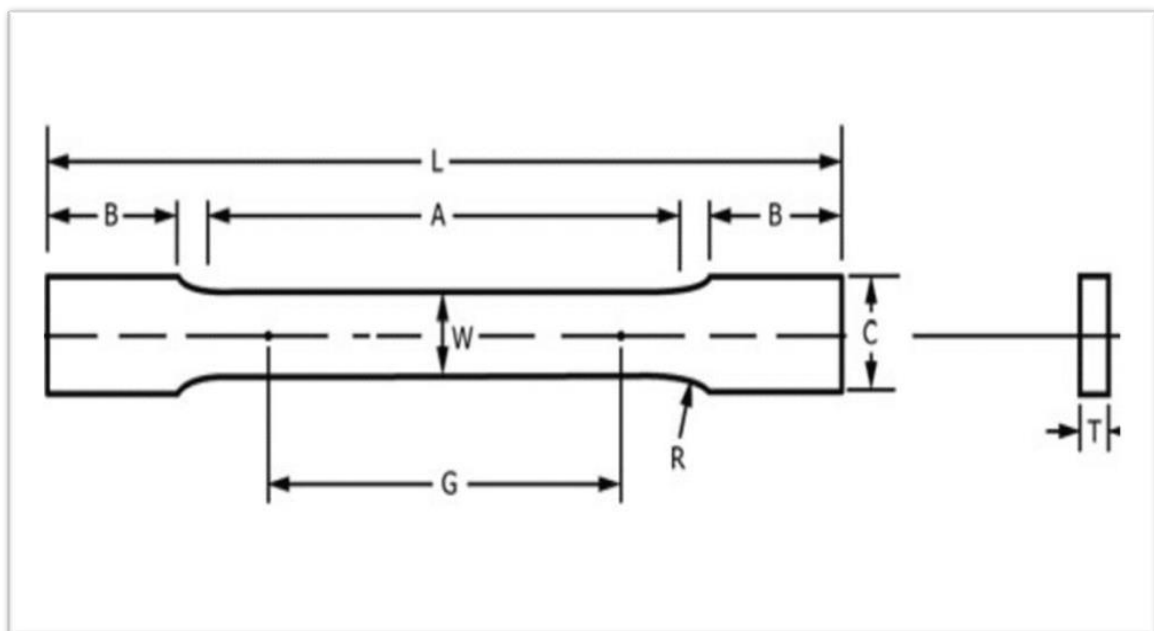


Fig 4.6: SPECIMEN SIZE

- G- Gauge length = 50mm
- W-Width = 15mm
- T-Thickness = 3-5mm
- R-Radius of fillet = 15mm
- L-Overall length = 180mm
- B-Length of grip section = 40mm
- C-Width of grip section = 25mm
- A-Length of reduced parallel section = 100mm

4.2.4 HOW TO MEASURE CHEMICAL PROPERTIES?

Optical Emission Spectroscopy (OES) evaluation can fast decide the chemical composition of diverse steel alloys. regularly referred to as a “spark test,” the approach uses a sparking manner where an electrical discharge is implemented to the region being analysed, causing a small quantity of fabric to be vaporized. This sparking procedure reasons an awesome chemical signature to be created permitting the professional Chemistry personnel at ATS to decide the basic breakdown of the pattern. Consequences are typically given in percent of each constituent detail

- An optical emissions spectrometer applies electrical power to examine the alloy or steel
- An electrode generates sparks or initiates an emission (including fluorescence radiation) from the sample, and the reactions of the sample are then analysed with the aid of the spectroscopy.
- The sparks or emissions bring about vaporized atoms in an excessive strength state inside the discharge plasma.
- As soon as the vaporized atoms attain the discharged plasma, it creates a selected emission spectrum to be analysed
- For the reason that emission spectrum is precise to each element, the spectrometer makes use of the spectrum to decide the composition of the pattern.

- A skilled technician uses the spectrum to decide the pattern composition primarily based on where inside the spectrum the outcomes fall..



Fig 4.7: OPTICAL EMISSION SPECTROMETER

4.3 STAINLESS STEEL 304

304 Stainless steel is the most not unusual stainless steel. The metal carries each chromium (among 18% and 20%) and nickel (among 8% and 10.5%) metals as the principle non-iron parts. it's far an austenitic stainless-steel. it's far much less electrically and thermally conductive than carbon metallic and is largely-magnetic however much less magnetic than metal. It has a better corrosion resistance than ordinary metallic and is widely used because of the benefit of ease formed into numerous shapes. 304 stainless steel has brilliant resistance to a wide range of atmospheric environments and plenty of corrosive media. It is subject to pitting and crevice corrosion in heat chloride environments and to strain corrosion cracking above approximately 60 °C.

4.3.1 FEATURES

- It has good heat-resistant
- It offers good corrosion
- Resistance to many chemical corrodents and industrial atmospheres.
- It has good formability,
- Easily weldable

4.3.2 APPLICATIONS

- household and industrial applications such as food handling
- processing equipment, screws, machinery parts
- utensils, and car headers
- architectural field for exterior accents such as water and fire features
- common coil material for vaporizers.

4.3.3 CHEMICAL PROPERTIES

Table 4.1 CHEMICAL PROPERTIES – SS 304

ELEMENT	PERCENTAGE (%)
CARBON	0.0548%
MANGANESE	0.9308%
SILICON	0.3383%
SULPHUR	0.0030%
PHOSPHEROS	0.0353%
NICKEL	8.310%
CHROMIUM	18.26%

4.3.4 TENSILE PROPERTIES -SAMPLE



Before testing After testing

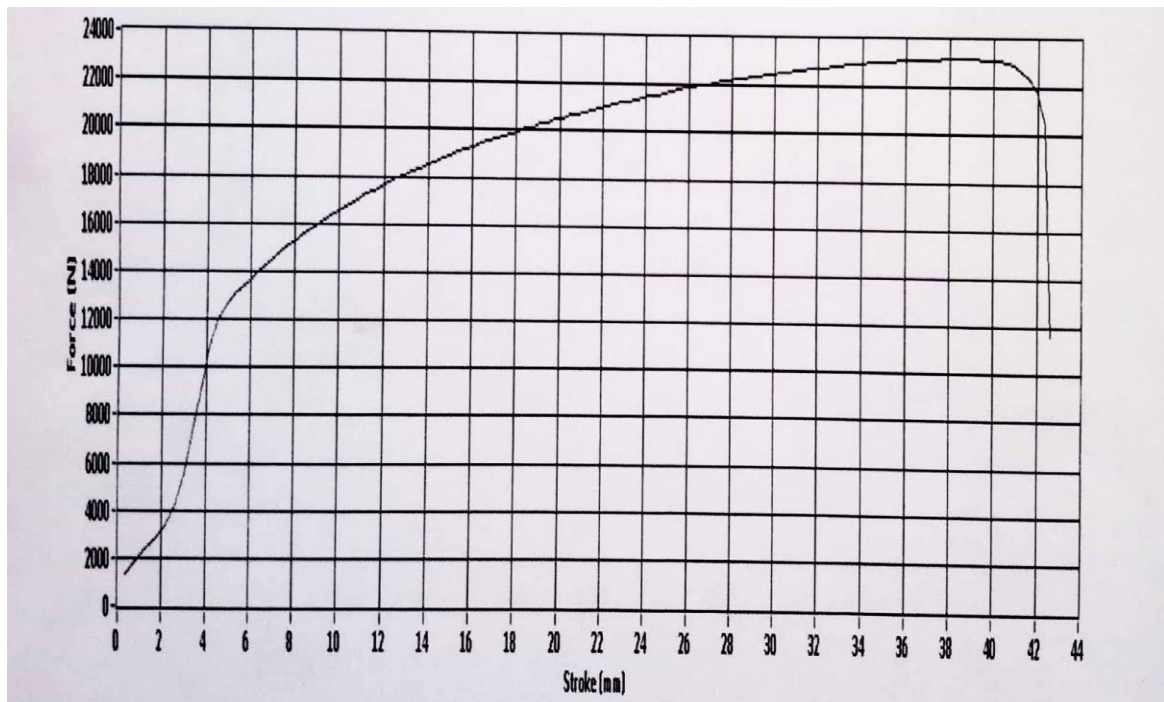
Before testing After testing

Fig 4.8: TENSILE SAMPLE – SS304

4.3.5 FORCE DISPLACEMENT GRAPH

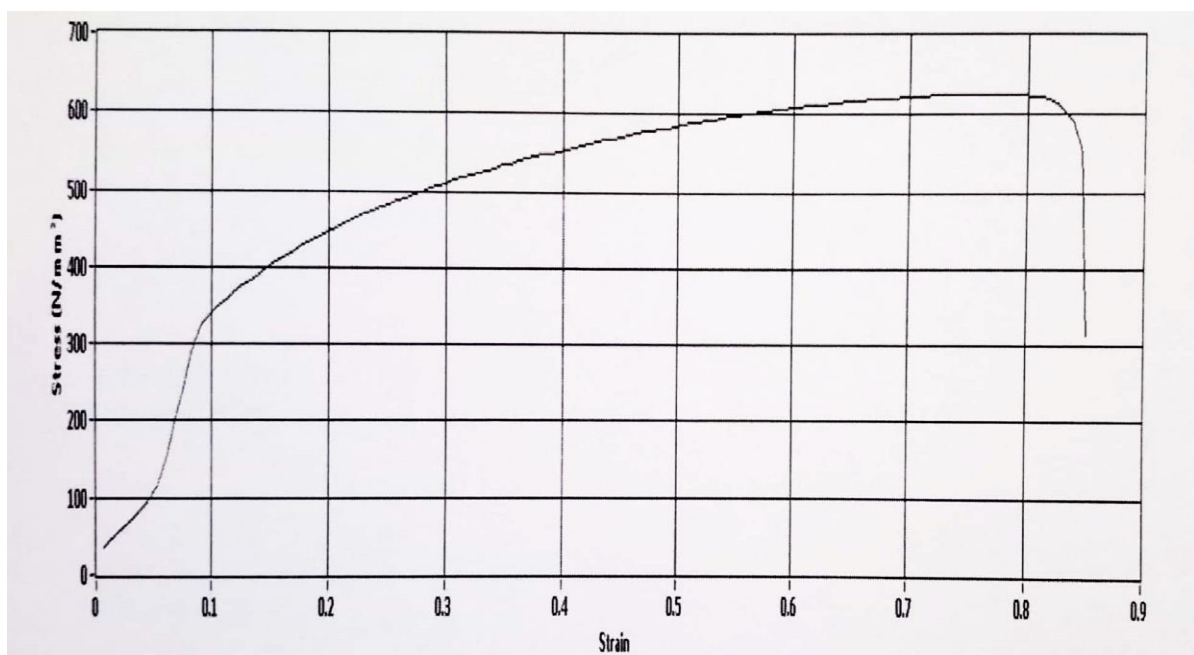
Table 4.2 INPUT DATA – SS 304

INPUT DATA:	
MODE OF TEST	Tension
SAMPLE TYPE	Flat
THICKNESS	2.95 mm
WIDTH	12.53 mm
AREA	36.96 mm ²
GUAGE LENGTH	50.00 mm
FINAL GUAGE LENGTH	73.410 mm



Graph 4.2 FORCE vs. STROKE GRAPH

4.3.6 STRESS STRAIN GRAPH



Graph 4.3 STRESS vs. STRAIN GRAPH

The above graph (Graph 4.1 and Graph 4.2) helps us to find the maximum force, ultimate tensile strength, elongation percentage and yield stress of a material.

4.3.7 TENSILE PROPERTIES

Table 4.3 TENSILE PROPERTIES – SS 304

TENSILE PROPERTIES:	
Fmax	24.24 KN
UTS	655.86 Mpa
%EL	46.82%
YIELD STRESS	489.37 Mpa

4.4 STAINLESS STEEL 309

309 is an austenitic heat resistant alloy with oxidation resistance to 1900°F below regular temperature situations. whilst frequent thermal cycling is involved, the alloy is resistant to approximately 1850°F. The high chromium and comparatively low nickel content of 309 offer precise resistance to excessive temperature sulphur bearing atmospheres. 309 has simplest slight resistance to carbon absorption and is not advised to be used in enormously carburizing atmospheres. Often in many product forms, the grain length and carbon content can meet each the 309S and 309H necessities. prolonged exposure to the 1100-1600°F temperature variety will cause some sigma to form, decreasing room temperature ductility and effect resistance. Should sigma formation be predicted, care need to be taken to keep away from heavy mechanical effect at room temperature.

4.4.1 FEATURES

- Oxidation resistant to 1900°F
- Moderate strength at high temperature
- Ease of fabrication
- Good sulfidation resistance

- Good weldability

4.4.2 APPLICATIONS

- Annealing covers and boxes
- Waste incinerators and Pulverized coal burners
- Brazing fixtures, Lead pans, neutral salt pots
- Muffles, retorts • Furnace fans and shafts
- Radiant tubes for aluminium and steel annealing
- Glass forming equipment
- Thermowells, Paper mill equipment

4.4.3 CHEMICAL PROPERTIES

Table 4.4 CHEMICAL PROPERTIES – SS 309

ELEMENT	PERCENTAGE (%)
CARBON	0.0774%
MANGANESE	1.858%
SILICON	0.2247%
SULPHUR	0.0014%
PHOSPHEROS	0.0331%
NICKEL	12.71%
CHROMIUM	22.32%

4.4.4 TENSILE PROPERTIES -SAMPLE



Before testing

After testing

Fig 4.9: TENSILE SAMPLE – SS309

4.4.5 FORCE DISPLACEMENT GRAPH

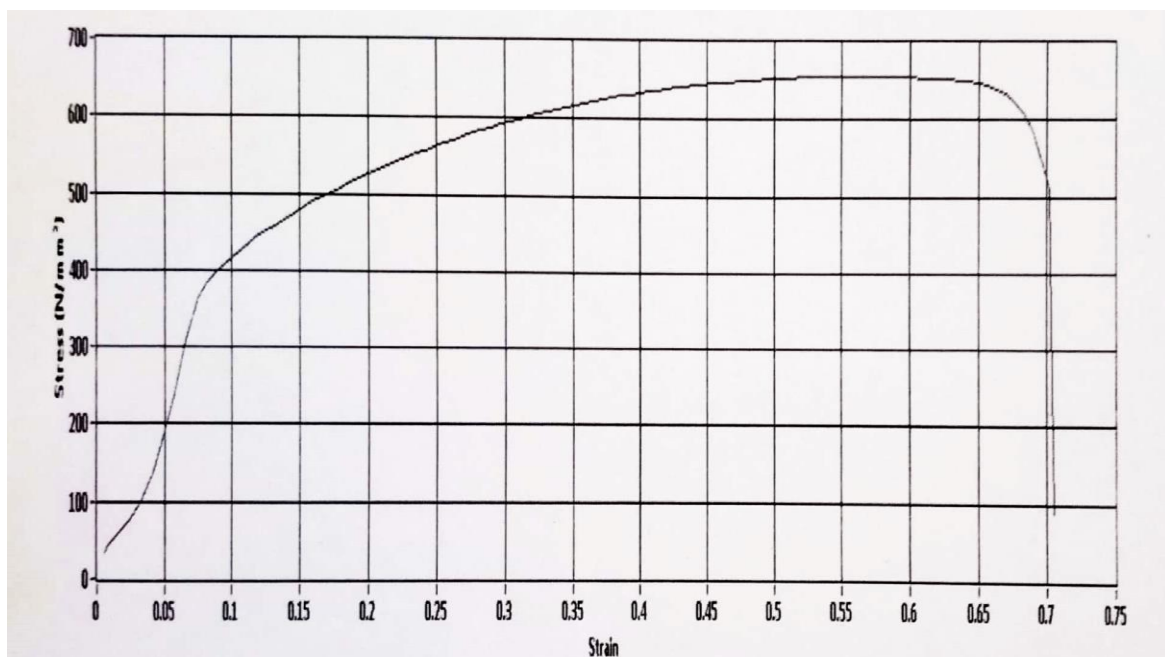
Table 4.5 INPUT DATA – SS 309

INPUT DATA:	
MODE OF TEST	Tension
SAMPLE TYPE	Flat
THICKNESS	2.95 mm
WIDTH	12.53 mm
AREA	36.96 mm ²
GUAGE LENGTH	50.00 mm
FINAL GUAGE LENGTH	73.410 mm



Graph 4.4 FORCE vs. STROKE GRAPH

4.4.6 STRESS STRAIN GRAPH



Graph 4.5 STRESS STRAIN GRAPH

The above graph (Graph 4.3 and Graph 4.4) helps us to find the maximum force, ultimate tensile strength, elongation percentage and yield stress of a material.

4.4.7 TENSILE PROPERTIES

Table 4.6 TENSILE PROPERTIES – SS 309

TENSILE PROPERTIES:	
Fmax	24.24 KN
UTS	655.86 Mpa
%EL	46.82%
YIELD STRESS	489.37 Mpa

4.5 INCONEL 800

INCOLOY alloys belong to the class of amazing austenitic stainless steels. These alloys have nickel-chromium-iron because the base metals, with components inclusive of molybdenum, copper, nitrogen and silicon. These alloys are known for their excellent strength at expanded temperatures and excellent corrosion resistance in a spread of corrosive environments.

INCOLOY alloy 800 composed of nickel, iron and chromium. The alloy is able to stay stable and keep its austenitic structure even after long term exposures to excessive temperatures. Other characteristics of the alloy are good strength, and excessive resistance to oxidizing, reducing and aqueous environments. The usual forms in which this alloy is present are round, flats, forging stock, tube, plate, sheet, cord and strip.

