Project report

on

DESIGN AND ANALYSIS OF I.C. ENGINE PISTON ON COMPOSITE MATERIAL USING CREO AND ANSYS SOFTWARE

Submitted in Partial Fulfillment of the Requirement for the Degree of
B.Sc. Physics

Submitted by
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School of Basic and Applied Science

CERTIFICATE

This is to Certify that Mr. **Shubham Yadav** has carried out his/her project work entitled " **DESIGN AND ANALYSIS OF I.C. ENGINE PISTON ON COMPOSITE MATERIAL USING CREO AND ANSYS SOFTWARE**" under my supervision. This work is fit for submission for the award of Bachelor's Degree in Physics.

(Signature)
(Dr. A.K. Jain)
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(Dr. Milan Singh)
Supervisor

DECLARATION

I hereby declare that the dissertation entitle**I.C. ENGINE PISTON AND PISTON-RING DESIGN OF TWO DIFFERENT MATERIAL AND ANALYSIS IT DATA USING CREO AND ANSYS SOFTWARE ON COMPOSITE MATERIAL**" submitted by me in partial fulfillment for the degree of M.Sc. in Physics to the Division of Physics, School of Basic and Applied Science, Galgotias University, Greater Noida, Uttar Pradesh, India is my original work. It has not been submitted in part or full to this University of any other Universities for the award of diploma or degree.

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Signature

Shubham yadav

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ABSTRACT

Piston is the Main component of the IC engine . If one single Piston fails then the whole working of the IC engine gets seized ,Piston is the critical part of the internal combustion engine . The main purpose of this project is to to understand, analyze and investigate the stress which is distributed in the piston. By "FEA " (finite element analysis) The stress distribution is measured on the four stroke engine piston . And some element analysis is done by using "FEA" software Couple field analysis is taken out to calculate stress and deflection due to gas pressure and thermal loads.We will use three different material for calculating stress.Then we will compare both 3 material and by this we will get best one in result outcome from this experiment.The three material which we will used are "Al" alloy, Cast Iron and SiC reinforced ZrB2 Composite material.The Vibration natural frequency Of the piston and ring where also obtained and characteristic of vibration are also analyzed.By the help of the software "Computer aided design" CAD and we will develop the structure model of piston.And by using "ANSYS" Software we will perform the finite element analysis.Silicon carbide reinforced zirconium Diboride is a CMC which is a "ceramic Matrix composite" and this material is also used,

KEYWORDS

- Ceramic Matrix composite CMC,
- Computer aided design CAD,
- Vibration mode Aluminum alloy,
- Cast Iron
- Natural frequency ,
- SIC,
- Four stroke engine piston
- Stress distribution ,
- Finite element analysis,
- ANSYS on Piston
- IC engine Piston
- "FEA" The finite element analysis
- Connecting rod or piston rod

CHAPTER-1

1. INTRODUCTION

As we see Large number urbanization is going on and people are adopting civilization thus our economy is growing .And by this per capita income of people also increasing gradually .By this there is a large demand of the automobile industry we can see around us. And if the automobile industry demand will increase the automobile component will also automatically be in great demand because increased demand and use of automobiles. Generally this demand is increasing gradually because Reduce cost of this component and improved performance of this of automobile industry component .The research and development team of many automobile companies and testing engineer develop this efficient component in short possible time to launch new product in lesser time .It is very necessary to know and understand the new technology and fast absorption in development of new product. This days there is development of IC engine with increase Power capacity.

The main aim of this paper to analyze three different piston made up of different material for creating advance piston of best possible material and by reducing body weight to reduce consumption of fuel and This improved engine design have been made possible .This paper describe the"FEA" technique to predict the higher stress and Critical region with using "CAD" software and the structural model of a piston will be made by using "ANSYS"

1.1 piston is the main component which is reciprocating of IC engine. Piston is a moving material or sliding particle. Which moves against fluid pressure which is fixed inside in the cylinder and the cylinder is made gas tight with piston ring .In Engine The main purpose of piston is to transfer force from the expanding gas contained by the cylinder to the crankshaft through a piston rod or connecting rod.

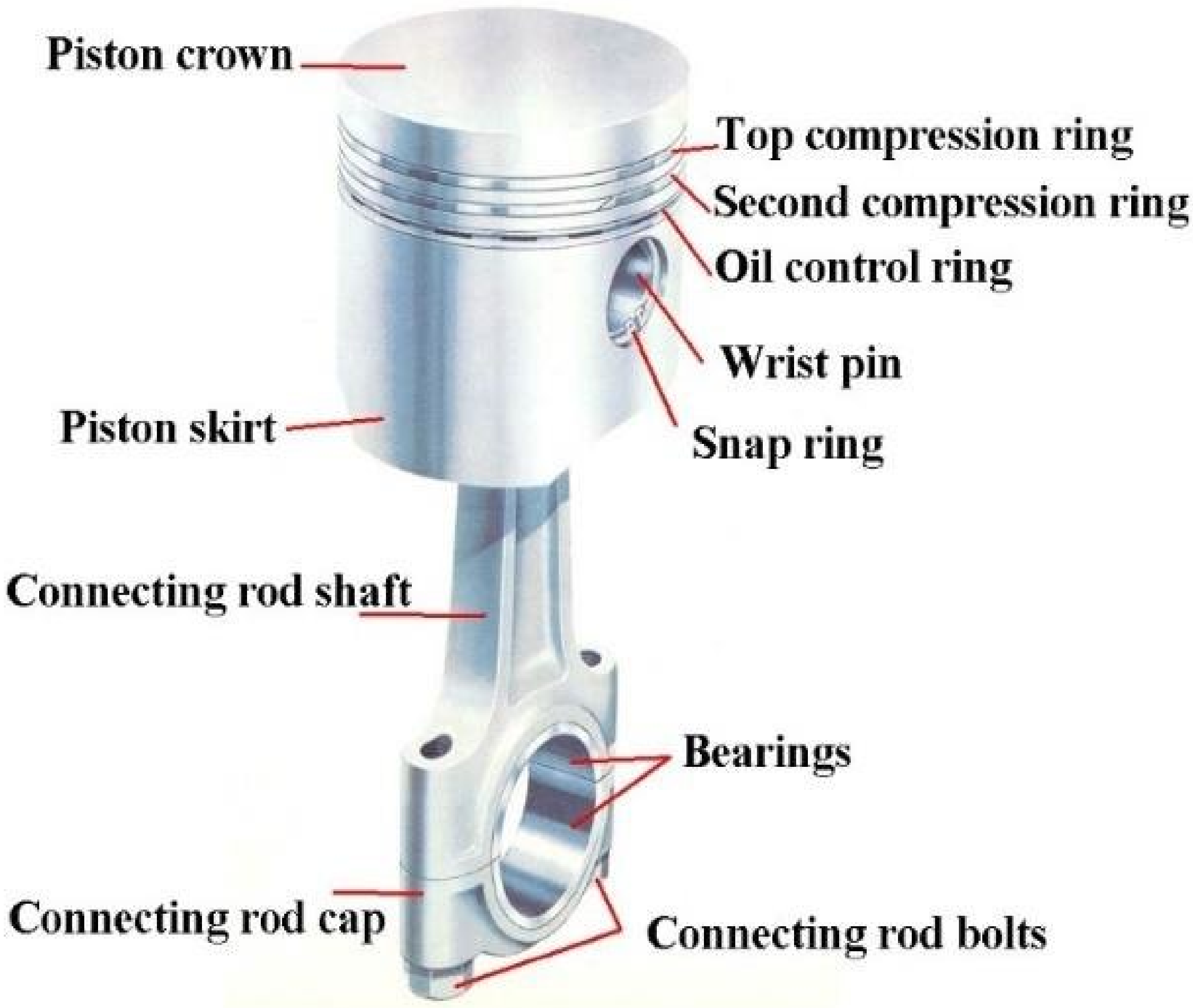

Figure no. 2.1 Piston

2. PARTS OF PISTON

2.1 **Piston ring** It is the most important component of an engine .It is used while combustion gas which is released in the time of engine combustion process. It protects from the gas should not bypass the piston.And it is also used to reduce friction between the piston and ring surrounded in the cylinder. Mainly the piston ring provide tight sealing between engine cylinder and piston .The piston ring is made up of cast iron and alloy cast iron.