4.5.1 FEATURES

- Oxidation resistant to 2100°F
- High creep-rupture strength
- Resistant to carburization and nitriding

- Resistant to thermal shock
- Good strength at higher temperatures
- Metallurgical stability
- Chloride ion stress corrosion cracking resistance

4.5.2 APPLICATIONS

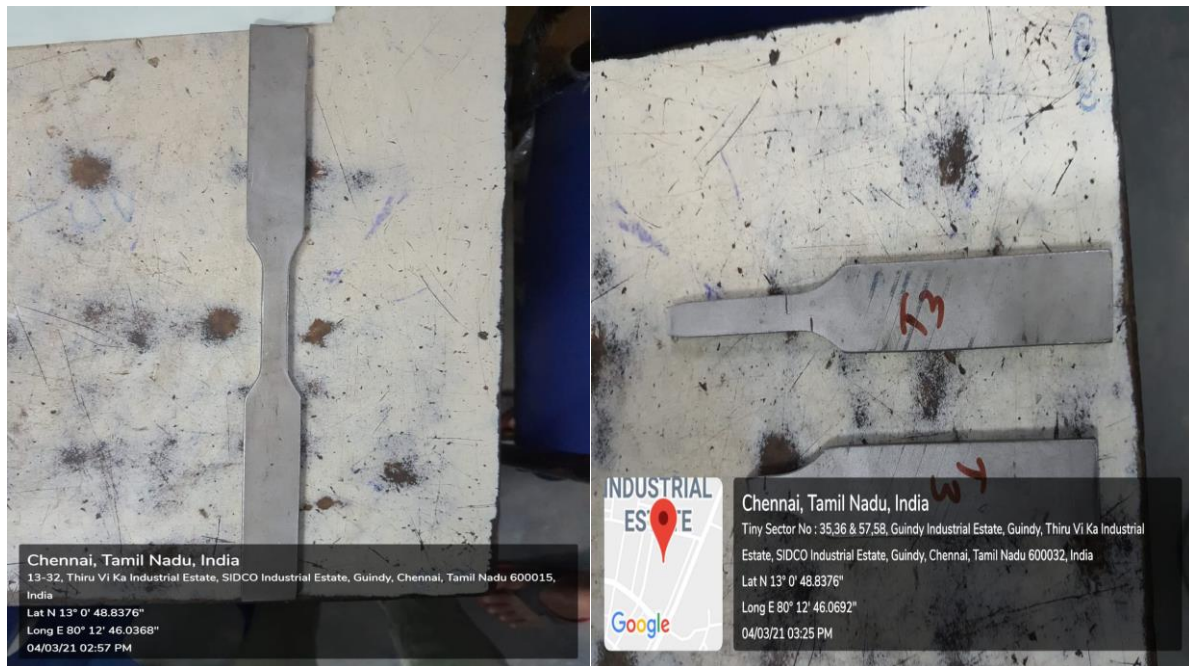
- Heat exchangers
- Carburizing equipment
- Heating elements
- Sheathing and nuclear steam generator tubing.

4.5.3 CHEMICAL PROPERTIES

Table 4.7 CHEMICAL PROPERTIES – INCONEL 800

ELEMENT	PERCENTAGE (%)
CARBON	0.0746%
MANGANESE	0.9053%
SILICON	0.2336%
SULPHUR	0.0005%
IRON	45.08%
NICKEL	31.96%
CHROMIUM	19.96%
COPPER	0.2603%
ALUMINIUM	0.3790%

4.5.4 TENSILE PROPERTIES -SAMPLE



Before testing

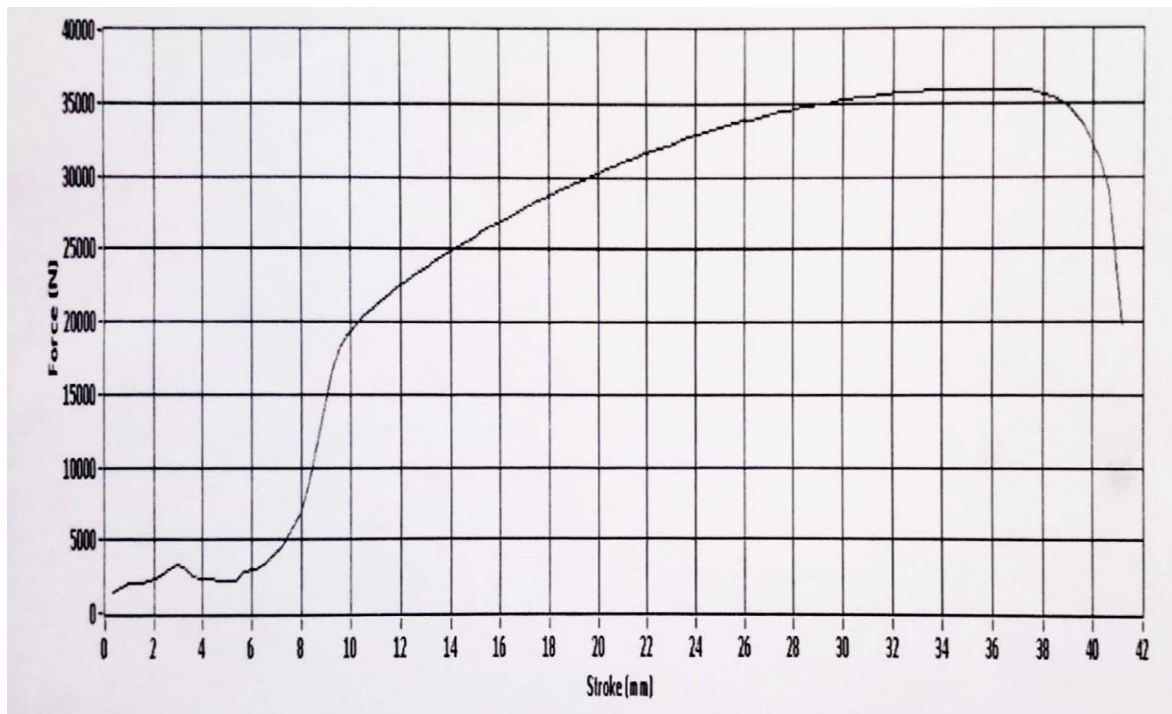
After testing

Fig 4.9: TENSILE SAMPLE – INCONEL 800

4.5.5 FORCE DISPLACEMENT GRAPH

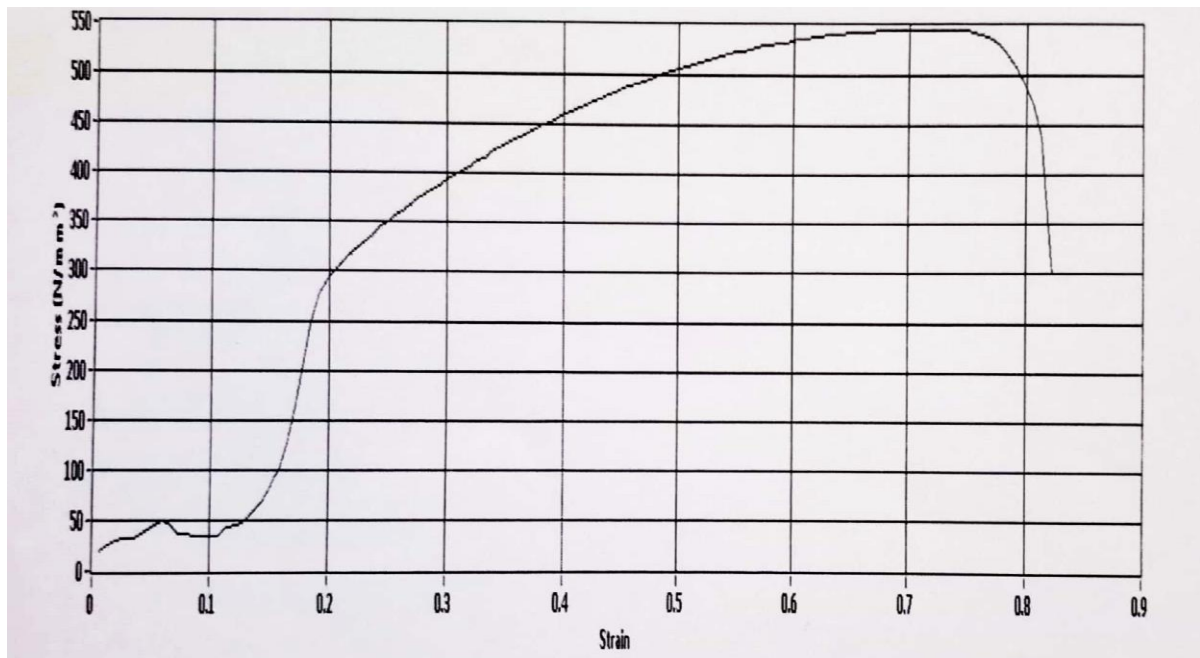
Table 4.8 INPUT DATA – INCONEL 800

INPUT DATA:	
MODE OF TEST	Tension
SAMPLE TYPE	Flat
THICKNESS	5 mm
WIDTH	12.58 mm
AREA	65.79 mm ²
GUAGE LENGTH	50.00 mm
FINAL GUAGE LENGTH	73.760 mm



Graph 4.6 FORCE vs. DISPLACEMENT GRAPH

4.5.6 STRESS STRAIN GRAPH



Graph 4.7 STRESS vs. STRAIN GRAPH

The above graph (Graph 4.5 and Graph 4.6) helps us to find the maximum force, ultimate tensile strength, elongation percentage and yield stress of a material.

4.5.7 TENSILE PROPERTIES

Table 4.9 TENSILE PROPERTIES – INCONEL 800

TENSILE PROPERTIES:	
Fmax	35.97 KN
UTS	546.66 Mpa
%EL	47.52%
YIELD STRESS	357.17 Mpa

CHAPTER 5

DESIGN AND ANALYSIS

5.1 METHODOLOGY

Step 1: This input parameter for the muffler as per the dimensions in present existing model.

Step 2: The Design model is done by the **CATIA** software respect to input parameter mentioned in dimension.

Step 3: Export the model in neutralized format (Parasolid or Step) to open in **ANSYS Workbench** environment

Step 4: In ANSYS **Design modeler environment** create the fluid domain using existing solid geometry for baseline (existing) model

Step 5 meshing the fluid domain

Step 6: Assigning Wall condition

Step 7: Defining fluid and solid properties

Step 8: Fluid and Solid Boundary condition

Step 9: Run the iteration

Step 10. Export the results to CFD Post -Post processor

Step 11: Post process Pressure in inlet and Outlet

Step 12: Migrate to the thermal analysis for heat transfer

Step 13: Import into Structure Analysis for obtaining thermal stress

Step 14: Repeat the same procedure for Other two materials

Step 15: Compare results and conclude which is best.

5.2 MODELING

5.2.1 INTRODUCTION TO MODELING

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. The role of digital computers played a major role in the manufacturing sectors development and progress. Nowadays computers are used as a major tool in designing and detailing of engineering components.

5.2.2 COMPUTER AIDED DESIGN

Computer-aided design (CAD) is described as any layout hobby that includes the powerful use of the laptop to create, modify, analyse, or file an engineering layout. CAD is maximum normally related to using an interactive laptop images system, known as a CAD system. Computer-aided design systems are powerful tools that are used for mechanical designing and also for geometric modelling of products and components.

The CAD systems are used mainly for the following reasons:

- To improve the productivity
- To improve the quality of the design
- To uniform layout requirements
- To create a manufacturing data base.
- To get rid of inaccuracies because of hand-copying of drawings and inconsistency among Drawings

5.2.3 BASIC REQUIREMENT OF MUFFLER DESIGN

There are various requirements that should be considered when designing a muffler for an automotive application. Such functional requirements may include size, durability, adequate insertion loss, backpressure, desired sound, cost, weight, compact shape and style.

Adequate Insertion Loss (IL):

An efficacious muffler will truncate the sound pressure of the noise source to the required level. In the case of an automotive muffler the noise in the exhaust system, engendered by the engine, is to be abbreviated. A mufflers performance or attenuating capability is generally defined in terms of transmission loss or insertion loss. Insertion loss is the distinction between the acoustic powers radiated with and without a muffler fitted. The transmission loss is defined as the difference (in decibels) between the sound power incident at the ingress to the muffler that of the transmitted by muffler. The muffler designer must determine the required insertion loss so that a congruous type of muffler can be designed for the automotive application.

Selection of size:

The proper selection and sizing of the silencer is of utmost consequentiality to ascertain that acoustical performance, pressure drop and other categorical design criteria are met. The cull of the correct type of engine exhaust silencer is resolute by the type of engine, the cessation utilization of the engine and the degree of muting required. Withal, the silencer size culled must accommodate the designated volume of exhaust gas flow keeping the back pressure within the inhibitions designated. The available space has a great influence on the size and ergo type of muffler that may be utilized. A muffler is geometry is generally designed for optimum attenuation and if it does not meet the space constraints, it is useless.

Backpressure:

Backpressure refers the extra static pressure exerted by the muffler on the engine by the muffler through the restriction in flow of exhaust gasses. Generally, the better a muffler is at attenuating sound the more backpressure is engendered. In a reactive muffler where good attenuation is achieved the exhaust gasses are coerced to pass through numerous geometry changes and a fair amplitude of backpressure may be

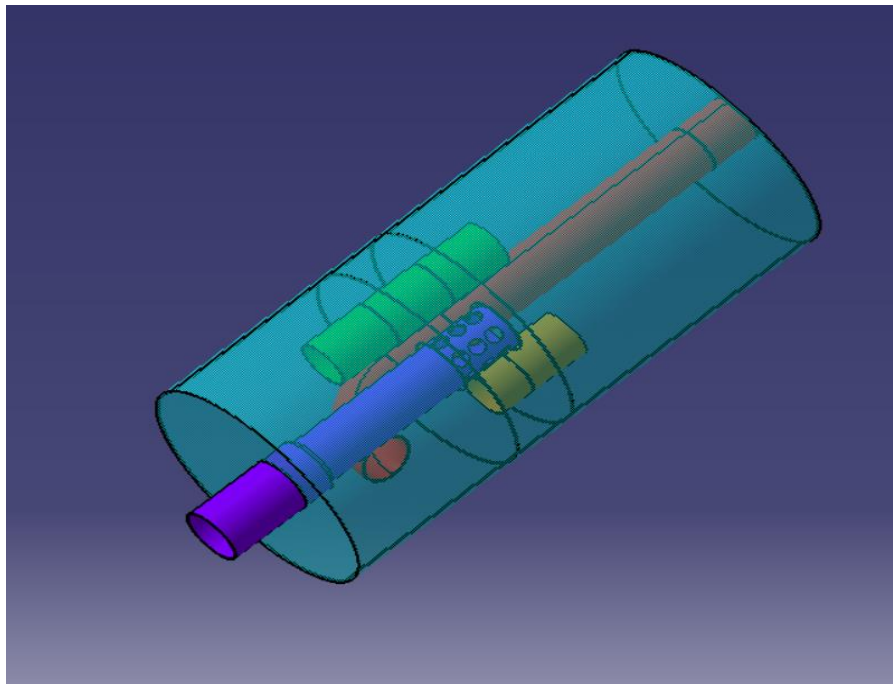
engendered, which truncates the puissance output of the engine. Backpressure should be kept to a minimum to avoid power losses especially for better performance of conveyance.

Cost and Weight:

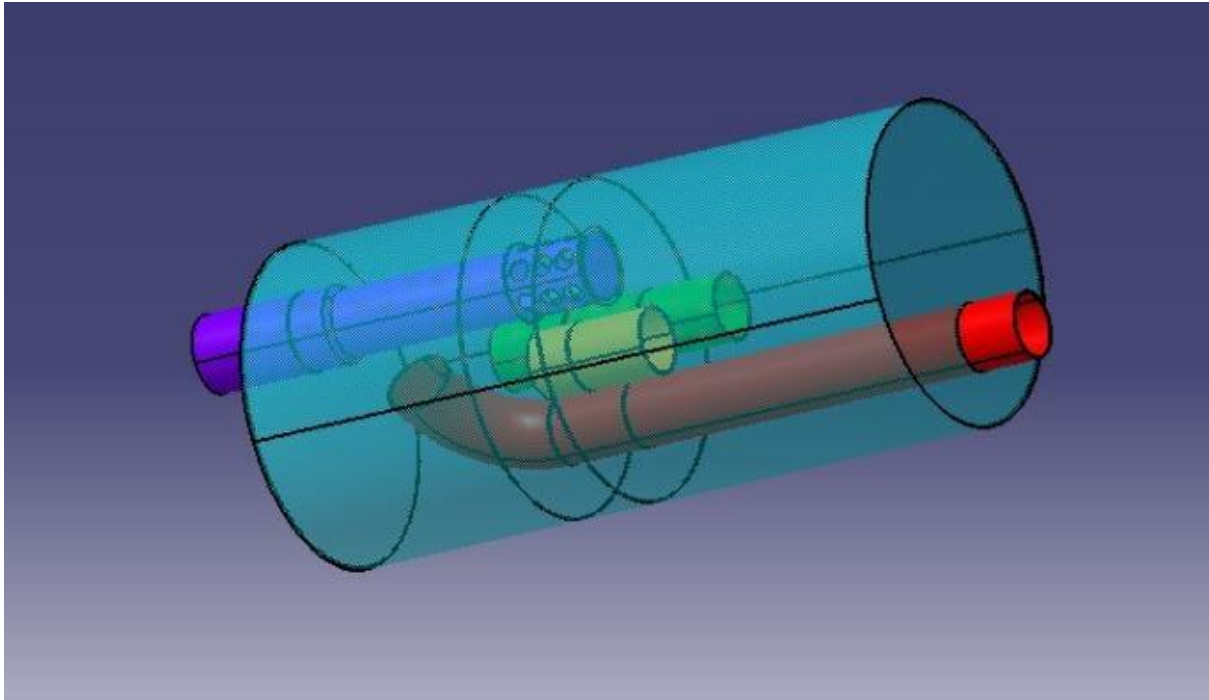
Generally, the more astronomically immense a muffler is, the more it weighs and the more it costs to manufacture. For a performance conveyance every gram preserved is crucial to its performance. Efficaciously fortifying a muffler is always a design issue and the more immensely colossal a muffler is the more arduous it is to fortify. A Muffler's mounting system not only needs to fortify the mufflers weight but it withal needs to provide vibration isolation so that the vibration of the exhaust system is not passing to the chassis and passenger cabin. This vibration isolation is customarily achieved with the utilization of hard rubber inserts and brackets that dampen or isolate vibration from the muffler to the chassis. Therefore, minuscule light weight muffler is desirable.

5.2.4 CAD MODEL

The existing muffler (ALTO 880 vxi) is designed in CATIA with the measured dimensions using conventional instruments like Vernier calliper and Micrometre.



(A)



(B)

Fig 5.1 CAD MODEL OF MUFFLER

5.2.5 LINE DIAGRAM

The following are the line diagram of the existing muffler. Here, the proper measurement of every segment of the muffler are mentioned with dimensions.

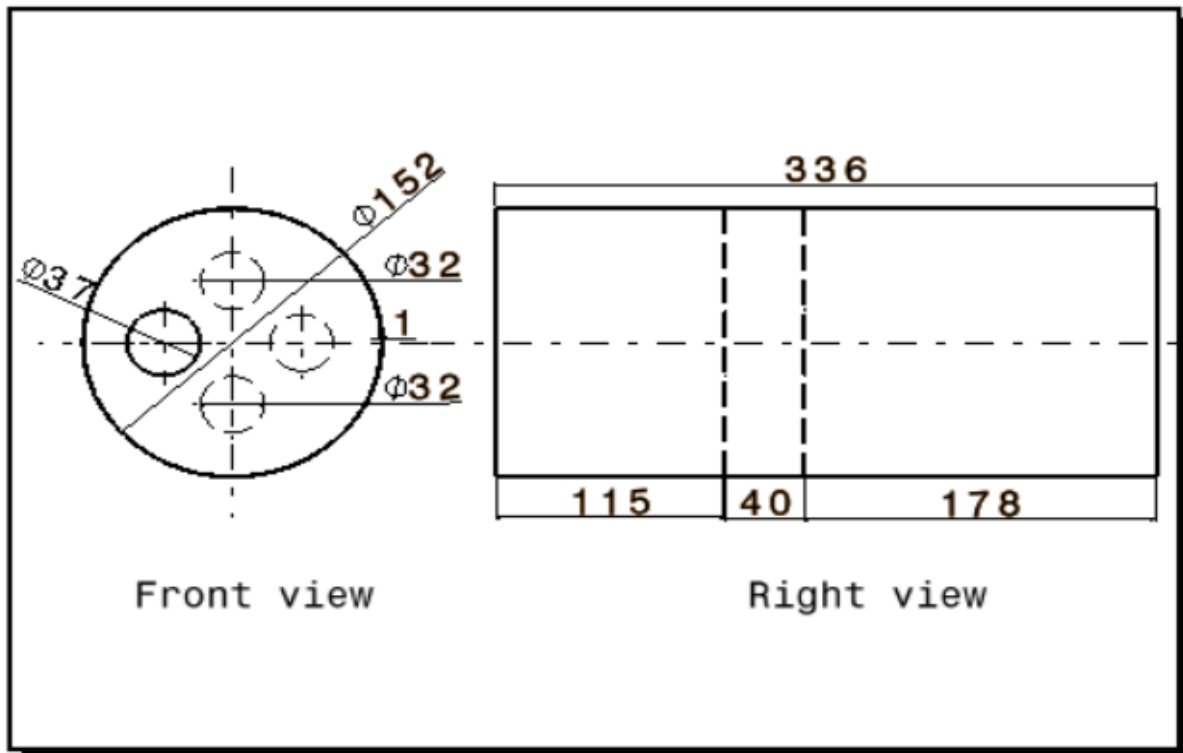


Fig 5.2 MUFLER CHMABER

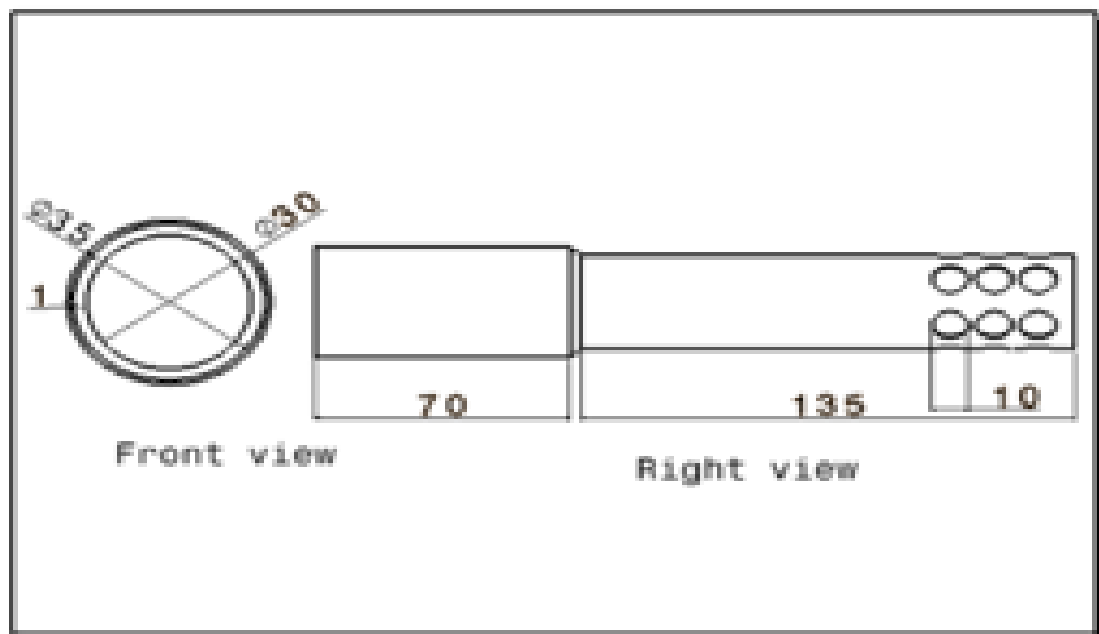


Fig 5.3 INLET TUBE

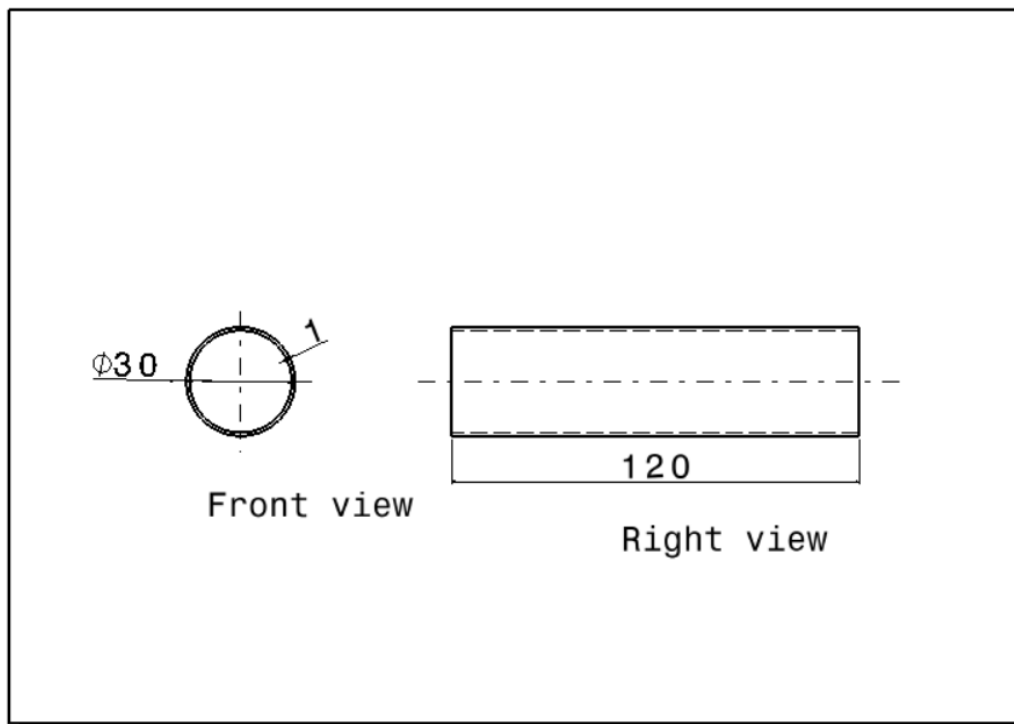


Fig 5.4 CHAMBER TUBE-1

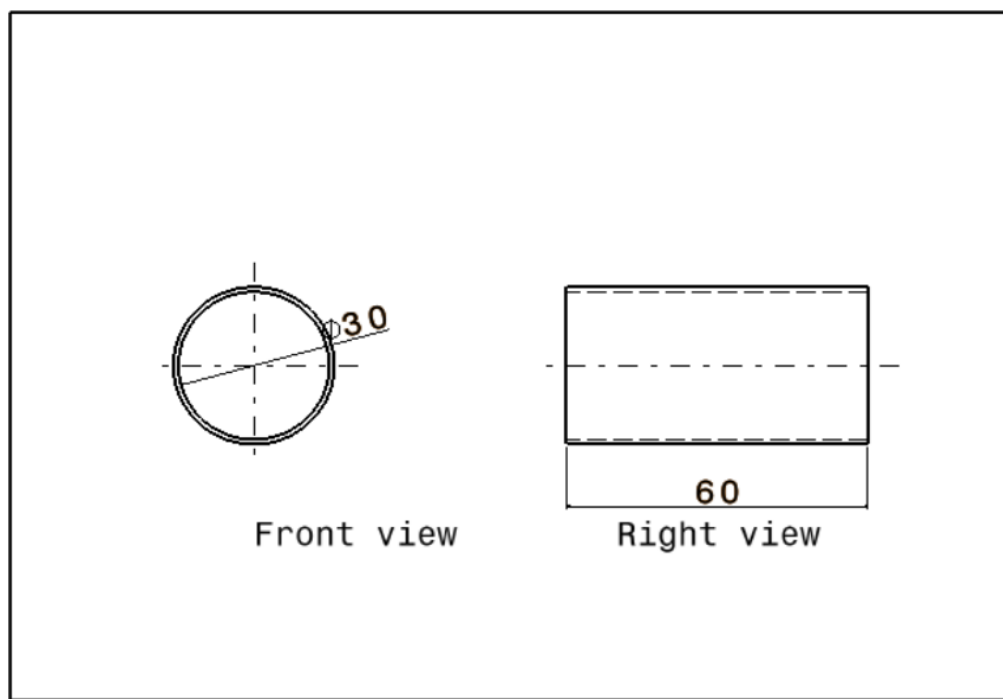


Fig 5.5 CHAMBER TUBE-2

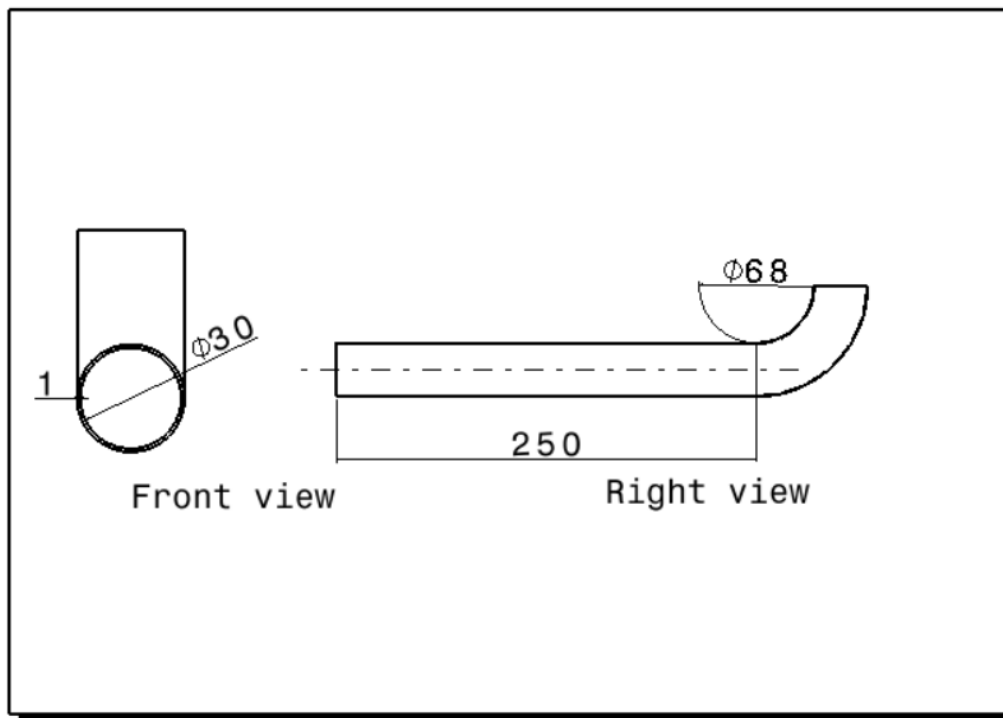


Fig 5.6 OUTLET TUBE

5.3 FINITE ELEMENT ANALYSIS

The Finite Element Analysis (FEA) is defined as the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers and designers use FEA software to minimize the number of physical prototypes and experiments and optimize components in their design phase to develop better products at faster rate by saving the expense.

It is indispensable to utilize mathematics to comprehensively understand and quantify any physical phenomena such as thermal convey, structural or fluid behaviour, the magnification of biological cells, wave propagation, etc. Most of these processes are described utilizing Partial Differential Equations (PDEs). However, for a computer to solve these PDEs, numerical methods and techniques have been developed over the last few decades and one of the efficient one is the Finite Element Analysis.

Here Two Analysis carried for Muffler model using ANSYS WORKBENCH

Namely

- CFD Analysis
- Thermal Analysis
- Structural Analysis

5.3.1 CFD ANALYSIS

Computational Fluid Dynamics (CFD) is the analysis of fluid flows utilizing numerical solution methods. Utilizing CFD, you are able to analyse intricate problems involving fluid-fluid, fluid-solid or fluid-gas interaction. CFD analysis are used in engineering field such as aerodynamics and hydrodynamics, where quantities such as lift and drag or field properties (pressures and velocities) are obtained. Fluid dynamics involves physical laws in the form of partial differential equations. CFD solvers transform these laws into algebraical equations and would be able to efficiently solve these equations numerically.

5.3.1.1 USAGE OF CFD

CFD analyses have a higher potential to save time in the design process and are therefore faster and cheaper compared to traditional testing for data acquisition. Also, in real life tests a minimum number of quantities are measured at a time, while in a CFD analysis all desired quantities can be measured at once with a high resolution in space and time.

Since CFD analyses approximate a real physical solution, it should be noted that these CFD analyses cannot fully exclude physical testing procedures. For verification purpose tests should have to be performed.

5.3.1.2 CFD – WORK PROCESS

A CFD analysis basically consists of the following three phases:

Pre-processing

In this phase the problem statement is transformed into a discretized and idealized computer model. Assumptions are made concerning the type of flow to be modelled (incompressible, steady/non-steady viscous/inviscid, compressible). Other processes involved are application of initial- and boundary conditions and mesh generation.

Solving

Solve performs the actual computations, and in this solving phase computational power is required. There are multiple solvers available, varying in capability and efficiency of solving certain physical phenomena.

Post-processing

At last, the gathered results are analysed and visualized in the post processing phase. In this stage the analyst can verify the results and conclusion can be drawn based on the obtained results. The way of presenting the obtained results are static or moving pictures, graphs or tables.

5.3.1.3 BOUNDARY CONDITION FOR CFD ANALYSIS

Boundary conditions (b.c.) are constraints obligatory for the answer of a boundary value problem. A boundary value problem is a system of differential equations to be solved in a domain on a boundary with a set of conditions known. It is opposed to the “initial value problem”, in which only the conditions on one extreme of the interval are known. Boundary value quandaries are profoundly paramount as they model a prodigious number of applications and phenomena, from solid mechanics to heat transfer, from fluid mechanics to acoustic diffusion. They arise naturally in every problem predicated on a differential equation to be solved in space, while initial value problems customarily refer to problems to be solved in time.