Figure No. 2.2 Piston ring

2.2 **Connecting rod** It is mainly made up of Cast aluminum alloy this connecting rod is very important particle of engine .This Piston rod connect crankshaft to piston .Its main function is similar as liiver arm and transfer motion from the Piston to crankshaft

Figure No. 2.3 Connecting Rod

2.3 **Piston crown It** is the uppermost part of the Piston cylinder .It is most critical part of entire piston engine .Due to its location it experience very high pressure & Temperature

Figure No. 2.4 Piston crown

2.4 **Other main Component**

1. Piston Rings
2. Piston Head or Crown
3. Piston ring grooves
4. Piston skirt
5. Piston pin
6. Connecting rod
7. Bolt
8. Connecting rod bearing and
9. Cap

10. **2.5 Piston material**. Previously Piston were made up of cast iron. but now a days to increase efficiency companies are using lightweight material for piston to reduce the frictional vibration of engine and make it efficient .The major material use for making piston are

1. Cast iron
2. Cast aluminum
3. Forged aluminum
4. Cast steel
5. Forged steel

CHAPTER-2

3. PISTON MATERIALS AND MANUFACTURING PROCESS

material used for piston of IC engine Cast iron,cast aluminum cast steel and SiC reinforced ZrB2 .Due to less weight aluminum alloy is mainly use for piston manufacturing. Aluminum piston can be either cast or forged previously the cast iron was abundant use to make piston because it possesses excellent qualities of wearing.But to make engine more efficient it is necessary to reduce it wait does for reduction of weight the use of aluminum for piston was necessary but Simentensly it is necessary to obtain equal strength and greater thickness like cast iron was previously. There is less advantage of the light metal in comparison to cast iron. The strength in wearing qualities of aluminum is less coefficient of expansion necessity is greater clearance in the cylinder to avoid risk of seizure .In Compare of cast iron the aluminum heat conductivity is thrice thus there is need of greater thickness in aluminum alloy piston to run at much lower temperature than a cast iron. As a result carbonized oil doesn't form on the underside of the piston and the crank case therefore keeps cleaner. Generally piston made sometimes thicker then the necessary strength to avoid heat transfer and improve cooling.

4. WORKING PRINCIPLE OF PISTON

Piston is enclosed in the cylinder with gas tight by piston ring .When the fuel put inside the cylinder then it burn and convert into gas buy this heated gas inside the cylinder expend the volume in the cylinder and provide uplift of the Piston just after that the heated gas get cold and thus the pressure of the cylinder decrease and suddenly the piston move downward to its initial state and ready to perform the cycle once again.

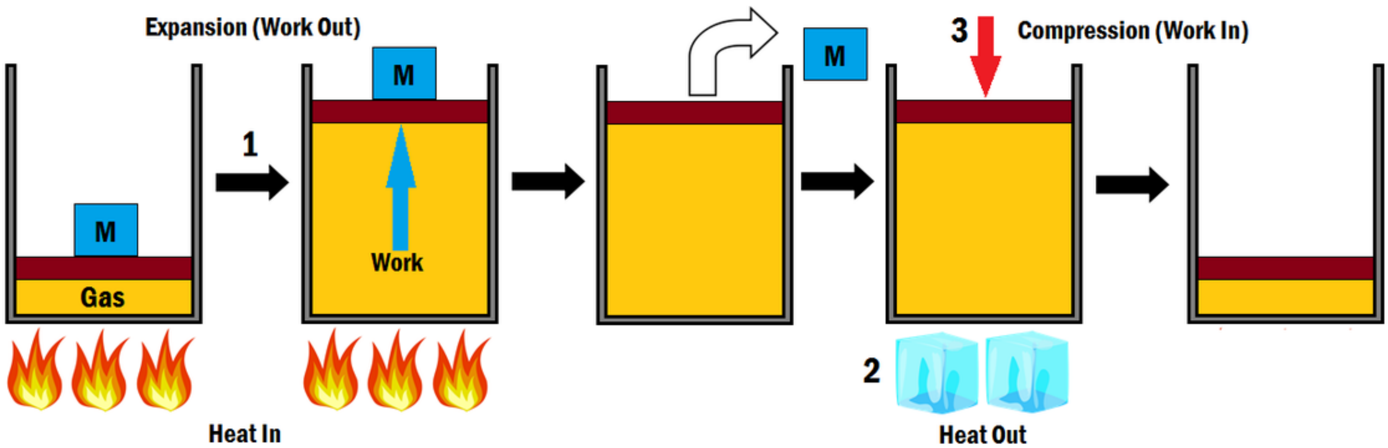

Figure No. 2.5 Working diagram of piston

CHAPTER-3

5. LITERATURE REVIEW

An optimized piston which is lighter and stronger is coated with zirconium for bio-fuel.

- **[1]** In this thesis by “ANSYS " the coated Piston undergoes Von mises test for Load applied on the top. In this paper various parts of the coated piston it’s stress distribution will be analyze for finding the stresses due to the thermal variation and gas pressure.Von Mises stress increased 16% and and after Optimisation deflection is also increased but in design consideration all the parameters are well.
- **[2]**The piston is stronger lighter with minimum cost and with less time.Since the engine performance is masurely affected by Pistons weight and design we analyze stress distribution in the various part of the Piston to know the stresses due to the gas pressure and thermal variation using with “ANASYS”
- **[3]**With the definite- element analysis software, a three- dimensional definite- element analysis has been carried out to the gasoline machine piston. Considering the thermal boundary condition, the stress and the distortion distribution conditions of the piston under the coupling effect of the thermal load and explosion pressure have been calculated, Result shows that main reason is temperature for the major causes of the Piston safety , great stress and Piston distortion . So it is necessary to decrease Piston temperature by optimizing Piston temperature.
- **[4]** This paper involve simulation of “KIRLOSKAR AV1" Piston to determine the temperature field, mechanical thermal and coupled thermal mechanical stress.The distribution and magnitude of the aforementioned strength parameter are useful in design, Optimisation and failure analysis of the the piston of particular engine. By “solid-works” the Piston model will develop and for processing, loading and post-processing it is imported into “ANSYS. Material model node was 10 node tetrahedral thermal solid 87. Piston material, combustion pressure , inertial effect in temperature are used as a parameter of simulation in this particular paper.By using" finite element method” (FEM)

- **[5]** this work describes the stress distribution of the piston by “computer-aided engineering” (CAE) . “This finite element method” (FEM) is performed
- **[6]** the main purpose of this thesis is to analyze and investigate the stress distribution of piston during the combustion process of the actual engine condition.By the fem technique this report describes the critical Optimisation to predict the critical region and higher stress on the different material piston, during the study the impact of Crown thickness, thickness of cylinder or barrel and Piston top land height on stress distribution and total deformation is monitored in the actual four stroke engine piston.For optimum geometry by using (ANSYS) the entire Optimisation is taken out based on “statistical analysis” and (FEA analysis).This thesis describe the stress distribution and thermal stress of three different Material of aluminum alloy piston by using (FEM) .The parameter taken for simulation are operating gas pressure ,Temperature in material properties of piston
- **[7]** In this project we will use 3 piston made up of different material and experiment done in(four strokes KIRLOSKAR AV1 piston engine)

5.1 Outcome of literature review -This paper presents an experimental study on the piston and its particle of diesel engine to test its effectiveness in relation to stress Distribution during combustion process in piston. First the experiment is done with the Piston made up of three different materials that are aluminum alloy, cast iron and SiC reinforced ZrB_2 .When this experiment is done virtually in different software. This shows different properties, efficiency and effectiveness of all this 3 Piston material of 4 stroke Kirloskar AV1 Piston engine.By this experiment it can be known that if you will decrease Piston weight it efficiency automatically increases. And by evaluating and analyzing the stress distribution around the Piston engine can give results to make Tough areas which are affected by the maximum stress to be modified. all this experiment are done in software like “CAD’ and “ANSYS” with the “This finite element method” (FEM) Technique

6. OBJECTIVE OF THIS PROJECT

- To Become familiar with the various performance parameters of IC engine piston .And by experiment trying to make the best Piston in different materials to increase the efficiency of the IC engines.
- By reducing weight of the piston with less weight material but strong enough to resist the collision between Piston and Piston cylinder. make more efficient engine for future development
- With finding stress distribution around the Piston cylinder it can calculate the most affected part of the Piston cylinder which may wear or crack early due to Strike of piston and friction between the Piston and Piston cylinder.This result to the engine seizure
- Breaking out 4 important parameter out of all the available parameter,i.e
  total deformation,Defamation y-axis, strain or stress, thermal analysis, heat flux

- By applying various combination using "CAD" and ANSYS simulation and comparison of those value with industry standard
- Construction of CAD of model geometry of a sample IC engine piston using solidworks
- With the Optimisation of performance parameter we ultimately aim to improve the performance characteristic of of IC engine piston to reduce fuel consumption ,vibration and to prevent from engine seizure and Increase the efficiency of entire engine

7. MOTIVATION

The motivation to do the project as with increase in globalization and fast moving economy the demand of engines are surging day by day due to which a lot of harmful gasses are being produced in the environment (i.e carbon mono-oxide , nitrogen oxide) which remains in the atmosphere for the longer period of time but these toxic particles are goes inside the body while inhaling causes the respiratory problems to human beings so due this people lost their prestigious lives. In order to work for the society we worked upon on optimizing the parameters in order to improve overall efficiency and reduced emissions in the environment

CHAPTER-4

8. METHODOLOGY

In this paper using ”FEA” the stress distribution is measured in the piston of a 4 stroke engine.