Table 5.1 BOUNDARY CONDITION - CFD

INLET CONDITION	
INLET VELOCITY	39.789 m/s
INLET TEMPERATURE	773 K
DENSITY (constant at temperature)	1.225 kg/m ³
OUTLET CONDITION	
OPENING AT OUTLET	0.05 Pa
OUTLET TEMPERATURE	300 K
ENERGY	On

5.3.1.4 FLUID PROPERTIES FOR CFD ANALYSIS

Create/Edit Materials

Name: **air** Material Type: **fluid**

Chemical Formula: **air** Fluent Fluid Materials: **air**

Mixture: **none**

Properties

Density (kg/m3): **constant** **Edit...**
1.225

Cp (Specific Heat) (j/kg-k): **constant** **Edit...**
1006.43

Thermal Conductivity (w/m-k): **constant** **Edit...**
0.0242

Viscosity (kg/m-s): **constant** **Edit...**
1.7894e-05

Fig 5.7 FLUID PROPERTIES

5.3.1.5 SOLID PROPERTIES

The screenshot shows the 'Create/Edit Materials' dialog box in ANSYS. The 'Name' field is set to 'steel-304'. The 'Material Type' is 'solid'. The 'Chemical Formula' field is empty. The 'Fluent Solid Materials' section shows 'steel' selected under 'Mixture'. The 'Properties' section shows three properties set to 'constant':
Density (kg/m3): 8030
Cp (Specific Heat) (j/kg-k): 502.48
Thermal Conductivity (w/m-k): 16.27

Fig 5.8 SOLID PROPERTIES

5.3.1.6 RESIDUAL

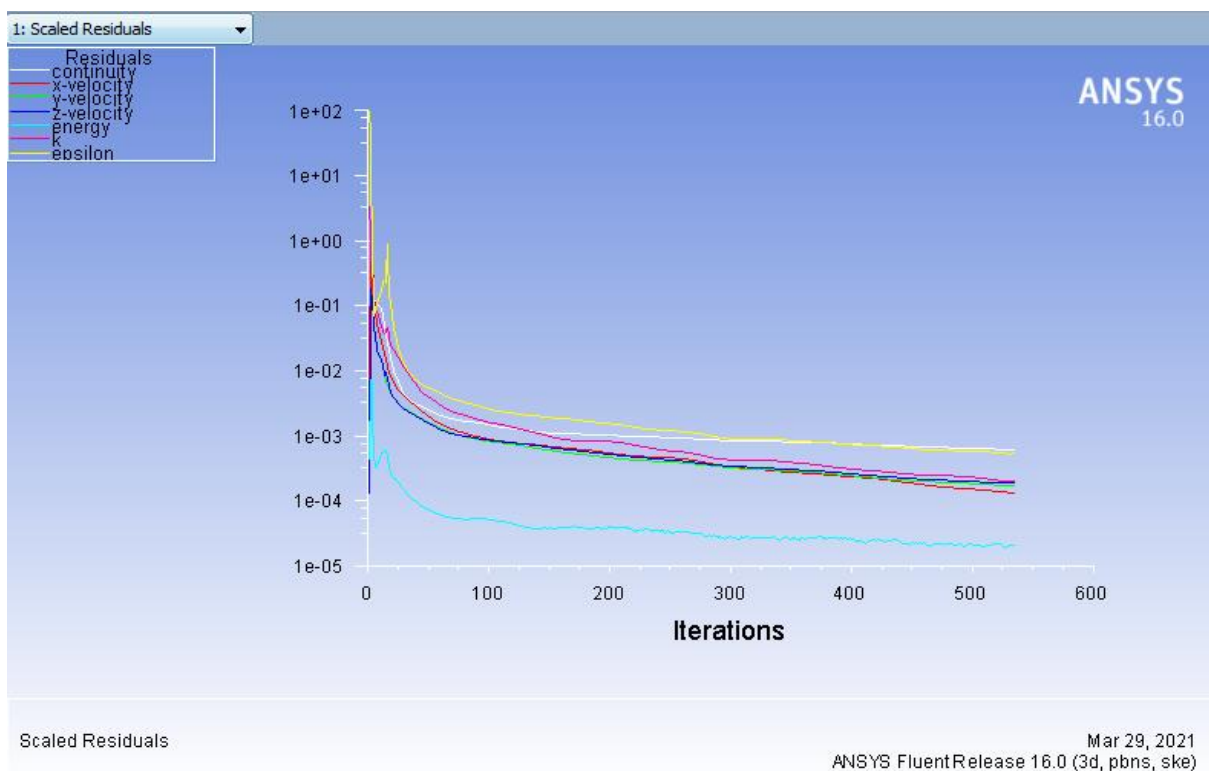


Fig 5.9 RESIDUAL

5.3.1.7 VELOCITY STREAMLINE

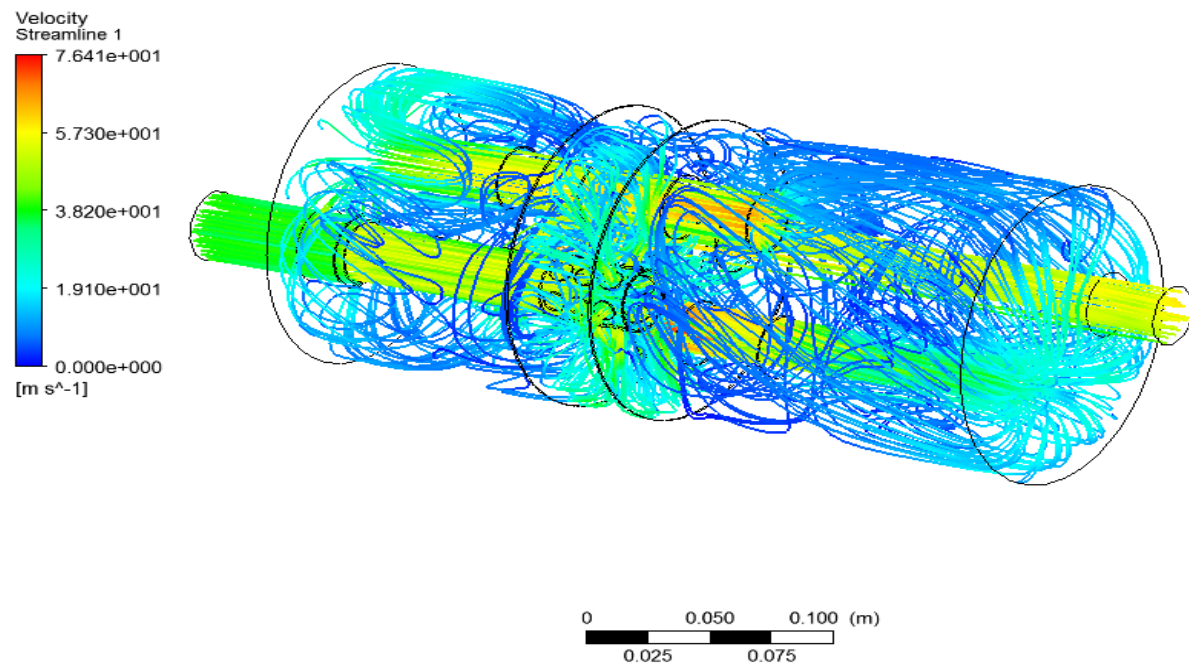
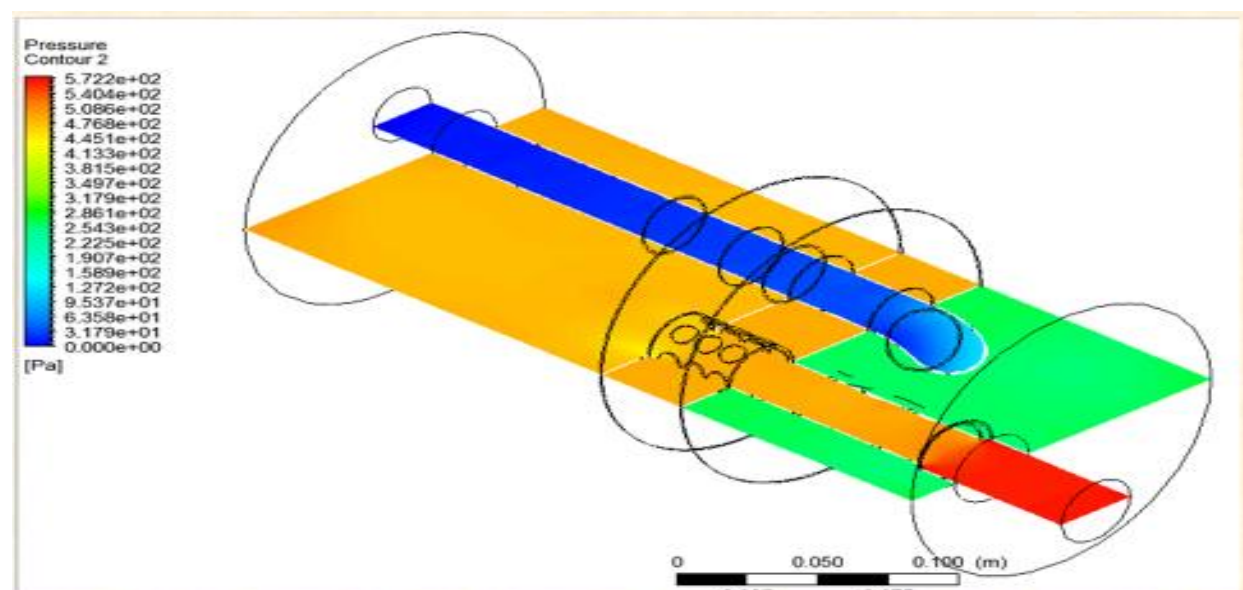


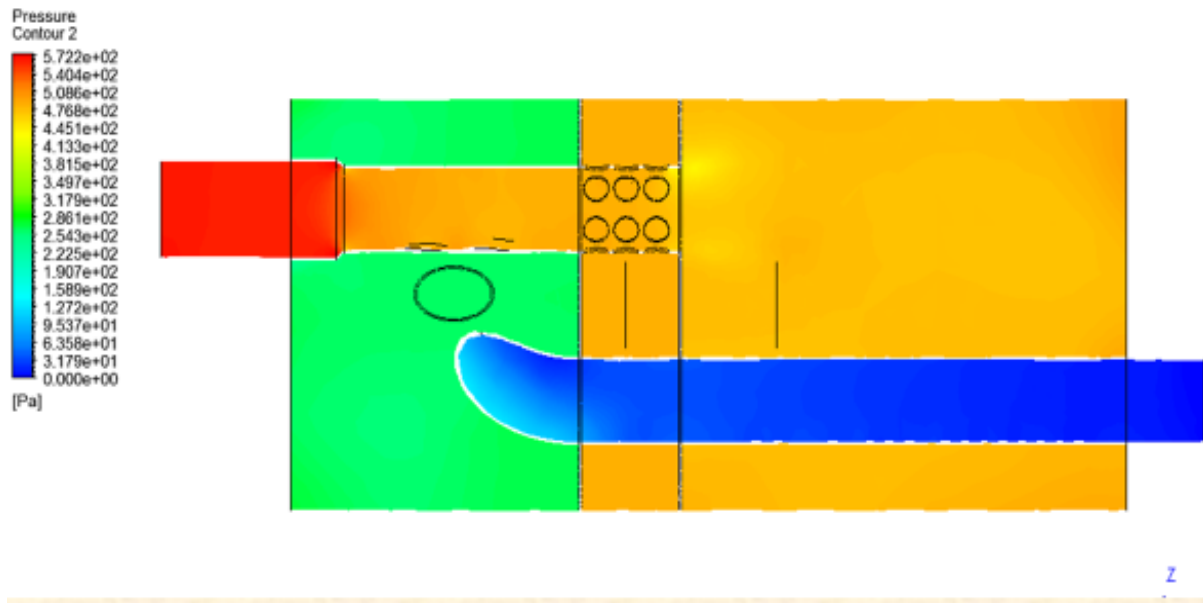
Fig 5.10 VELOCITY STREAMLINE

For the given force and boundary conditions, the flow of gases through muffler is identified as shown in Fig 5.10. The velocity stream line, pressure and temperature contour are found through CFD analysis.

5.3.1.8 PRESSURE CONTOUR



(A)

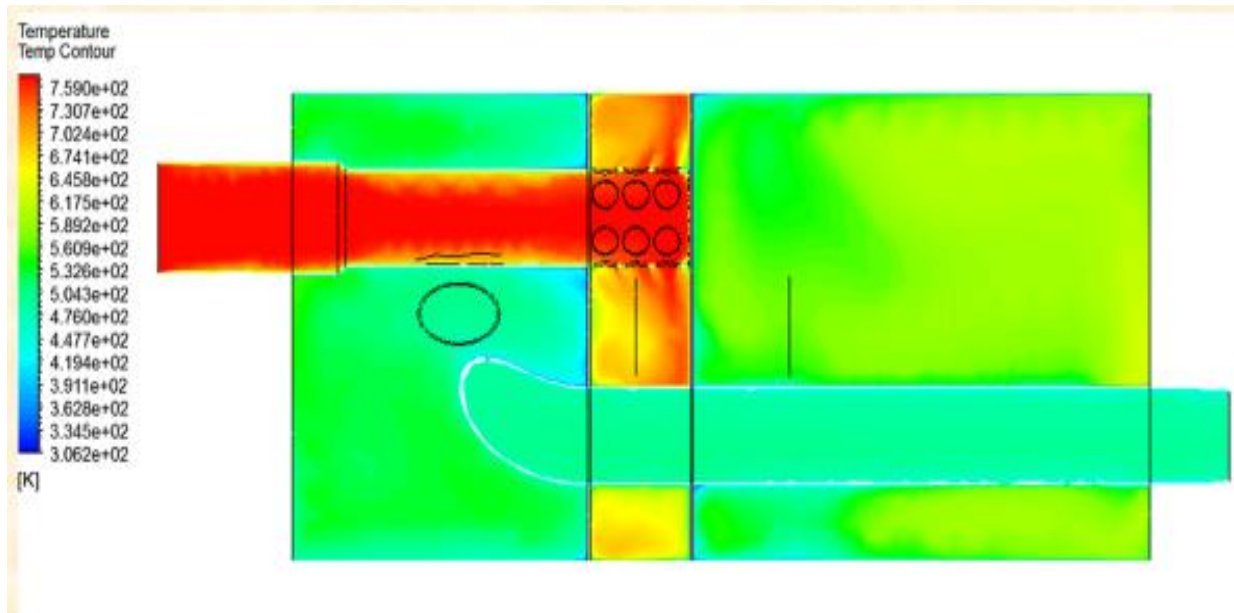


(B)

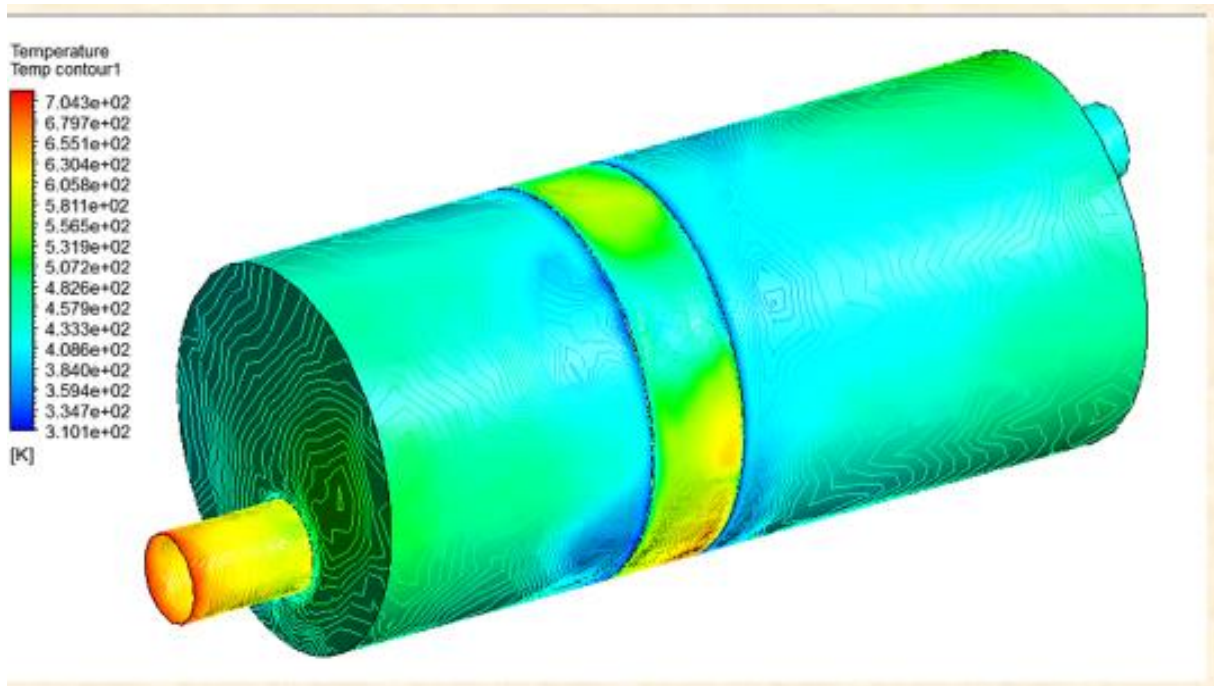
Fig 5.11 (A, B) PRESSURE CONTOUR

The above figures (Fig 5.11 (A, B)) show the pressure distributed inside the muffler. The sectional view with respect to the inlet pipe is considered to find the pressure contour of the muffler.

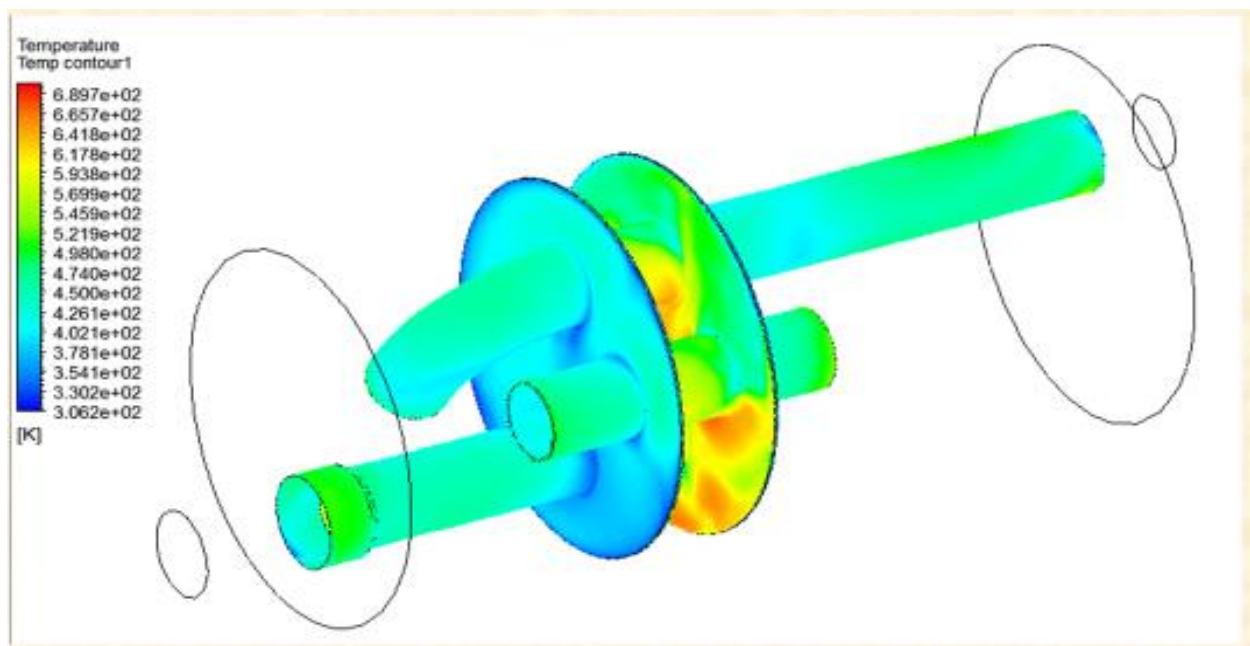
5.3.1.9 TEMPERATURE CONTOUR



(A)



(B)



(C)

Fig 5.12 (A, B, C) TEMPERATURE CONTOUR

The above figures (Fig 5.12 (A, B, C)) show the temperature distributed inside the muffler. with respect to the inlet pipe, inside the solid surface and outside the solid surface. We can see there is high temperature range between the baffles where most of the temperature and sound reduction takes place.

5.3.2 THERMAL ANALYSIS

Ansys Workbench can link a thermal analysis to a structural analysis, sharing Engineering Data, Geometry and Model directly. When directly connected, structural model bodies cannot be suppressed independently of the thermal analysis, and contacts and meshing cannot be done differently.

A structural analysis can be linked at the Geometry level, but the user will have to re-do all of the Model details, including meshing controls, Connections (including Contacts), and desired Coordinate Systems. This keeps the structural analysis independent from the thermal analysis.

5.3.3 STRUTURAL ANALYSIS OF STRESS DEFLECTION

Structural analysis can be defined as the interpretation and examination of the structure's stability.

If we are endeavouring to examine the stability of a structure under a temperature change, we require more than a heat transfer analysis. Heat transfer analysis will tell us only the temperature distribution of the structure as a result, so thermal stress analysis must be carried out to perform a congruous structural analysis for a temperature transmutation in the structure.

Thermal stress analysis is done by using the temperature distribution obtained through heat transfer analysis as a temperature input load. Thus, it can be interpreted as an analysis of the structure's stability against heat.

5.4 MESHING OF THE MODELS

For meshing purpose solid element has been selected. This type of element is used to mesh solid model in ANSYS. These volumes can be imported from a CAD system or created in the ANSYS pre-processor. Tetrahedral element can used to mesh any volume three or four node points in a plane, while Hexahedral elements (bricks) can be used to mesh regularly shaped rectangular type volumes and experience bending deformation when loaded by forces transverse to their surfaces. The above element are the different types of solid element used in ANSYS for different condition.

5.4.1 GEOMETRY OF MUFFLER

Geometry
10/03/2021 8:45 AM

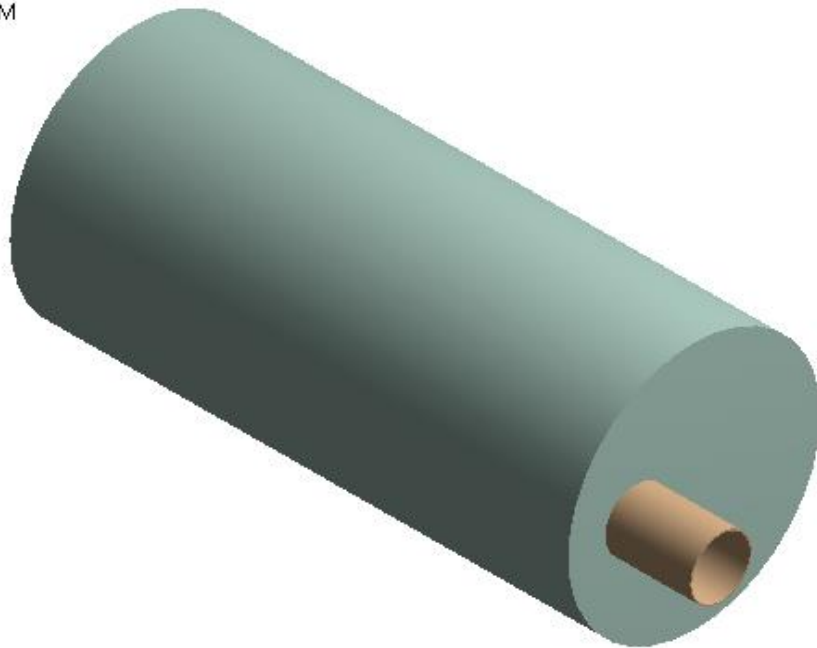


Fig 5.13 GEOMETRY OF MUFFLER

5.4.2 CONTACT BETWEEN COMPONENTS

When two solid bodies come in contact, heat flows from the hotter body to the colder body. We know, the temperature profile along the two bodies differs. Whenever there is an interface between the two surfaces in contact. A temperature drop is visually examined. This phenomenon is verbalized to be a result of a thermal contact resistance subsisting between the contacting surfaces. Thermal contact resistance refers to the ratio between the temperature drop and the average heat flow across the interface.

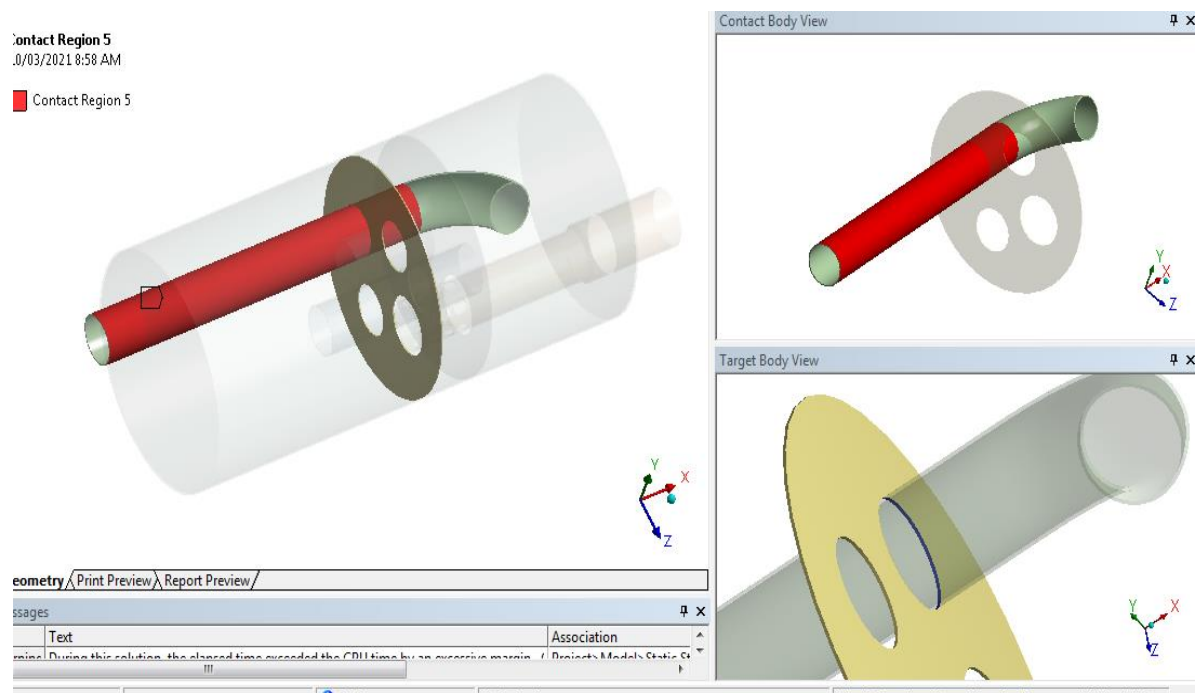


Fig 5.14 CONTACT BETWEEN COMPONENTS

5.4.3 MESH TYPE: HEXAHEDRAL

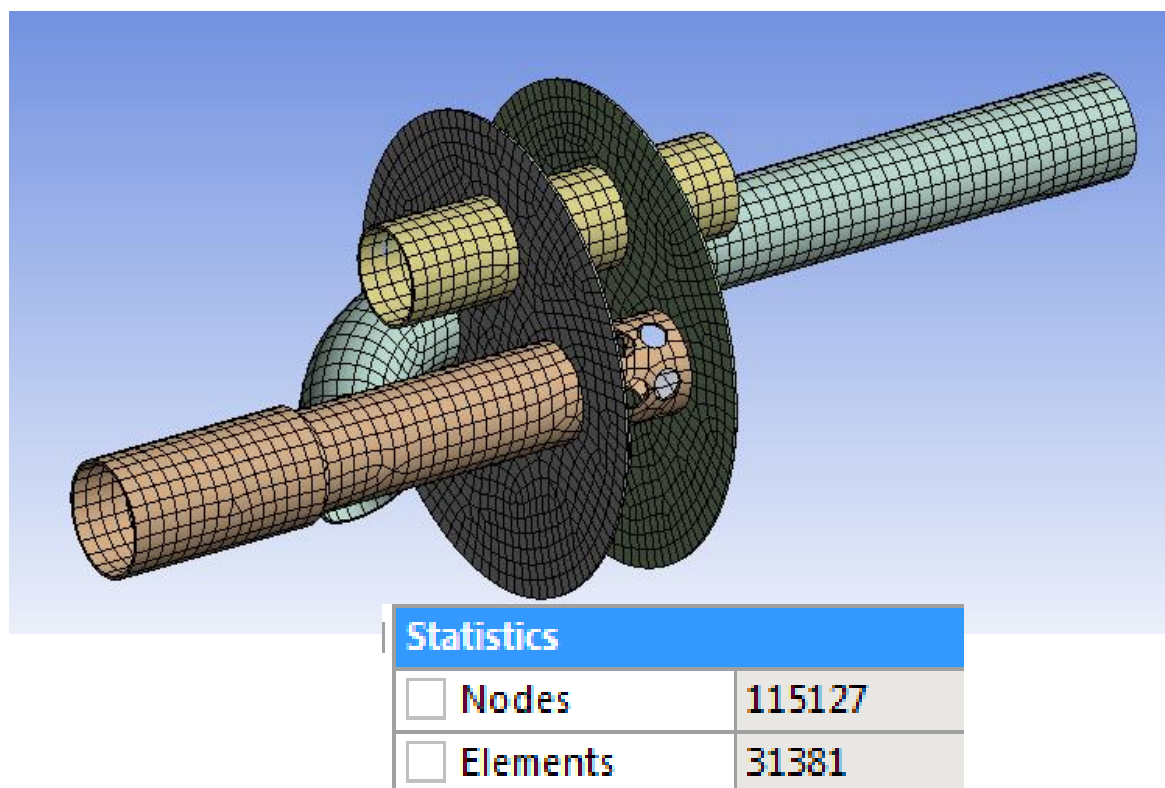


Fig 5.15 MESH TYPE

5.4.4 MESHED MODEL

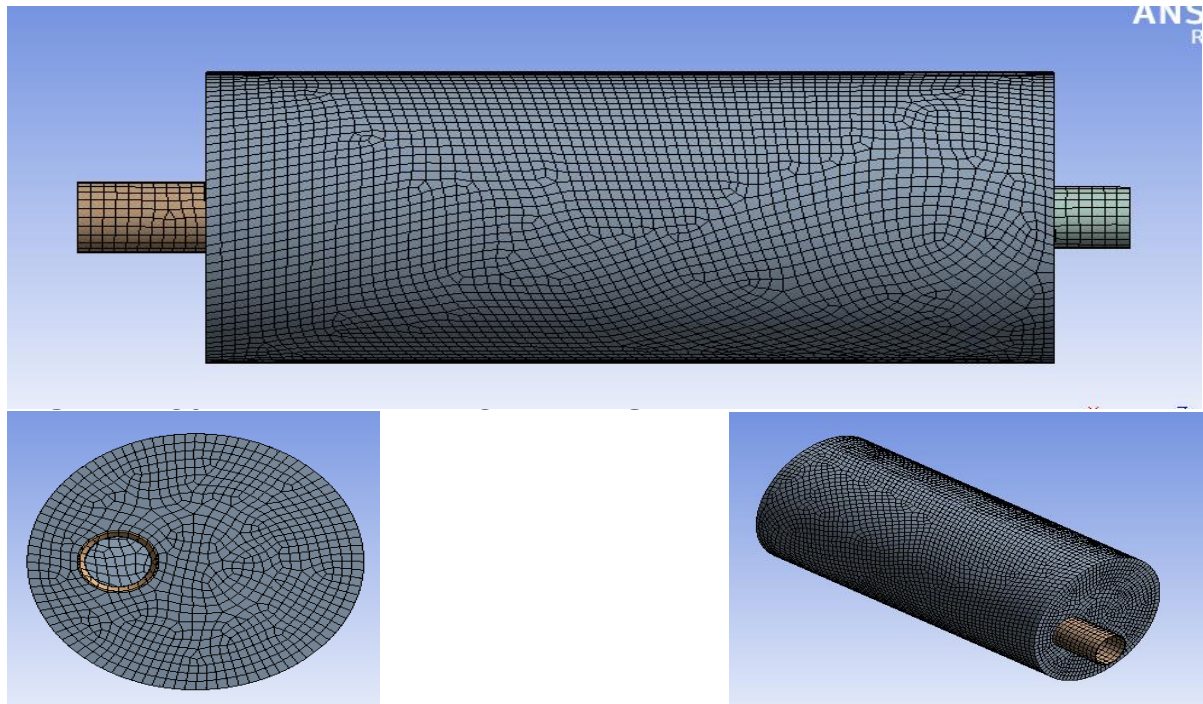


Fig 5.16 MESHED MODEL

The model is meshed with default meshing size. The meshing is done for finite element analysis on each nodes and elements. The model is finely meshed under hexahedral element. The meshed model is displayed in the figure 5.15 and figure 5.16.

5.5 THERMO STRUCTURAL ANALYSIS

After completing CFD Analysis, thermo Structure Analysis is done (To find thermal stress and deformation) with three material namely

- STAINLESS STEEL 304
- STAINLESS STELL 309
- INCONEL 800

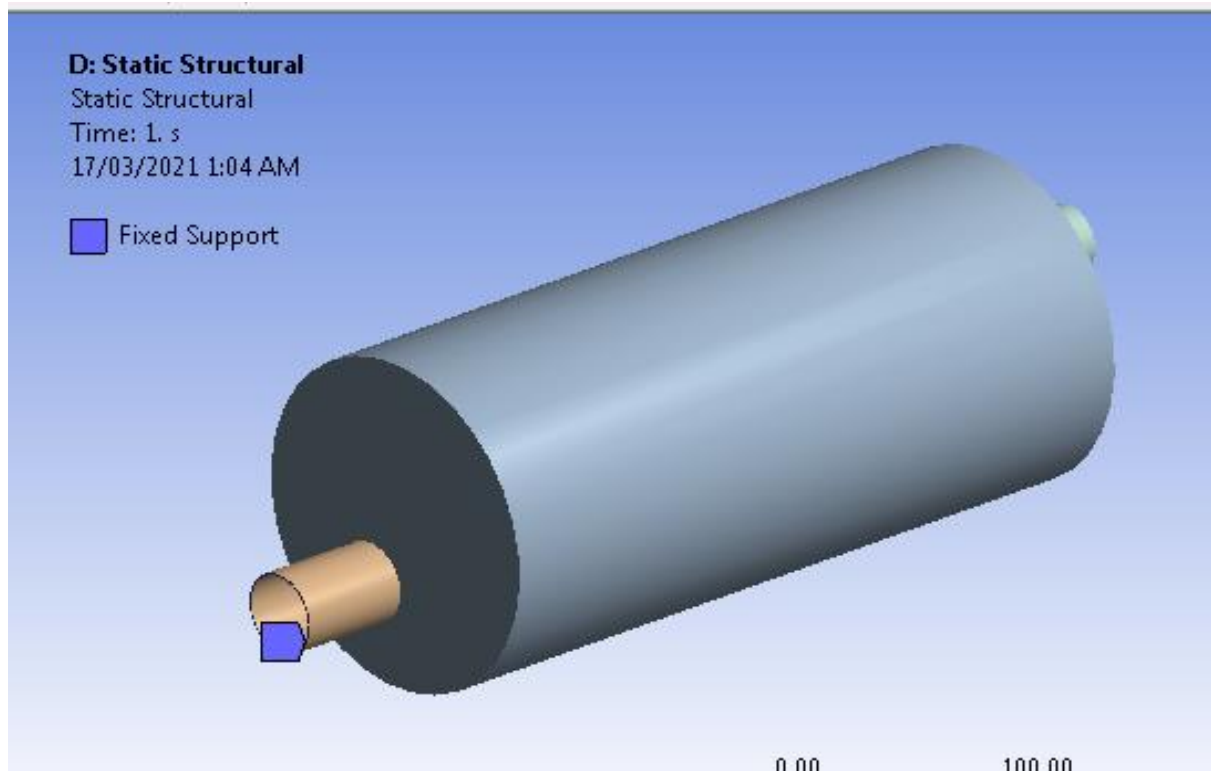
5.5.1 STAINLESS STEEL 304

5.5.1.1 PROPERTIES

Table 5.2 PROPERTIES – SS 304

Properties of Outline Row 3: Stainless Steel 304					
	A	B	C	D	E
1	Property	Value	Unit		
2	 Material Field Variables	Table			
3	 Density	8.03	g cm ⁻³		
4	 Isotropic Secant Coefficient of Thermal Expansion				
5	 Coefficient of Thermal Expansion	1.7E-05	C ⁻¹		
6	 Isotropic Elasticity				
7	Derive from	Young's Modu...			
8	Young's Modulus	1.9E+11	Pa		
9	Poisson's Ratio	0.265			
10	Bulk Modulus	1.3475E+11	Pa		
11	Shear Modulus	7.5099E+10	Pa		
12	 Tensile Yield Strength	2.07E+08	Pa		
13	 Compressive Yield Strength	2.07E+08	Pa		
14	 Tensile Ultimate Strength	5.86E+08	Pa		
15	 Compressive Ultimate Strength	0	Pa		

5.5.1.2 FIXED SUPPORT



5.5.1.3 IMPORTED THERMAL LOAD FROM CFD

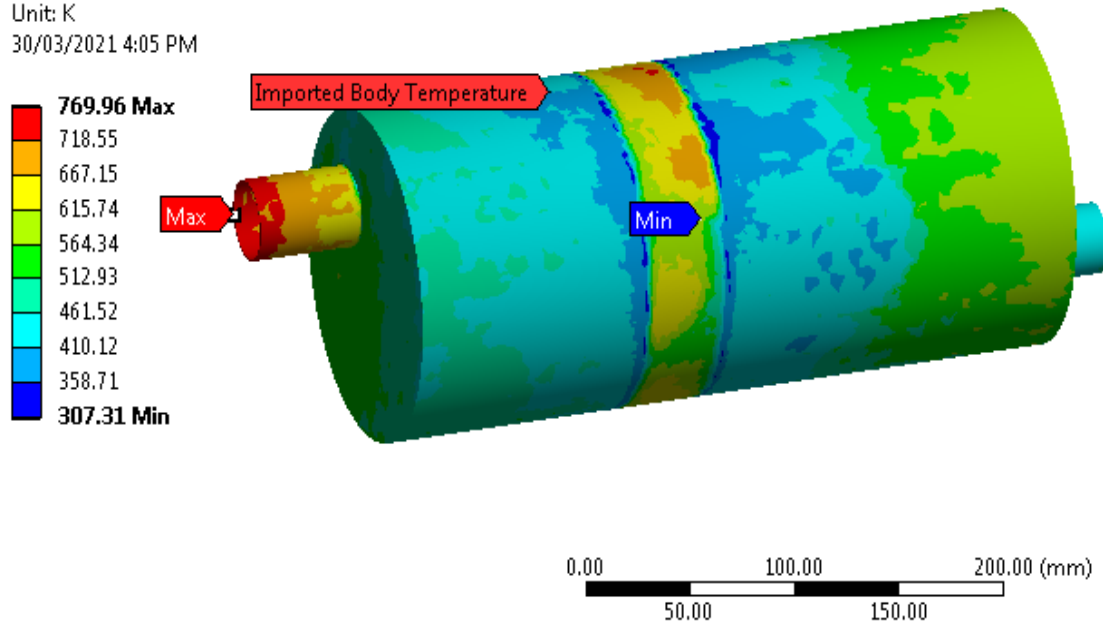
B: Static Structural

Imported Body Temperature

Time: 1. s

Unit: K

30/03/2021 4:05 PM



The above figure shows the thermal load which is imported from the CFD analysis. This load acts as the input load in thermo-structural analysis through which we could able to find thermal stress and thermal expansion.