By using ”FEA” The finite element analysis is performed. The couple field analysis it's taken out how to calculate deflection and stress due to the gas pressure and thermal loads. The materials used to make the piston in this project are aluminum alloy,Cast iron and SiC reinforced ZrB2.

The natural frequency and vibration of the piston both natural frequency are obtained and its characterization of vibration are also analyzed.The structure and model of this piston of different material is designed in "computer aided design”(CAD.)And in the last the finite element analysis is performed with “ANSYS”

The methodology of analysis is as follow:

- 2D drawing of piston made like 3D model
- Using CREO 2.O the 3D model is created
- In Piston model of aluminum alloy material thermal analysis is performed with temperature of 180 degree celcius
- From the thermal analysis for or all the three aluminum alloy, cast iron and SiC reinforced ZrB2 Temperature distribution is plotted
- Structural analysis is performed by applying temperature distribution from the thermal analysis as body loads and working pressure of 3.3 Mpa to find the stress distribution due to the thermal and structural load for aluminum alloy material
- For the above analysis plot stress and deflection for the piston
- And all this above experiment procedure repeated for cast iron and SiC reinforced ZrB2
- Perform model analysis for all the three material
- And in last stage Compare the all three material of piston for the result it off making most efficient piston

9. DESIGN DESCRIPTION OF PISTON

The design considerations of piston as follows:

• It should be extremely strong in order to endure pressure.

• It should be light enough to withstand inertia forces.

• It should establish an effective oil seal in the cylinder and offer enough bearing area to avoid wear and tear.

• It should be able to reciprocate at a fast pace without making any noise.

• It must be sufficiently robust to endure temperature and mechanical distortions, as well as provide adequate support for piston pins.

10. SOLID MODEL OF SOLID WORK:

Figure No .2.6 Components of Engine

11.DESIGN CONSTRAINTS ADDRESSED

Modeling the piston is difficult, but due to the piston's thermos-elastic behavior throughout the combustion process, various assumptions are made based on the features and precision required in modeling.

- The material for the piston should be homogeneous and isotropic.
- Before any analysis, the piston should have been free of stress.
- The heat conductivity of the material utilized in the analysis is consistent across the board.
- The material's specific heat remains constant regardless of temperature.

CHAPTER-5

12. RESULT AND DISCUSSION

We are using ansys after making the cad model to perform the analysis on 3 materials…… and their specifications and boundaries condition applied according to research paper

S.No	Name of the property	Aluminium Alloy	SiC reinforced ZrB2
1	Density	2770 kg/m3	2060 kg/m3
2	Coefficient of Thermal Expansion	1 e -06 K-1	5.9 e-06 K-1
3	Youngs Modulus	71e3 mpa	4.86e5 mpa
4	Poissons Ratio	0.33	0.11
5	Ultimate Strength	310 mpa	1070 mpa
6	Specfic Heat	0.13 J/Kgk	500 J/kgk
7	Thermal Conductivity	174 W/mk	93.7 W/mk
8	Yield Strength	280 mpa	930 mpa

Figure No .2.7 Data chart of material

• Boundary Conditions for Piston Head –

Pressure Applied = 3.3 KPa and Fixed support is given

ANSYS Simulations -

PISTON

12.1 SiC reinforced ZrB2: TOTAL DEFORMATION:

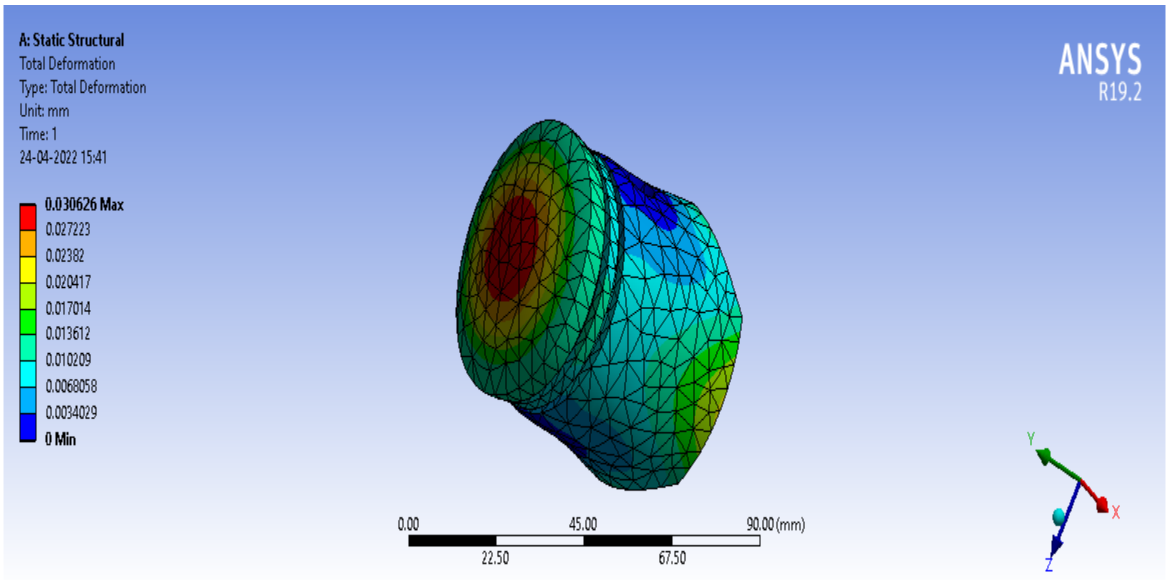

Figure No. 2.8 Total Deformation of SiC reinforced ZrB2

Cast iron:

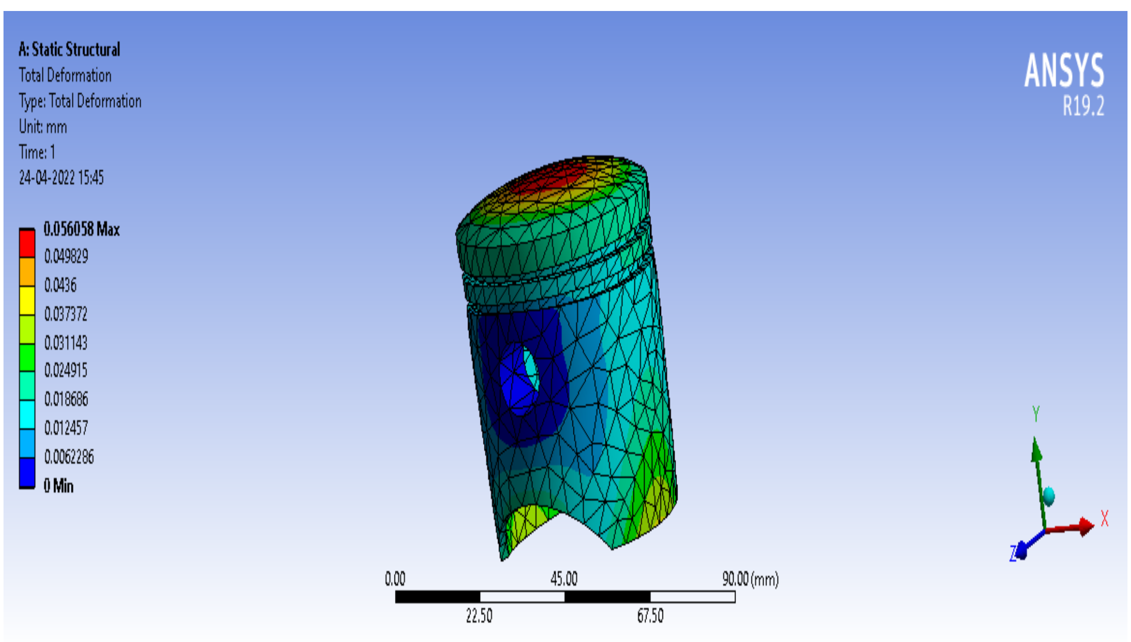

Figure No. 2.9 Total Deformation of Cast Iron

Aluminum

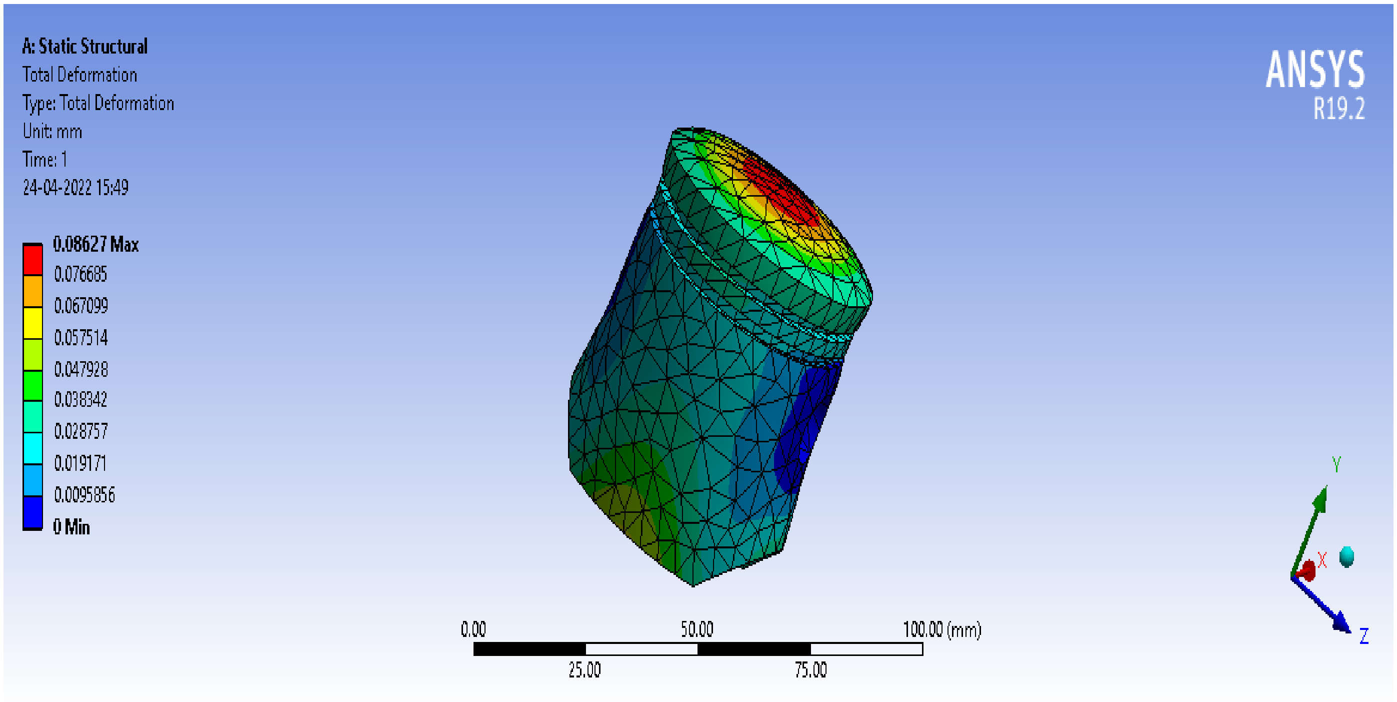

Figure No. 3.0 Total Deformation of Aluminium

12.2 SiC reinforced ZrB2: deformation y-axis

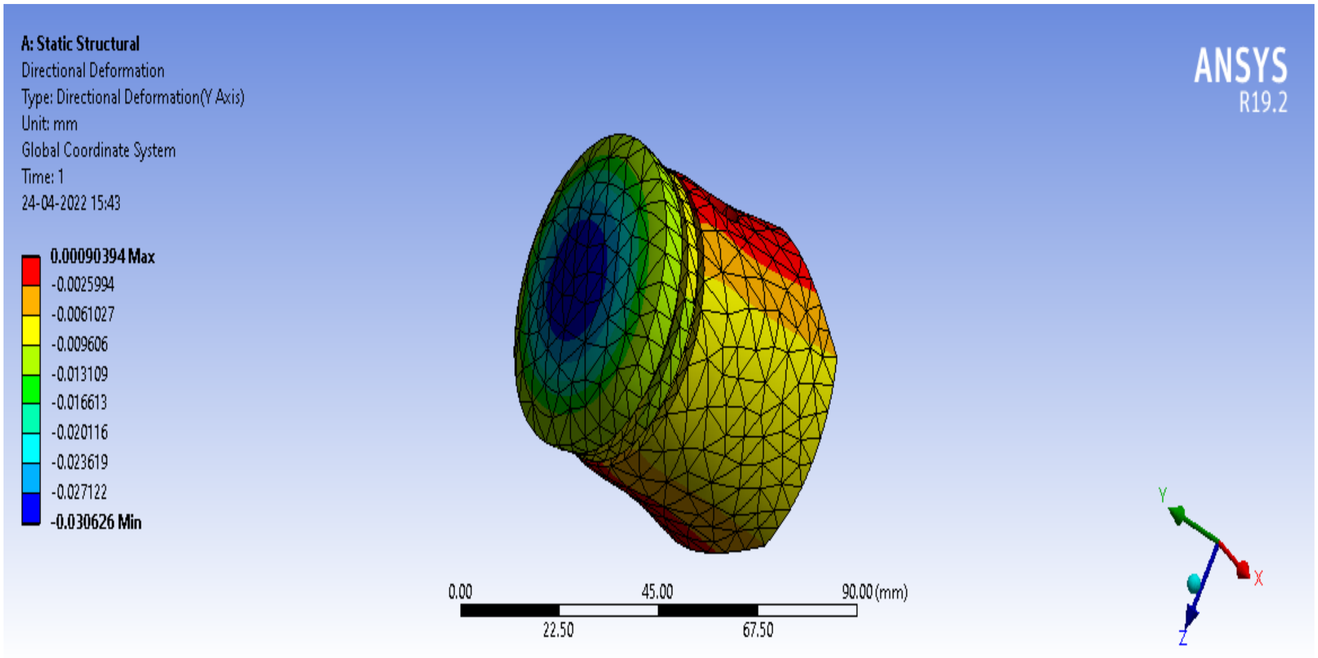

Figure No.3.1 SiC reinforced ZrB2: deformation y-axis

Cast iron:

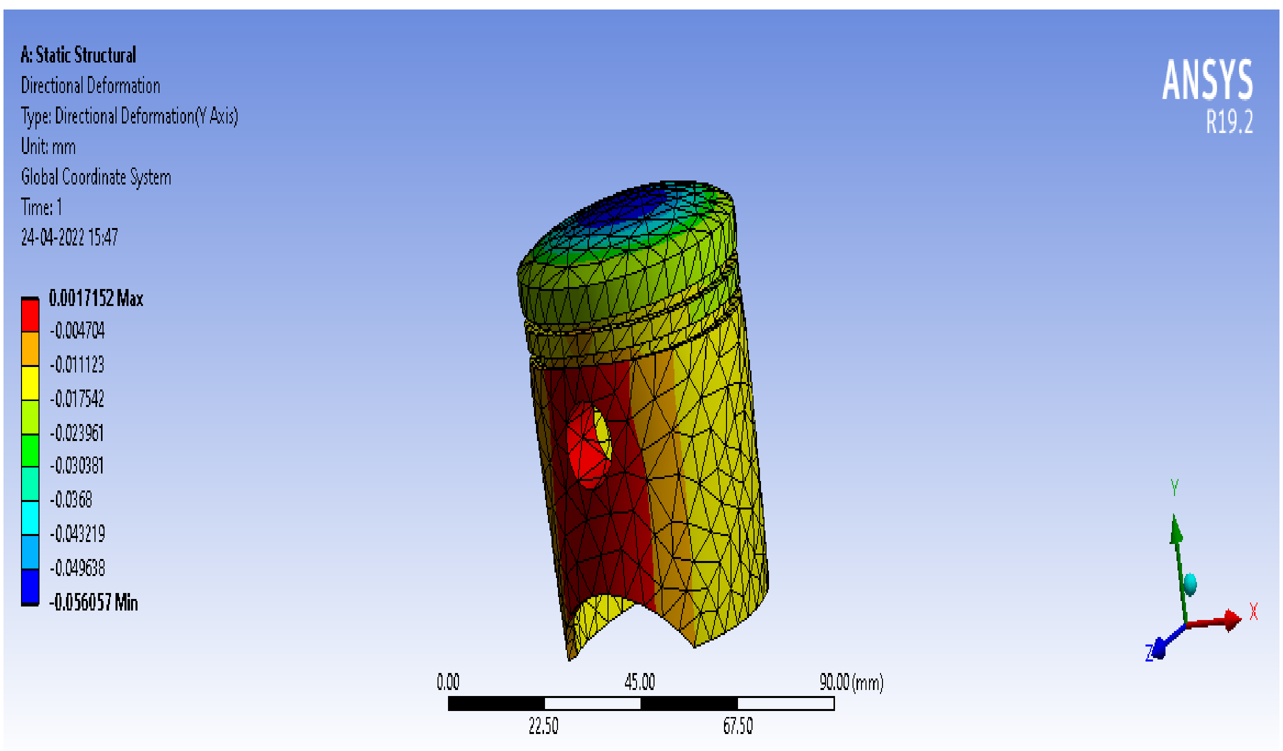

Figure No. 3.2 Cast iron: deformation y-axis

Aluminium

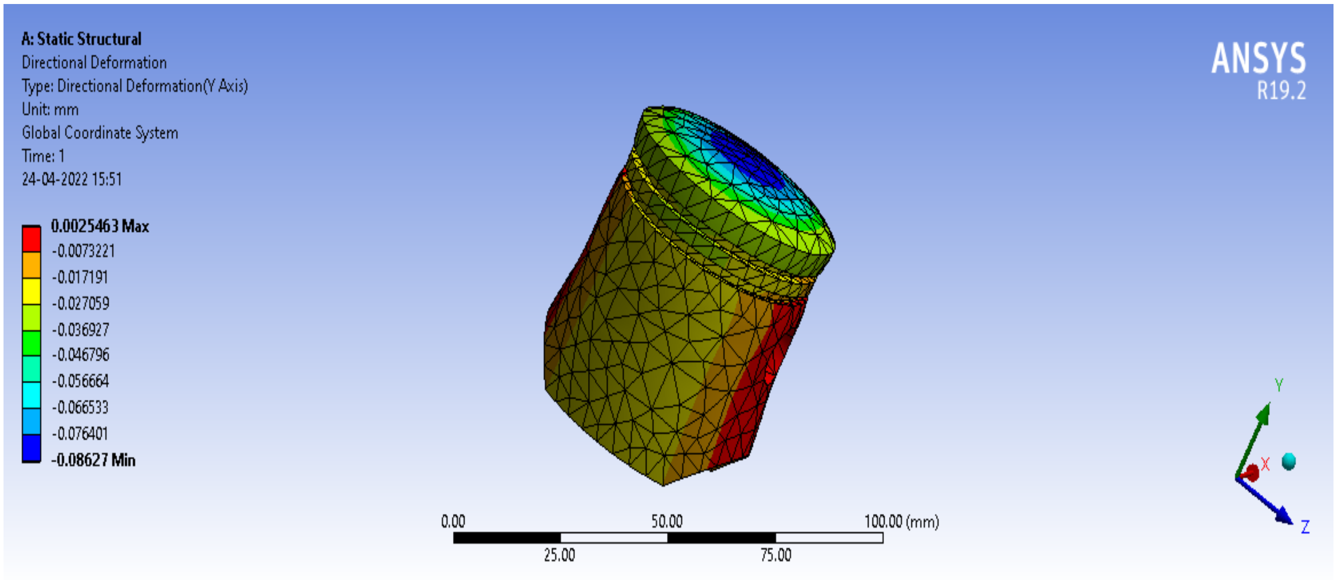

Figure No. 3.3: Aluminum deformation y-axis

12.3 SiC reinforced ZrB2: strain

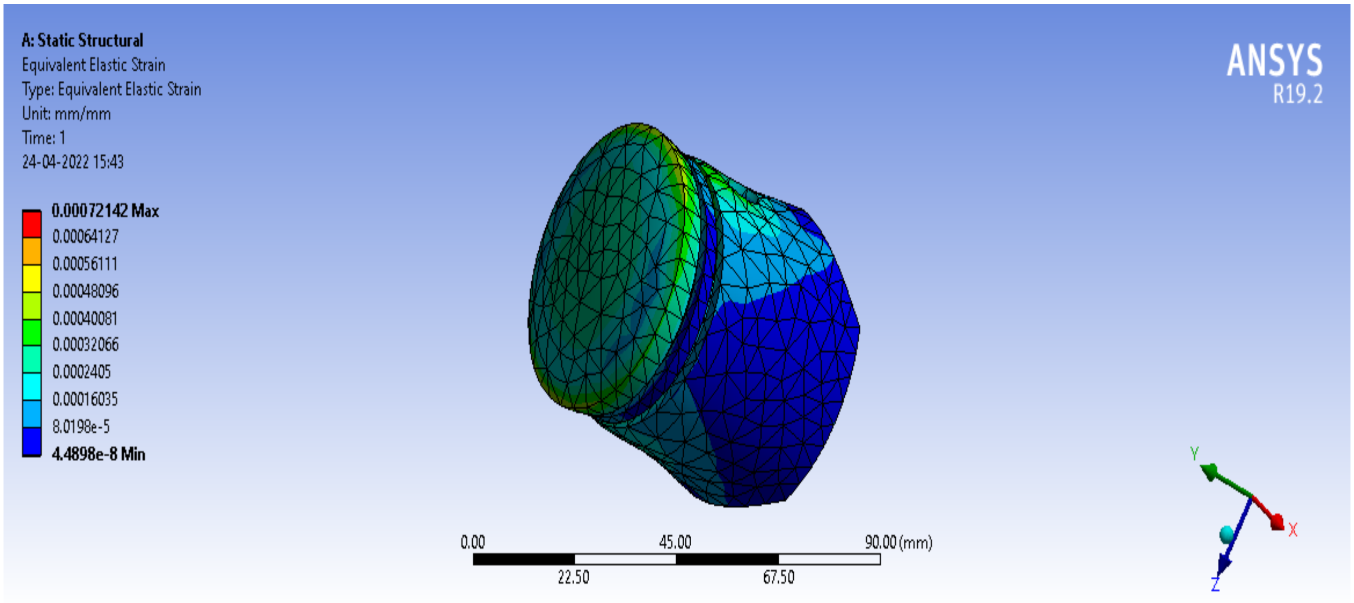

figure number 3.4 SiC reinforced ZrB2 strain

Cast iron:

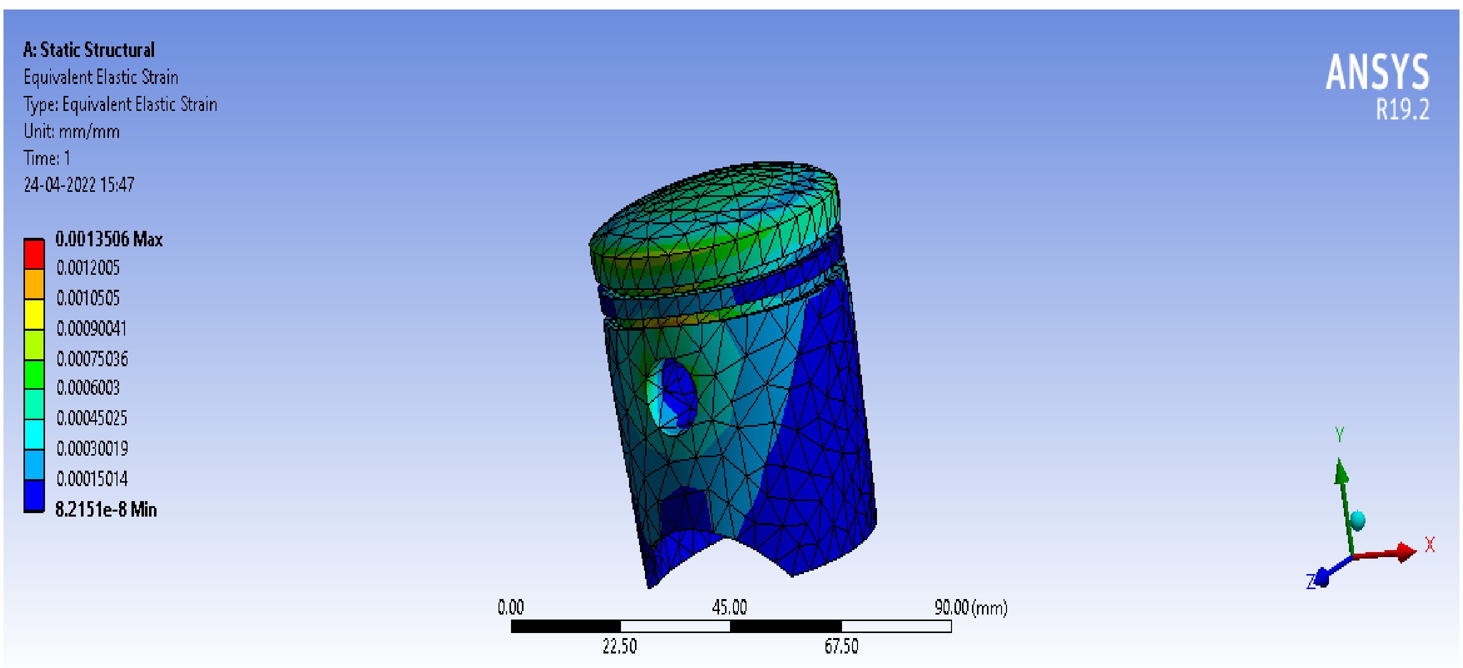

Figure number 3.5 Cast iron strain

Aluminium

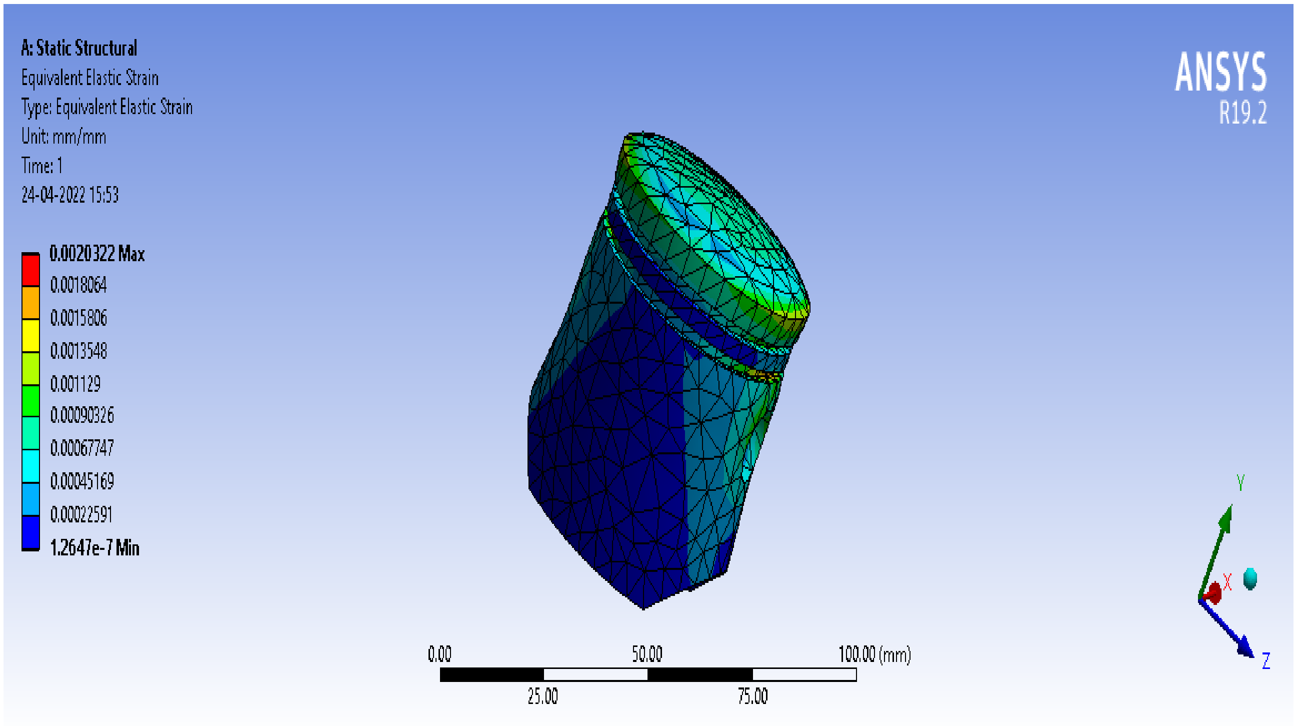

Figure number 3.6 aluminum strain

Piston	Total deformation	Direction deformation (y-axis)	Equivalent Elastic strain
SiC reinforced ZrB_2	0.030626 mm	0.00090394 mm	0.00072142
Cast Iron	0.056058 mm	0.0017152 mm	0.0013506
Aluminum	0.08627 mm	0.0025463 mm	0.0020322