5.5.1.4 THERMAL DEFORMATION

The boundary conditions are given to the model. The fine meshed model undergoes Thermo-structural analysis for the given load for the selected material. The result obtaining is total deformation and Equivalent thermal stress.

The below figure (Fig 5.17 (A, B)) shows the thermal expansion of the muffler made with Stainless steel 304. Generally, we can see the thermal deformation occurs more in the center part i.e., between the muffler baffles. This is due to more accumulation of heat in the center part. The deformation gradually decreases when it comes to outlet pipe.

B: Static Structural

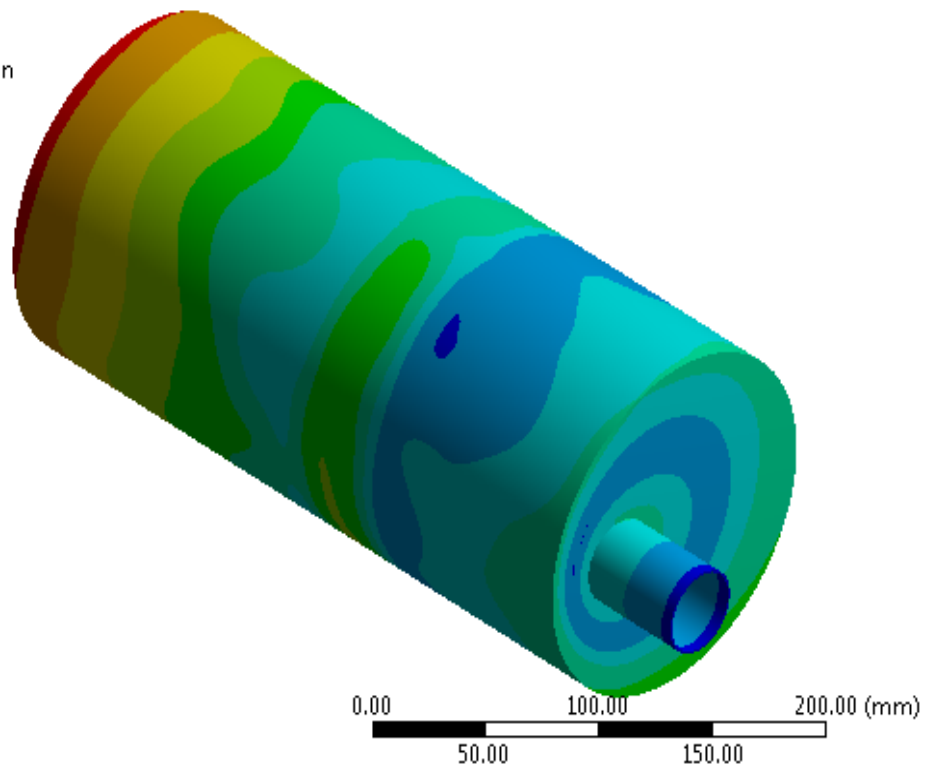
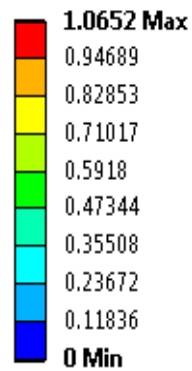
Total Deformation

Type: Total Deformation

Unit: mm

Time: 1

30/03/2021 4:02 PM



(A)

B: Static Structural

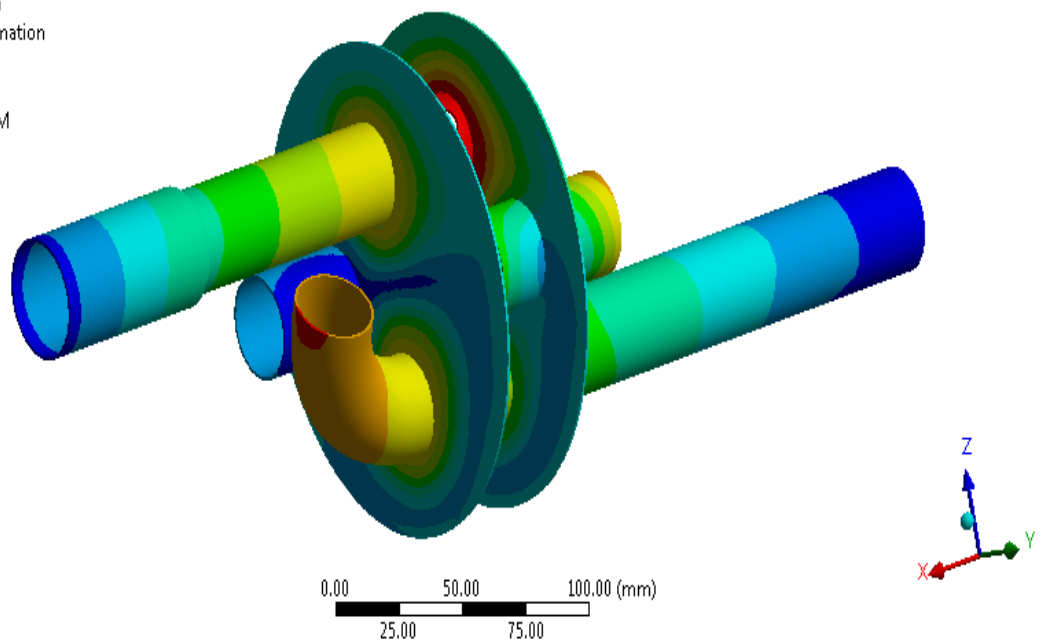
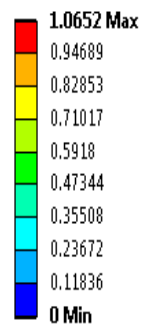
Total Deformation

Type: Total Deformation

Unit: mm

Time: 1

30/03/2021 4:04 PM



(B)

Fig 5.17 (A, B) THERMAL DEFORMATION FOR SS 304

5.5.1.5 THERMAL STRESS DUE TO CHANGE IN TEMP ON ENTIRE BODY

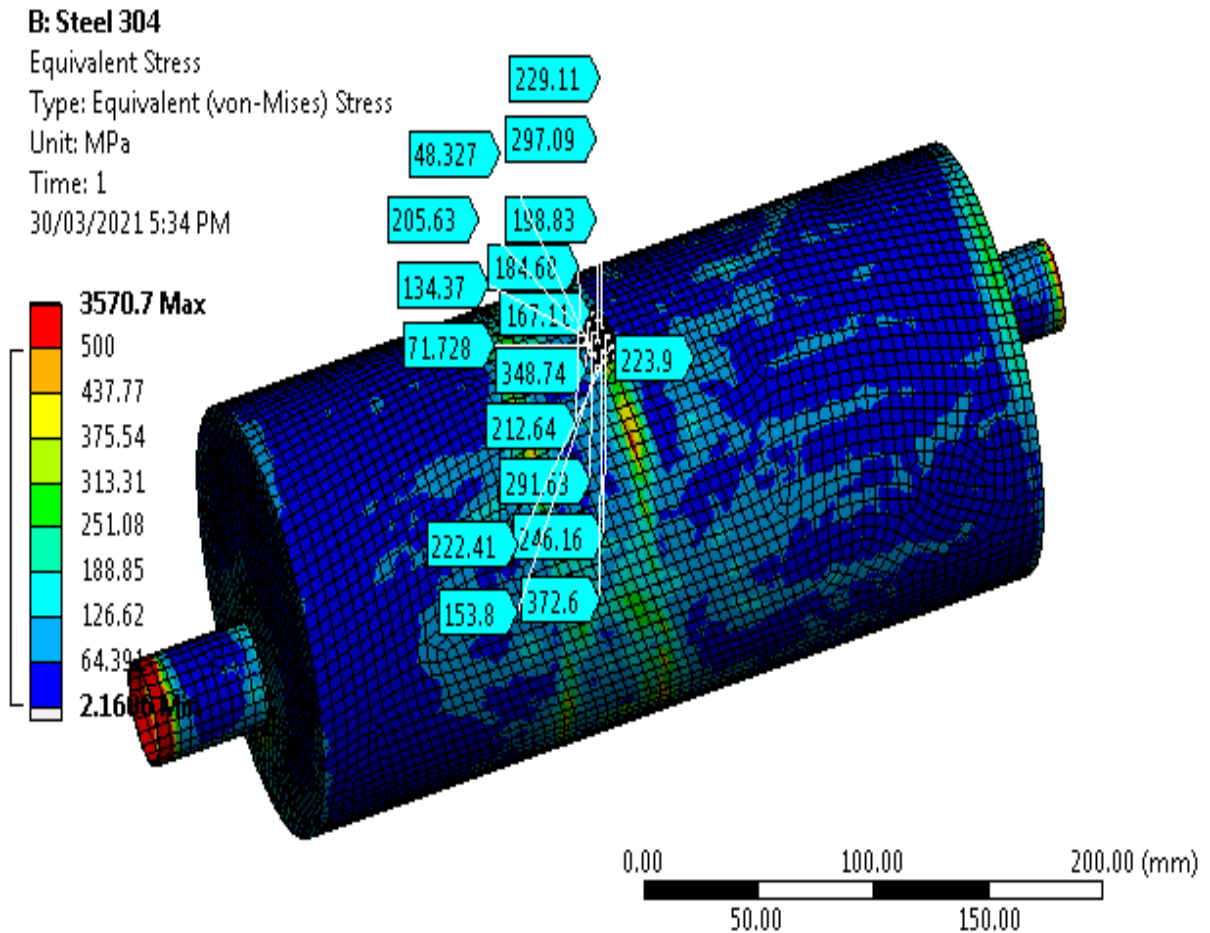


Fig 5.18 THERMAL STRESS (SS 304)

Max average thermal stress on the muffler surface is 189
Mpa

The above figure shows (Fig 5.18) the thermal stresses induced on the muffler made with Stainless steel 304 due to the change in temperature. We can find that the stress induced at the centre of the muffler are higher and it gradually reduces as it reaches its end. The average thermal stress is taken from the centre to find the stress induced in the muffler.

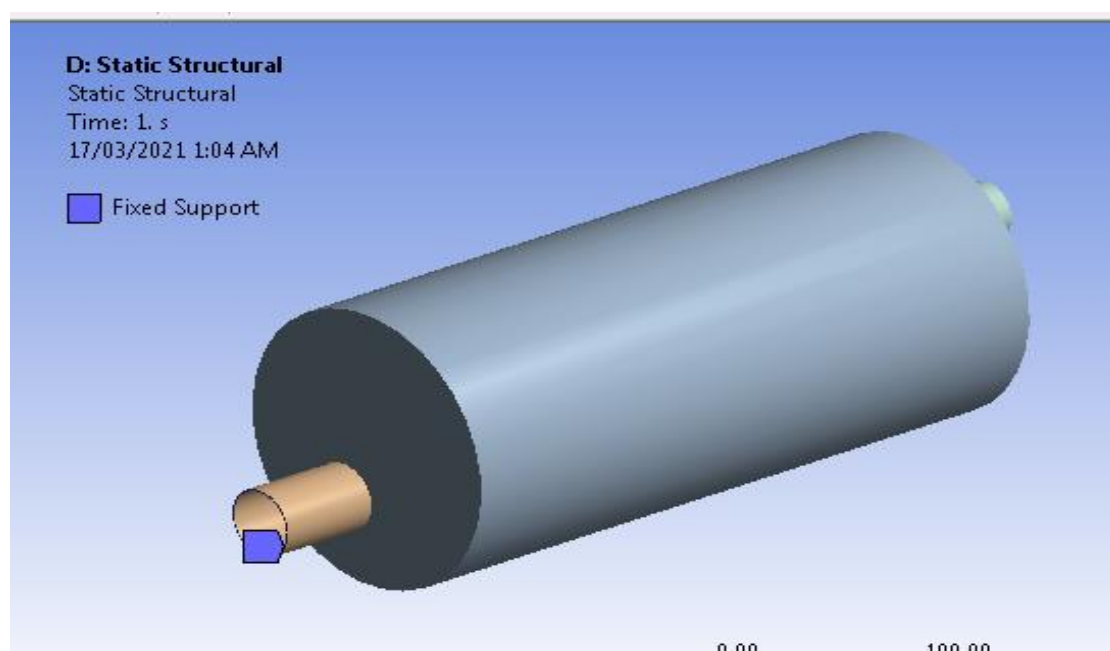
5.5.2 STAINLESS STEEL 309

5.5.2.1 PROPERTIES

Table 5.3 PROPERTIES – SS 309

2	Material				
3	Stainless Steel 309			General	
Properties of Outline Row 3: Stainless Steel 309					
	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	8	g cm ⁻³		
4	Isotropic Secant Coefficient of Thermal Expansion				
5	Coefficient of Thermal Expansion	1.49E-05	C ⁻¹		
6	Isotropic Elasticity				
7	Derive from	Young's Modu...			
8	Young's Modulus	2E+11	Pa		
9	Poisson's Ratio	0.27			
10	Bulk Modulus	1.4493E+11	Pa		
11	Shear Modulus	7.874E+10	Pa		
12	Tensile Yield Strength	2.07E+08	Pa		
13	Compressive Yield Strength	2.07E+08	Pa		
14	Tensile Ultimate Strength	5.86E+08	Pa		
15	Compressive Ultimate Strength	0	Pa		

5.5.2.2 FIXED SUPPORT



5.5.2.3 IMPORTED THERMAL LOAD FROM CFD

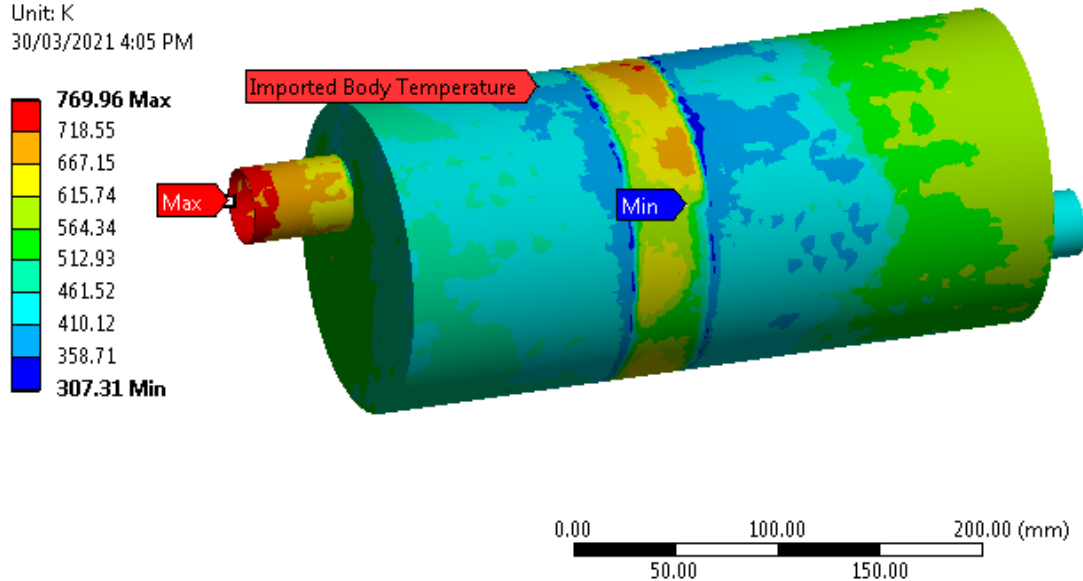
B: Static Structural

Imported Body Temperature

Time: 1. s

Unit: K

30/03/2021 4:05 PM



The above figure shows the thermal load which is imported from the CFD analysis. This load acts as the input load in thermo-structural analysis through which we could able to find thermal stress and thermal expansion.

5.5.2.4 THERMAL DEFORMATION

C: Steel 309

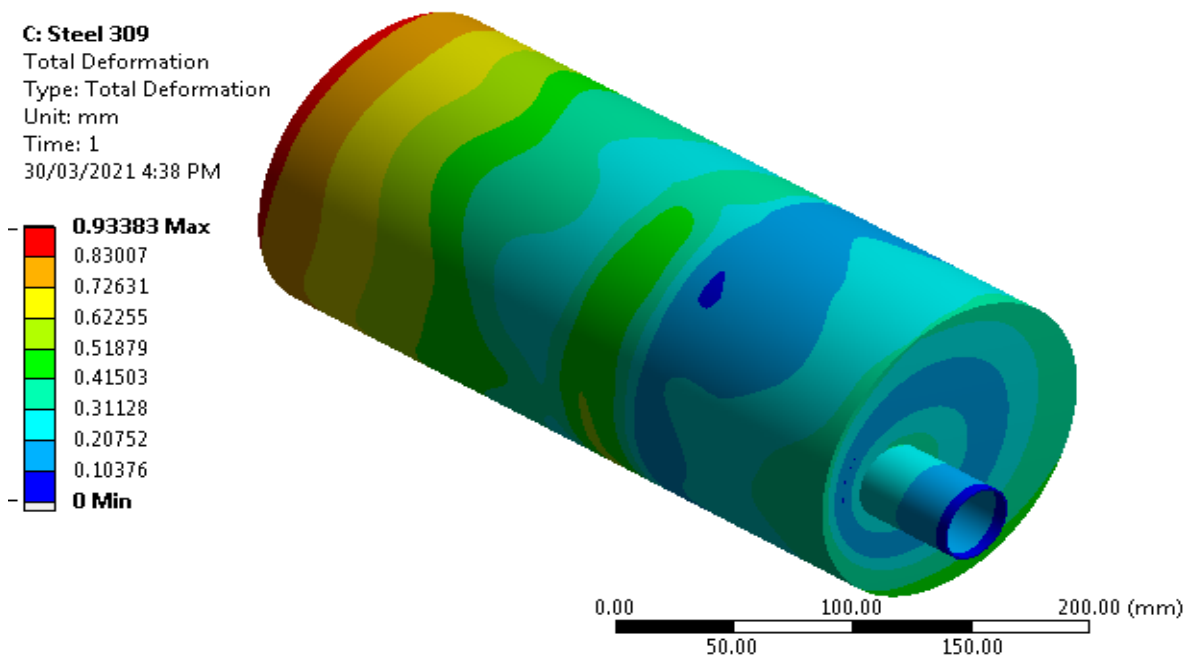
Total Deformation

Type: Total Deformation

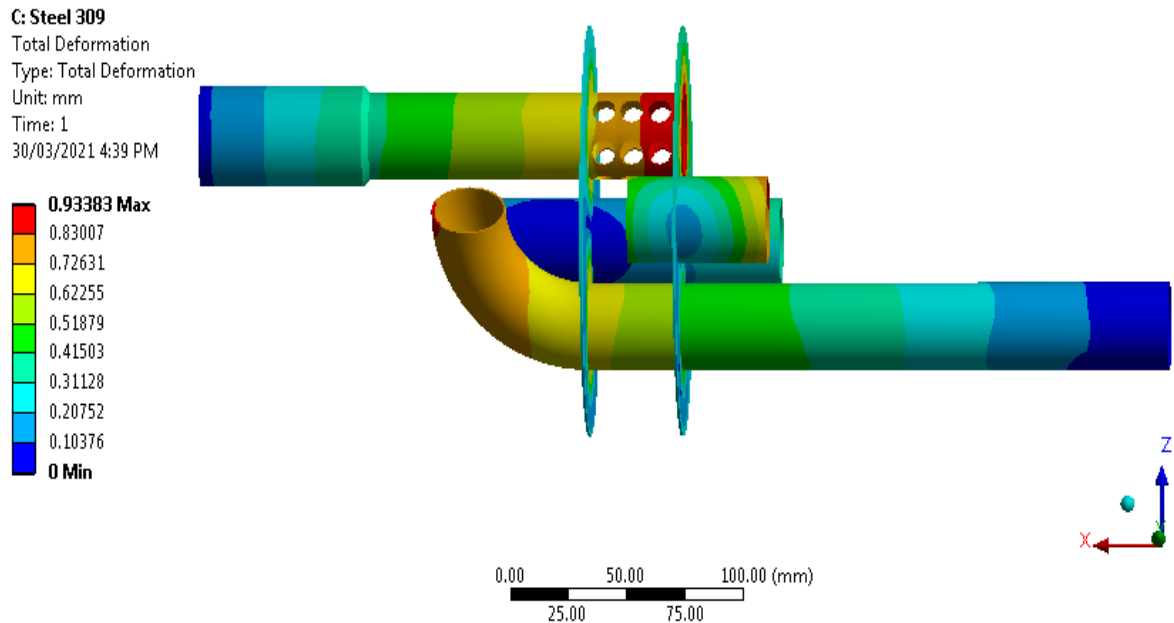
Unit: mm

Time: 1

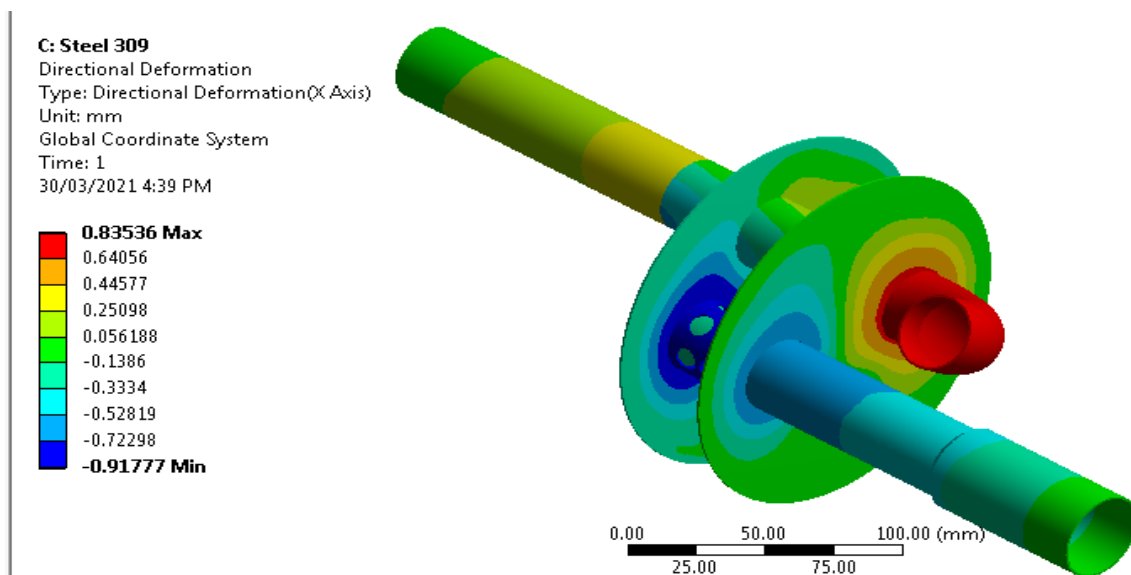
30/03/2021 4:38 PM



(A)



(B)



(C)

Fig 5.19 (A, B, C) THERMAL DEFORMATION FOR SS 309

The boundary conditions are given to the model. The fine meshed model undergoes Thermo-structural analysis for the given load for the selected material. The result obtaining is total deformation and Equivalent thermal stress.

The above figures (Fig 5.19 (A, B, C)) show the thermal expansion of the muffler made with Stainless steel 309. Generally, we can see the thermal deformation occurs more in the center part i.e., between the muffler baffles. This is due to more accumulation

of heat in the center part. The deformation gradually decreases when it comes to outlet pipe.

5.5.2.5 THERMAL STRESS DUE TO CHANGE IN TEMP ON ENTIRE BODY

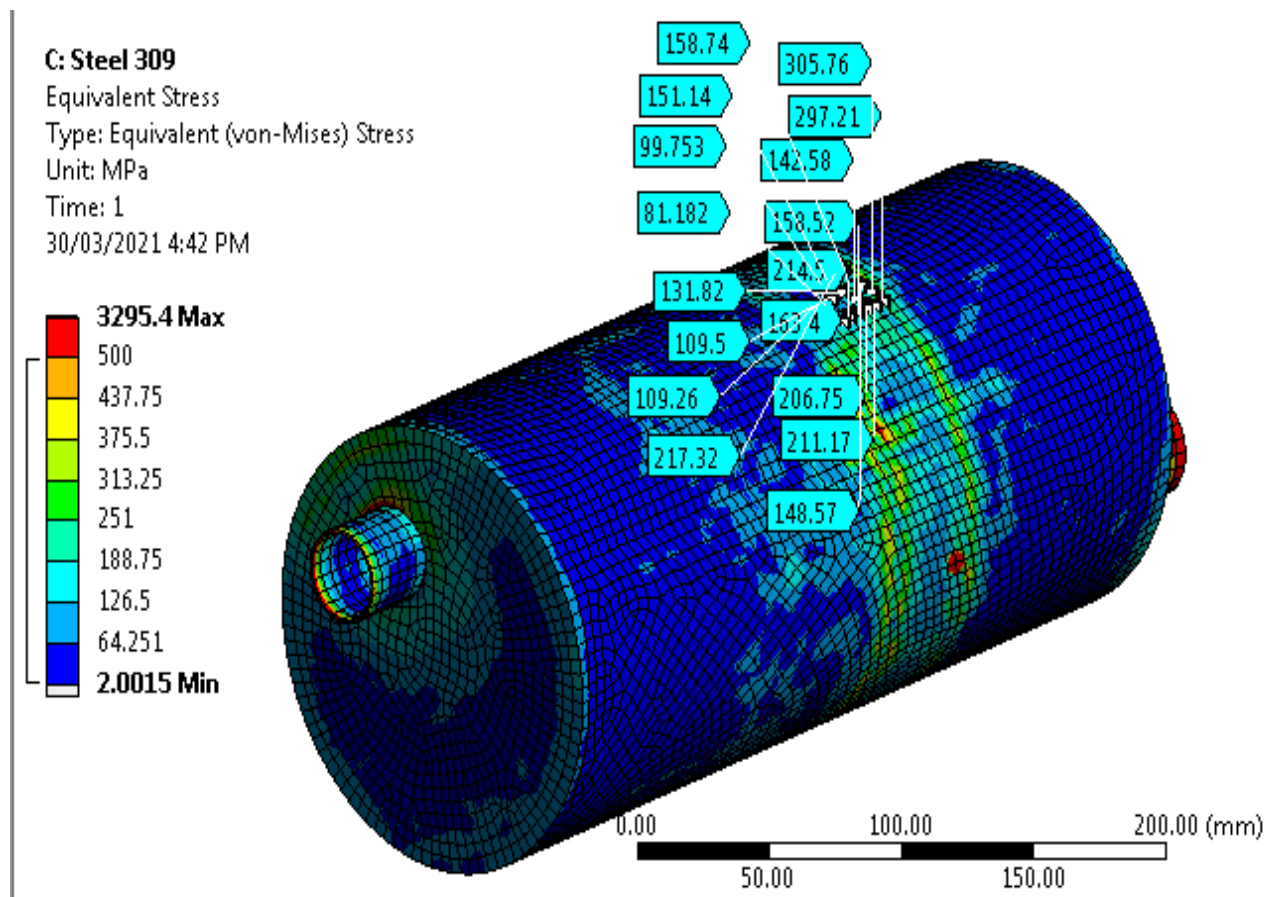


Fig 5.20 THERMAL STRESS (SS 309)

Max average thermal stress on the muffler surface is 164
Mpa

The above figure shows (Fig 5.20) the thermal stresses induced on the muffler made with Stainless steel 309 due to the change in temperature. We can find that the stress induced at the centre of the muffler are higher and it gradually reduces as it reaches its end. The average thermal stress is taken from the centre to find the stress induced in the muffler.

5.5.3 INCONEL 800

5.5.3.1 PROPERTIES

Table 5.4 PROPERTIES – INCONEL 800

Material

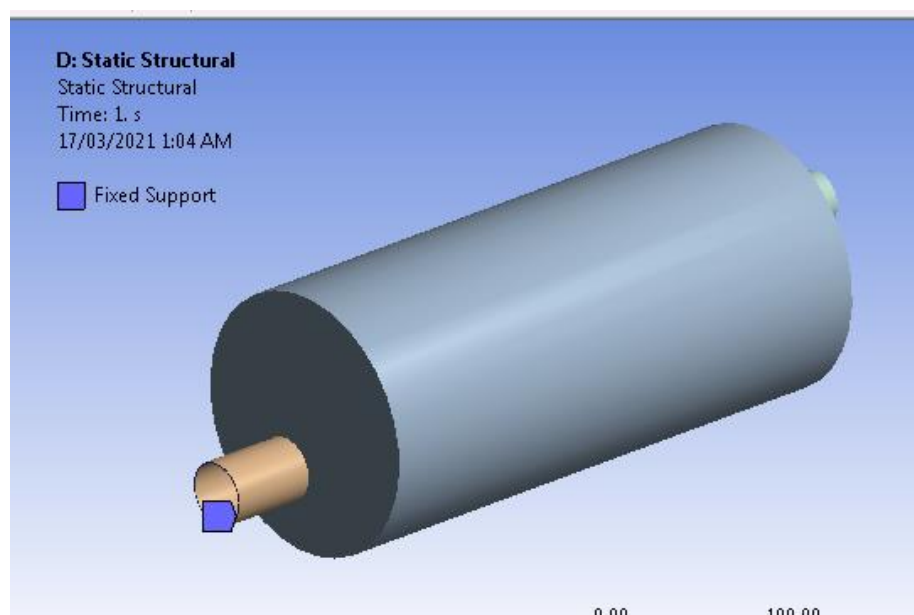
 INCONEL 800

 General

Properties of Outline Row 3: INCONEL 800

	A	B	C	D	E
1	Property	Value	Unit		
2	 Material Field Variables	 Table			
3	 Density	7.94	g cm ⁻³		
4	 Isotropic Secant Coefficient of Thermal Expansion				
5	 Coefficient of Thermal Expansion	1.42E-05	C ⁻¹		
6	 Isotropic Elasticity				
7	Derive from	Young's Modu... 			
8	Young's Modulus	1.96E+11	Pa		
9	Poisson's Ratio	0.33			
10	Bulk Modulus	1.9216E+11	Pa		
11	Shear Modulus	7.3684E+10	Pa		
12	 Tensile Yield Strength	2.07E+08	Pa		
13	 Compressive Yield Strength	2.07E+08	Pa		
14	 Tensile Ultimate Strength	5.86E+08	Pa		
15	 Compressive Ultimate Strength	0	Pa		

5.5.3.2 FIXED SUPPORT



5.5.3.3 IMPORTED THERMAL LOAD FROM CFD

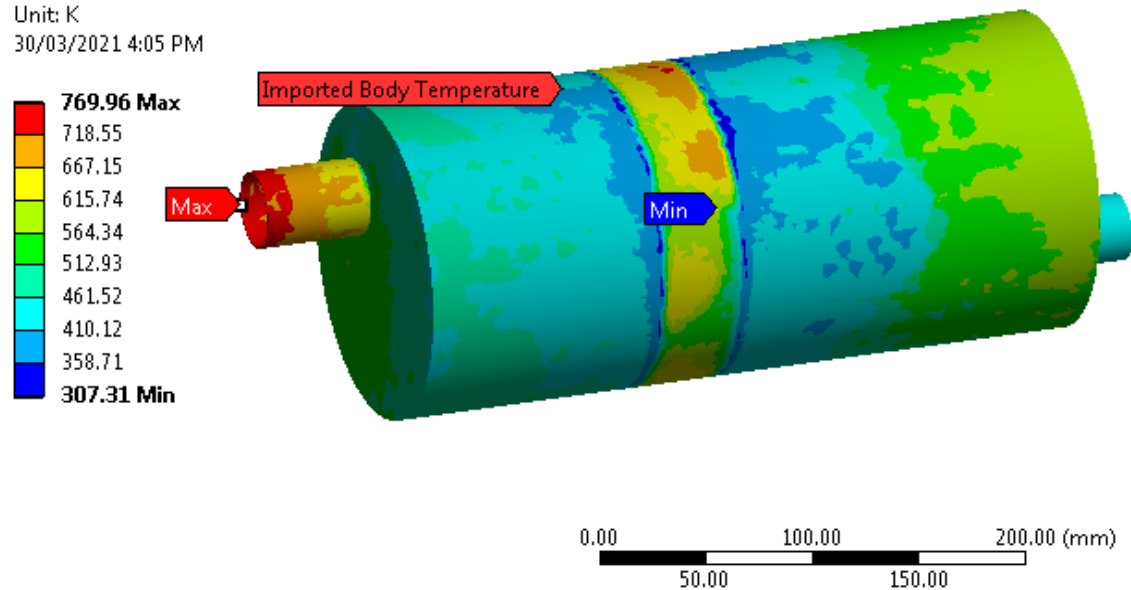
B: Static Structural

Imported Body Temperature

Time: 1. s

Unit: K

30/03/2021 4:05 PM



The above figure shows the thermal load which is imported from the CFD analysis. This load acts as the input load in thermo-structural analysis through which we could be able to find thermal stress and thermal expansion.