Static Analysis Comparison post ANSYS Simulation

12.4 THERMAL ANALYSIS OF PISTON HEAD IN ANSYS

- Boundary Conditions applied for Piston Head –

  Temperature applied = 180^0C

  Convection applied = 5E – 0.004 W/mm^2-K

- ANSYS Simulations -

SiC reinforced ZrB2

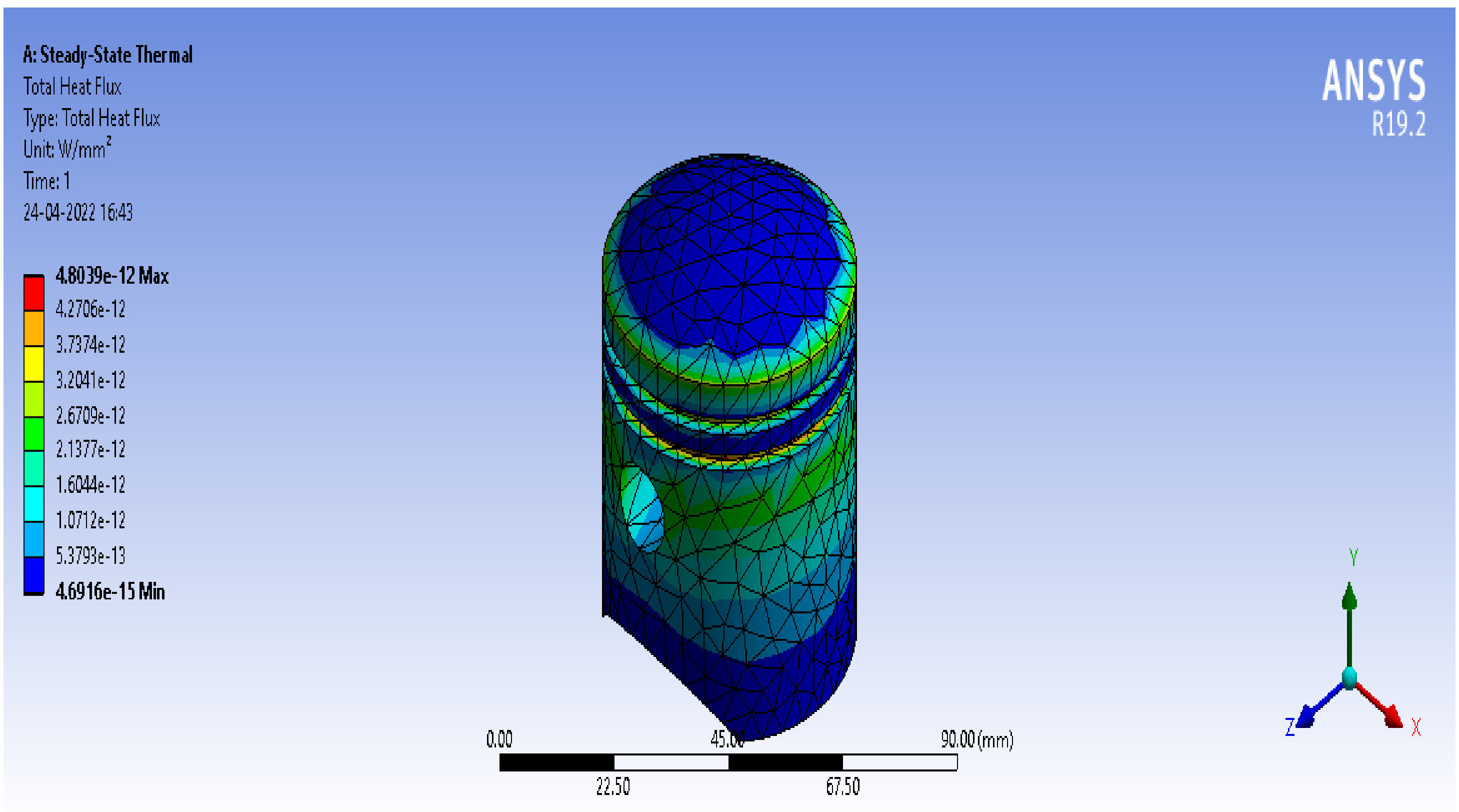

figure number 3.7 SiC reinforced ZrB2 Thermal analysis on Piston head

Aluminium

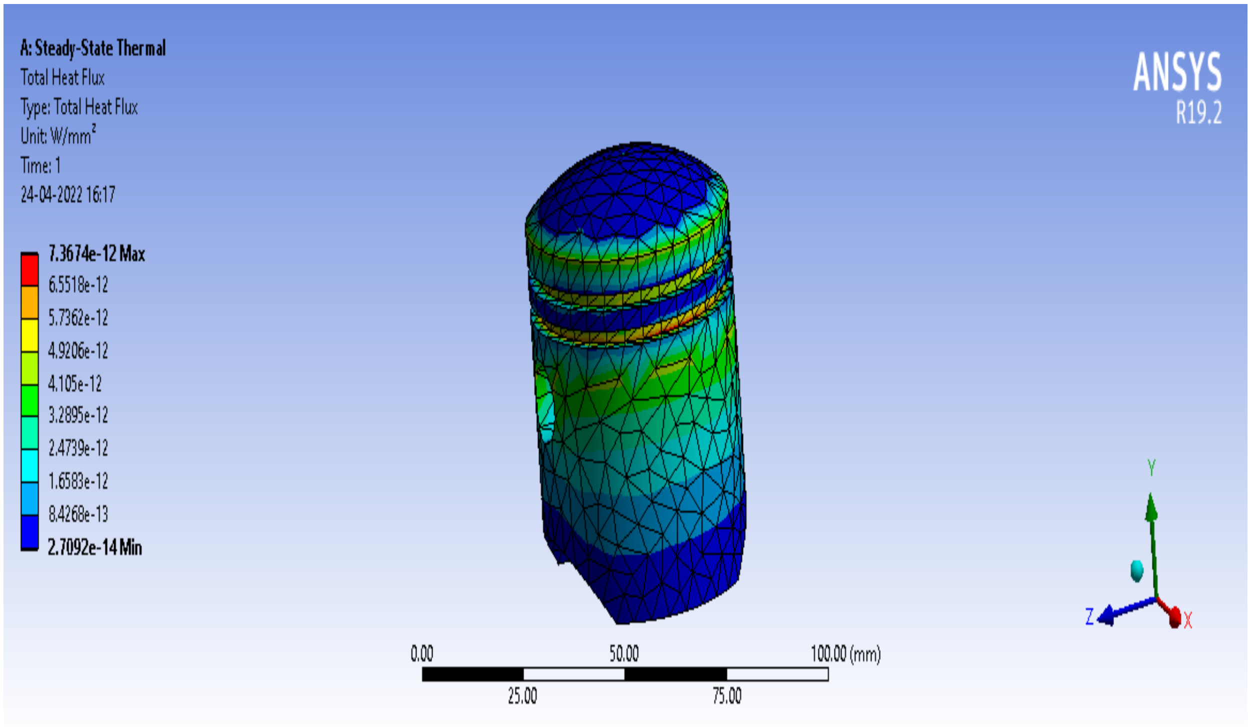

Figure number 3.8 aluminum thermal analysis of piston head

Cast Iron:

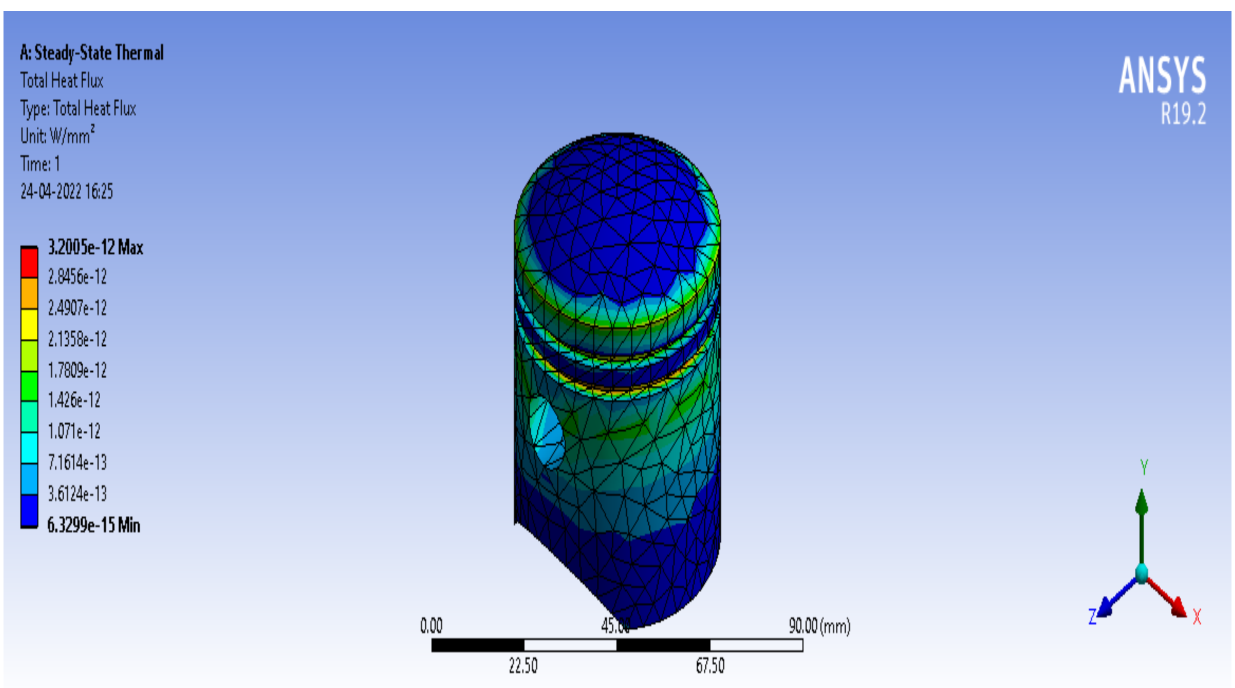

Figure number 3.9 cast iron thermal analysis of piston head

12.5 Directional heat flux:

SiC reinforced ZrB2

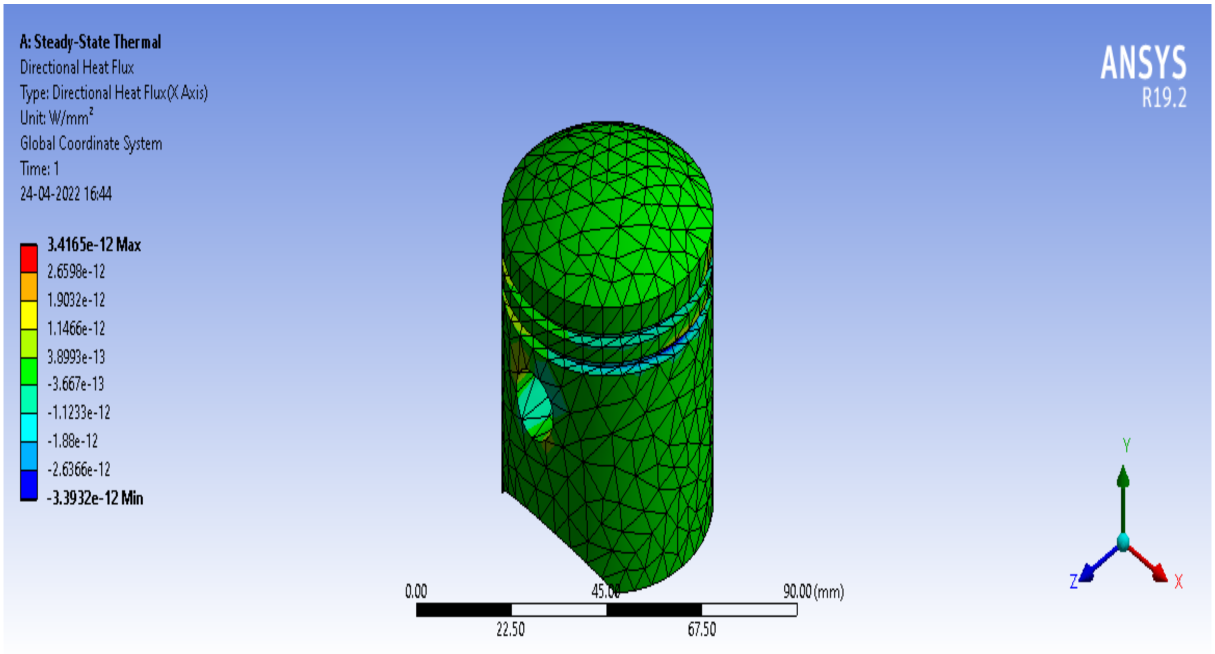

Figure number 4.0 directional heat flux of SiC Reinforced ZrB2

Aluminum

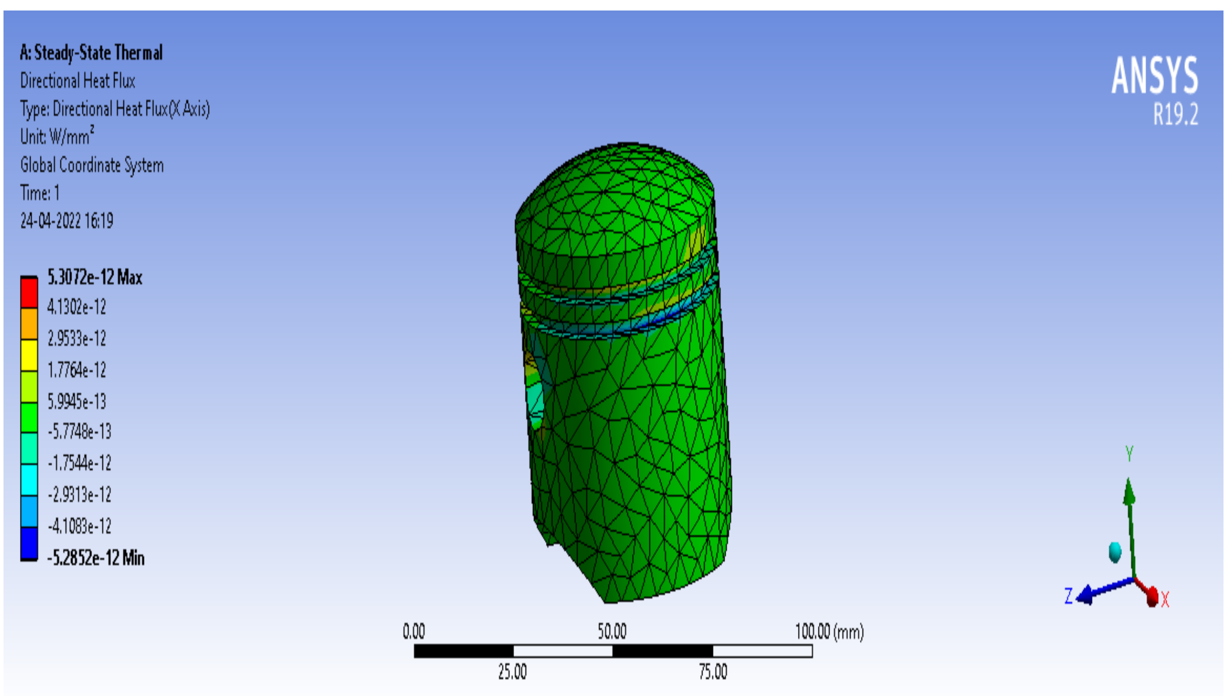

Figure number 4.1 directional heat flux of of aluminum

Cast iron:

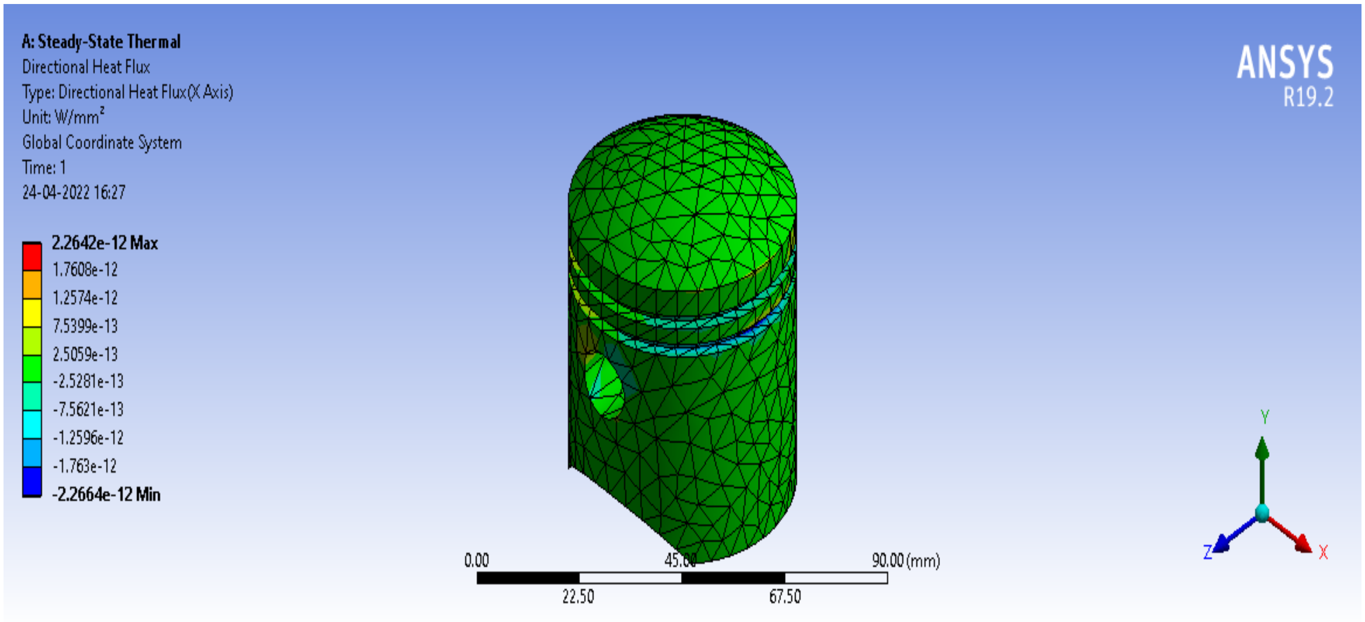

Figure number 4.2 directional heat flux of Cast iron

Piston	Total heat flux	Directional Heat flux(Y-axis)
SiC reinforced ZrB_2	4.8039e-12	3.4186e-12
Cast Iron	3.2005e-12	2.2799e-12
Aluminium	7.3674e-12	5.2777e-12

Thermal Analysis Comparison post ANSYS Simulation

_CHAPTER-6

13. CONCLUSION

• Equivalent elastic strain is the maximum limit upto which the body regains its original shape after the removal of load.

• In total deformation , by comparing it is found that SiC reinforced ZrB_2 has least deformation and better than aluminum and cast iron, results in increasing the piston life and reduced wear. • In deformation along Y- axis as the piston reciprocates vertically along cylinder the material - SiC-ZrB_2 has least deformation among the cast iron and aluminum results sturdy in nature can be operated under high temperature environments.

• In equivalent elastic strain it is found that SiC-ZrB_2 is the best among three because it has least delta L/L after the load is released in terms when combustion takes place high intensity of force acts over it and can withstand ultra high temperatures, in turn increases the life span of piston and decreases the cost.

• In heat flux SiC-ZrB2 to be better than aluminum because it can withstand high temperature combustion over the piston top and radiates the heat radially along all directions and few chances to occur cracks along grain boundaries results in increasing the life span of piston.

• Along X-direction the heat flux of the material ZrB2-SiC is found to be better than aluminum so that dissipation of heat takes place uniformly in order to avoid unnecessary increase in temperature around the piston walls.

14.SCOPE OF FUTURE WORK

Although India's economy is improving at a faster rate, the demand for engines will continue to be critical in the startup ecosystem and during the industrialization period. The goods are manufactured and services are provided, but capital goods must be transported interstate and intrastate. It is clear that as roads become more fuel efficient and emit fewer pollutants, the burden on transporters in terms of price and maintenance will decrease. However, gasoline blended fuel is currently humanity's only long-term hope. Sintered soft magnetic materials of high densities provide a performance increase in terms of weight, high strength, and hardness, and powder metallurgy is a green technology that goes hand in hand with the future of environmentally friendly autos . As the number of people who own automobiles continues to rise, marketing research indicates that the likelihood of one car meeting the needs of one person in every nation is high.

By 2026, India is predicted to be the third-largest automobile market in the world in terms of volume.The key advantages have been a vast, untapped local market for compact automobiles (along with a sizable middle class), small production costs (because to the availability of low-cost labor and other inputs), and strong engineering skills. By 2026, India is predicted to be the third-largest automobile market in the world in terms of volume. In April-March 2020, India's automobile industry produced 22.7 million cars, including passenger cars, commercial vehicles, three-wheelers, two-wheelers, and quadricycles, of which 4.1 million were exported. Domestic automotive manufacturing climbed at a 2.36 percent CAGR from FY16 to FY20, with 26.36 million cars manufactured in FY20.

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