5.5.3.4 THERMAL DEFORMATION

D: INCONEL 800

Total Deformation

Type: Total Deformation

Unit: mm

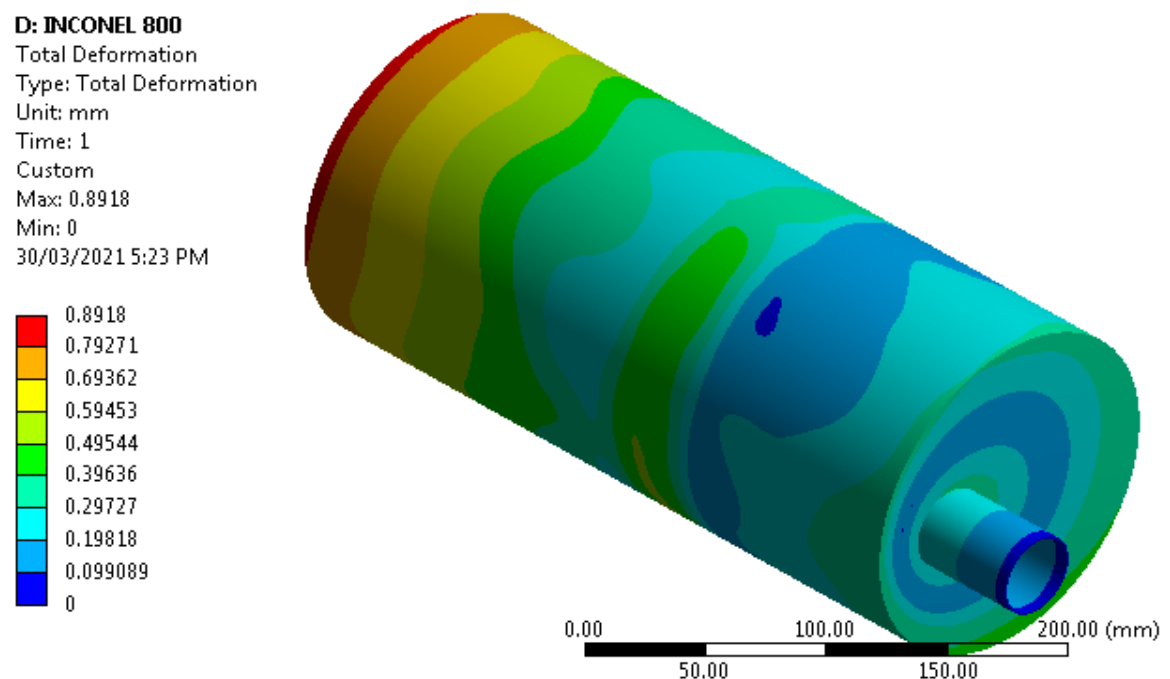
Time: 1

Custom

Max: 0.8918

Min: 0

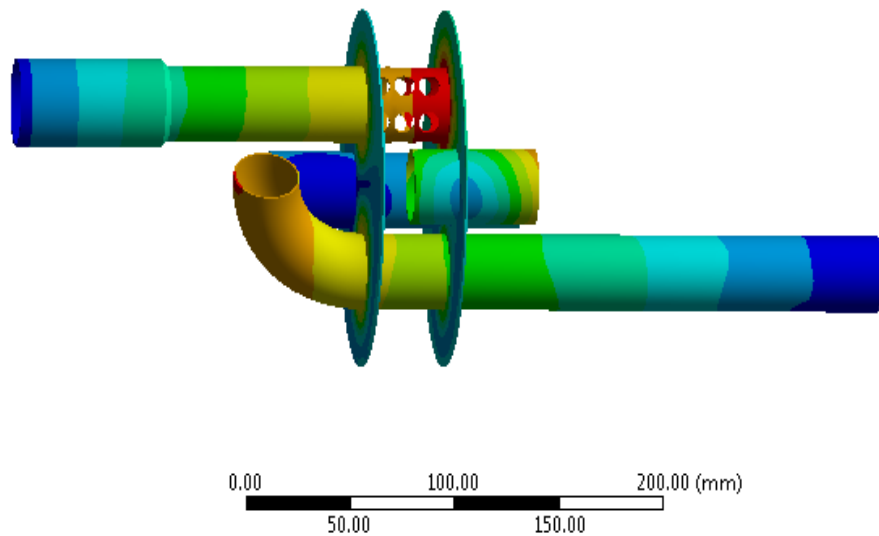
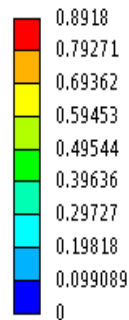
30/03/2021 5:23 PM



(A)

D: INCONEL 800

Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
Custom Obsolete
Max: 0.8918
Min: 0
30/03/2021 5:25 PM



(B)

D: INCONEL 800

Directional Deformation
Type: Directional Deformation(X Axis)
Unit: mm
Global Coordinate System
Time: 1
Max: 0.79398
Min: -0.87615
30/03/2021 5:26 PM

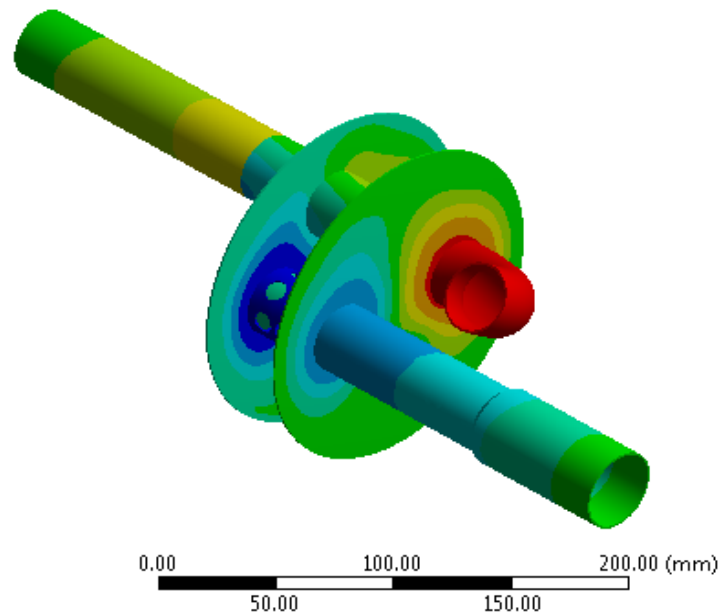
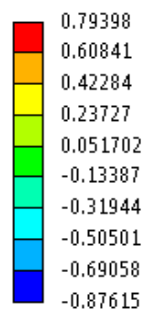


Fig 5.21 (A, B, C) THERMAL DEFORMATION FOR INCONEL 800

The boundary conditions are given to the model. The fine meshed model undergoes Thermo-structural analysis for the given load for the selected material. The result obtaining is total deformation and Equivalent thermal stress.

The above figures (Fig 5.21 (A, B, C)) show the thermal expansion of the muffler made with Inconel 800. Generally, we can see the thermal deformation occurs more in the

center part i.e., between the muffler baffles. This is due to more accumulation of heat in the center part. The deformation gradually decreases when it comes to outlet pipe.

5.5.3.5 THERMAL STRESS DUE TO CHANGE IN TEMP ON ENTIRE BODY

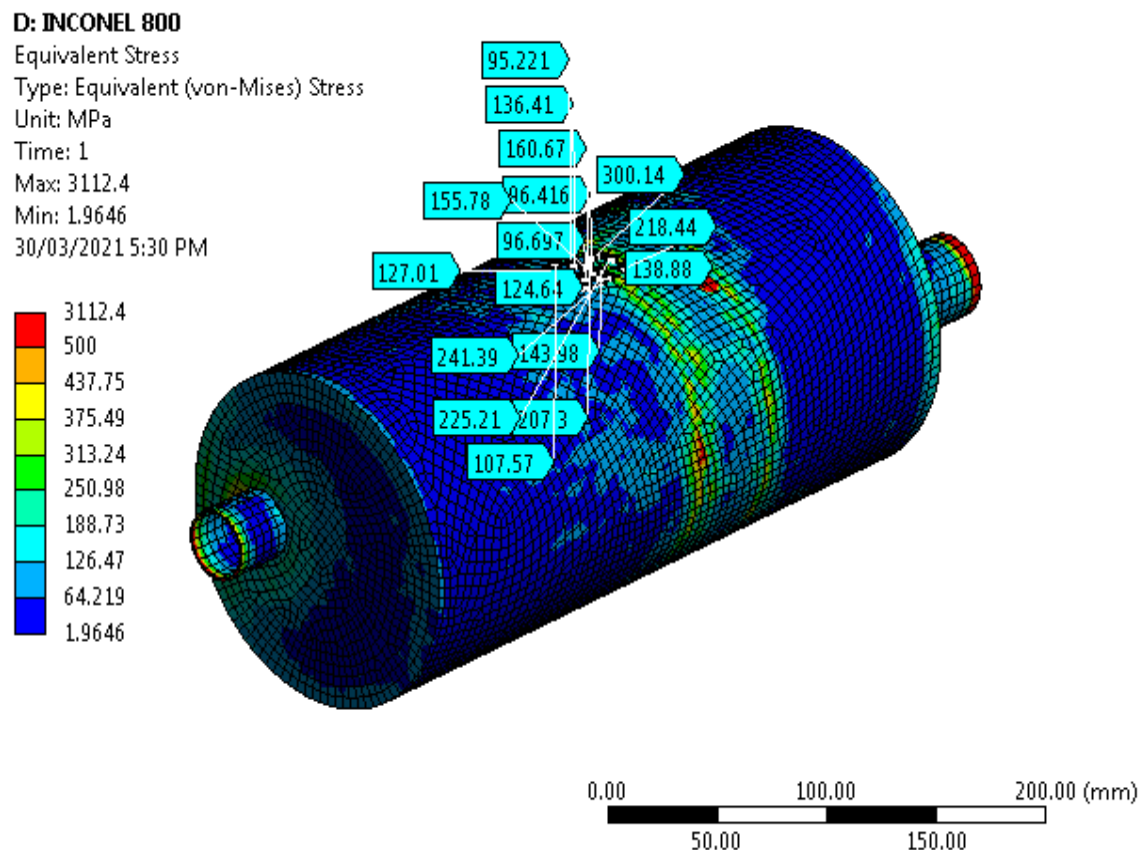


Fig 5.22 THERMAL STRESS (INCONEL 800)

Max average thermal stress on the muffler surface is 160
 Mpa

The above figure shows (Fig 5.20) the thermal stresses induced on the muffler made with Inconel 800 due to the change in temperature. We can find that the stress induced at the centre of the muffler are higher and it gradually reduces as it reaches its end. The average thermal stress is taken from the centre to find the stress induced in the muffler.

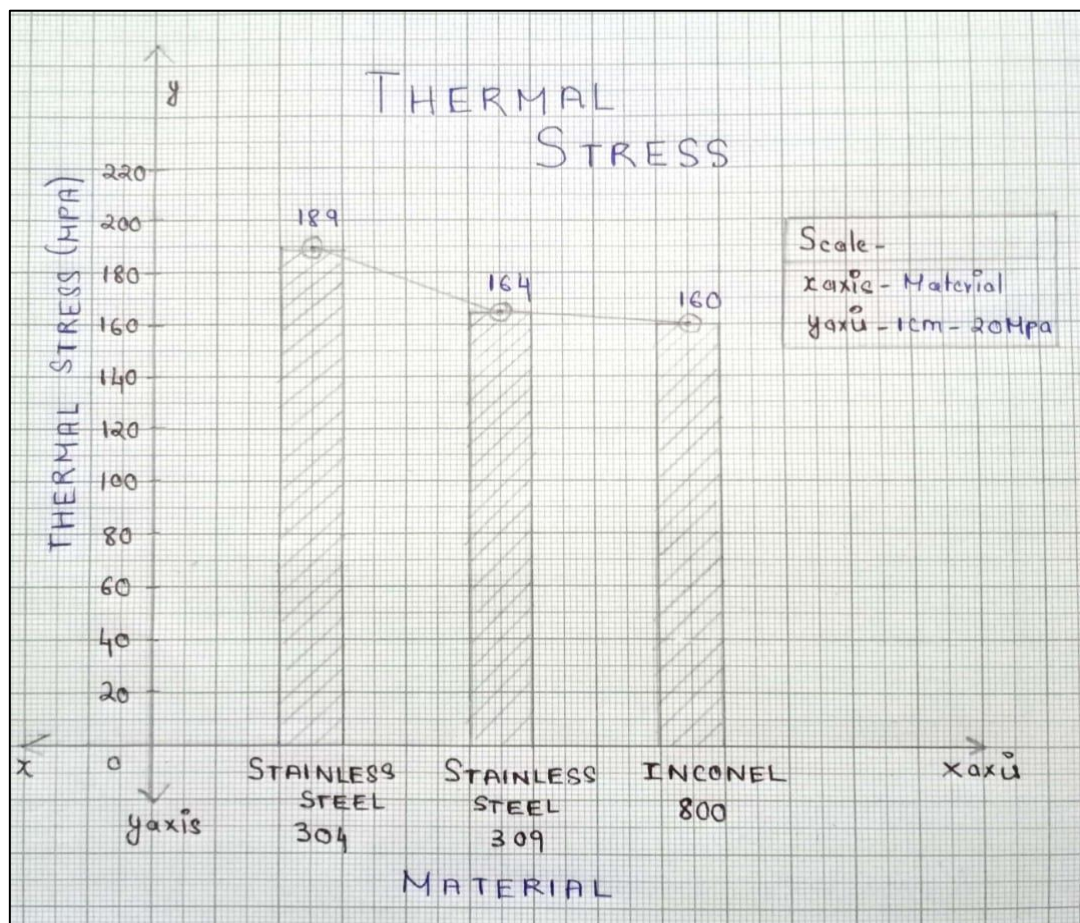
CHAPTER 6

RESULT AND CONCLUSION

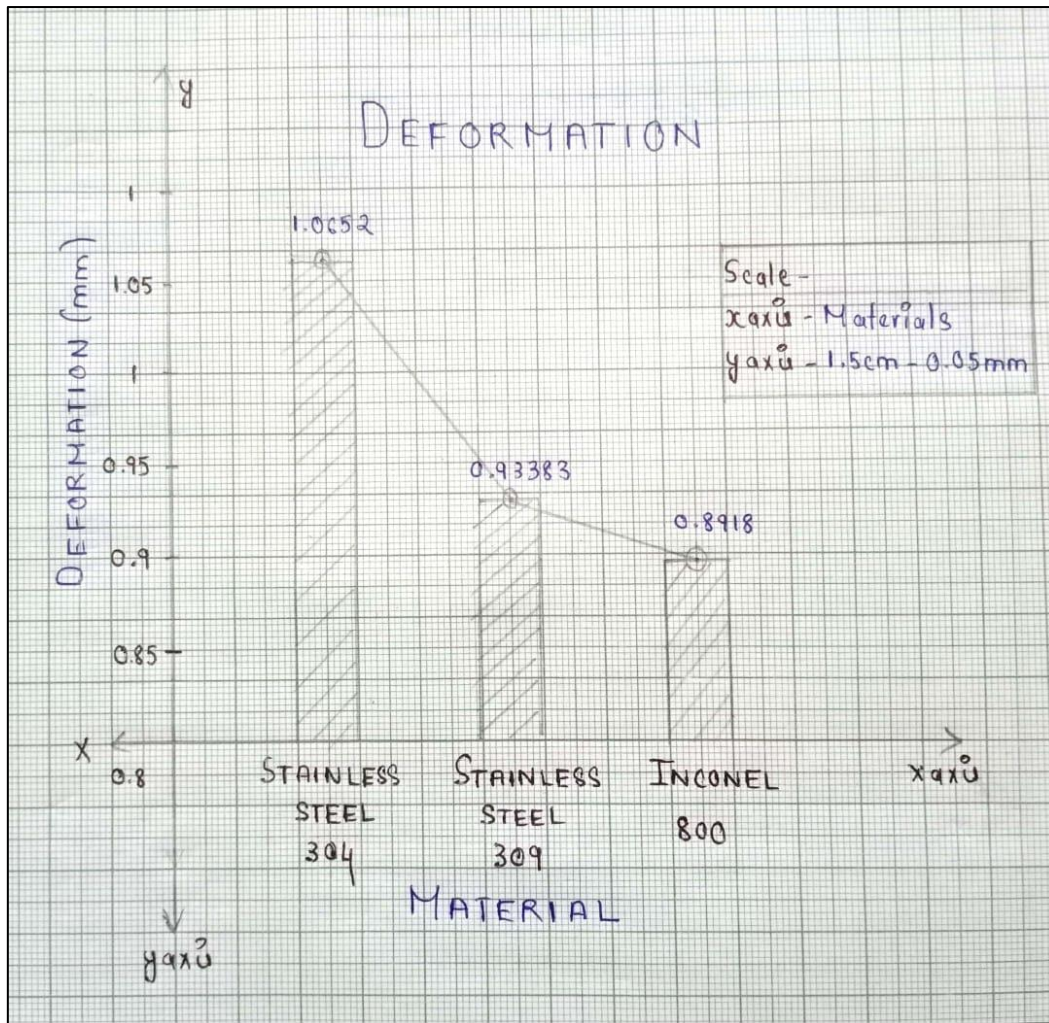
6.2 RESULT

Table 6.1 RESULT COMPARISON

MATERIAL	THERMAL STRESS (Mpa)	DEFORMATION (mm)	COST
STAINLESS STEEL 304	189	1.0652	185 / KG
STAINLESS STEEL 309	164	0.93383	195 / KG
INCONEL 800	160	0.8918	500 / KG



Graph 6.1 THERMAL STRESS



Graph 6.2 DEFORMATION

In this project, we have designed an existing muffler (ALTO's muffler) using modelling software- CATIA and have analysed with the ANSYS WORKBENCH. Through ANSYS, firstly we found the flow of muffler through CFD flow analysis by importing hot gases inside the muffler. Then we found the temperature distribution of the muffler caused due to the hot gas flowing inside the muffler. After that we are importing the thermal load got from the CFD analysis to the structural analysis, through that we have found the thermal stress and thermal expansion (deformation). Similarly, we have found the thermal stress and thermal expansion for the alternate material (SS 309, Inconel 800) we have chosen and compared the result with the existing material. The above graph (Graph 6.1 and Graph 6.2) tells us the variation of thermal stress and deformation shown by the three materials.

6.2 CONCLUSION

Through CFD and thermo-structural analysis we have found the thermal stress and expansion of the muffler made with three materials (SS 304, SS 309, INCONEL 800). From the above table and analysis result, we can conclude that the material which possess less deformation and the material which induces less thermal stress on it can be considered as the efficient material for making a muffler. In our project, both the material that we have chosen possess less deformation and less thermal stress compared to the muffler made in existing material (SS 304). If we look the above table Inconel 800 has very good results when compared to SS 309. But the cost of Inconel 800 is higher than SS 309 (approx..250% higher). Even though, Inconel 800 has high corrosive resistance and withstand at higher temperature, SS 309 is showing similar results at a very cheaper cost. Thus SS 309 is cost efficient and is just Rs.10 ($\text{Rs } 195 - \text{Rs. } 185 = \text{Rs.}10$) higher than SS 304 and are showing a very good result with a considerable decrease in both thermal stress (thermal stress of SS 309 [189 Mpa] < SS 304 [164 Mpa]) and deformation (deformation of SS 309[1.0652 mm] < SS 304[0.9383 mm]). Therefore, we can conclude by saying that SS 309 is efficient than the other materials because of its cost efficiency and less thermal stress and thermal expansion.

CHAPTER 7

REFERENCES

7.1 REFERENCE

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- Vaibhav D. Prajapati, Ankit J. Desai "Design and Analysis of Automotive Muffler". International Journal of Engineering Research & Technology, vol. 5, issue 5, 2018.

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Report Title:	CHAP 1-4
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