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Analysis of Friction Disc of Single Plate Clutch by using Ansys

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Abstract: A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft. A clutch thus provides an interruptible connection between two rotating shafts. The present used material for friction disc is Grey Cast Iron, Sintered Iron, Kevlar, Aluminium Metal Matrix Composite etc . In this thesis analysis is performed using C45 and Sialons materials. These materials are considered due to their Specific Properties. In this thesis C45 and Sialons materials are taken. A single plate clutch is designed and modeled using SpaceClaim in Ansys software. Static analysis is done on the clutch to determine stresses and deformations using materials Grey Cast Iron, Sintered Iron, Kevlar, Aluminium Metal Matrix Composite, C45 and Sialons. Analysis is done in Ansys. Theoretical calculations are also done to determine stresses.

Keywords: Clutch, Friction Disc, Static Analysis, Ansys, SpaceClaim.

I. INTRODUCTION

Although the first use of a dry single-plate clutch was by Duryea in 1893, it was not until 1921 that a design was developed that would not burn out in a few hundred miles, thanks to Englishman Herbert Frood, who perfected more durable friction materials. In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts). In these devices, one shaft is typically attached to an engine or other power unit (the driving member) while the other shaft (the driven member) provides output power for work. While typically the motions involved are rotary while linear clutches are also possible. Some of the consideration for designing clutch assembly is Suitable Friction Material for friction liner, Sufficient torque transmitting capacity, Engagement with minimum Shock and jerking, Weight of rotating parts should be low to decrease the inertial forces to increase the sensitivity of application of forces, Suitable provision for changing the friction lining and thermal distribution due to frictional heat should be uniform and the rate of increase of temperature should be less. In case of clutch the main problem occurs in the clutch material. The material gets damaged and so the maximum performance can’t be achieved further. Some important requirements of clutch material is high co-efficient of friction, co-efficient of friction should be remain constant throughout the working temperature of clutch plate, good thermal conductivity for better thermal distribution, remain unaffected by environmental conditions, moisture and dirt particles, high resistance to abrasive and adhesive wear, good resilience to provide good distribution of pressure at the connecting surfaces.

II. LITERATURE REVIEW

A. Kartik Virmani

In this project, a single plate dry friction clutch for TATA 609 is designed, analyzed & optimized. The performance of clutch plate friction lining with different materials is simulated. However, the results obtained can be extended to models other than TATA 609 using a 280 mm clutch plate and similar engine specifications. But still, the methodology can be reimplemented for other engine specifications. New materials were tested through ANSYS simulation to the traditional ones (asbestos, iron). It was observed that generated heat between friction disk and flywheel, which is the main reason for clutch wear can also be minimized by giving away the convection constraint at the outer diameter of the disk. It is illustrated that by making grooves/channel in the close vicinity of the mean radius (obtained through uniform pressure theory) allow convection of the frictional facing that affects the maximum temperature achieved on the heated surface and it is lower than the effective depth of heat penetration, which depends on thermal diffusivity of material and the time of slipping. The results of the theoretical analysis showed that the new materials successfully manifest their usage as a friction material for clutch, of which Ceramic (with reinforced organic material) was proved to be the best candidate in terms of weight, cost & in a good agreement with the results obtained from the literature survey.

B. Mahendra Sahu

In our project we have designed a friction plate of single plate clutch y using catia V5. Structural analysis is done on the friction plate to find out the equivalent stress on the friction plate y using different friction materials such as cast iron, sintered iron Kevlar and aluminium metal metrix composite. From above results we can conclude that sintered iron, kevlar and aluminum metal matrix composite compared to cast iron, shows less value of deformation as well as less von-mises stress under static structural analysis. In addition aluminium metal matrix composite has very high strength to weight ratio compared to cast iron and hence cast iron can be replaced by aluminium metal matrix. Aluminium metal matrix is better than all three other material.

C. Sagar Jay Bhoite

In this work, clutch plate of an automotive clutch assembly has been designed using different materials and simulated using ANSYS software for comparison. Among those different lining materials cermet friction material was selected as the best lining material as compared to the above selected 5 materials. Effect of same pressure intensity of 1 MPa for different materials was observed, clutch wear can be minimized by selecting suitable material. A good contact pressure also reduces wear during slippage time. This data helps the researchers to select proper material to reduce wear and increase life of clutch.

D. Kedar Kishor Patil

In this work, clutch plate of Tata Sumo has been designed. Clutch plate has been modelled in CATIA software and simulated using ANSYS software for different materials. Effect of same pressure intensity of 0.5N/mm2 for different materials has observed. Heat flux, Total deformation, stress, strain and first six modal frequencies for different materials are observed. By comparing the results tabulated in table 4 it is clear that ceramic has less deformation and less modal frequencies than all other. This data helps the researchers to select proper material to reduce wear and increase life of clutch.

E. Sunny Narayan

In this work, clutch plate of an automotive clutch assembly has been designed using different materials and simulated using ANSYS software for comparison. Among those different lining materials cermet friction material was selected. Generated Heat between friction disk and flywheel, which is the main reason for clutch wear can be minimized by selecting suitable material. A good contact pressure also reduces wear during slippage time.

F. N. A. Barve

In the present work, the modal analysis and transient structural analysis were performed. The 3D model of clutch assembly was created in Pro-e software. Finite element analysis was performed in ANSYS software. 3D model was built to obtain the optimal design parameters of the clutch. The modal analysis of simplified clutch was performed to determine natural frequencies. The results show that natural frequencies of original model and natural frequencies of simplified model are in good agreement with each other.

G. P.Viswabharathy

In this project, a single plate clutch is modelled in 3D modelling software CREO 2.0 and theoretical calculations and also static and dynamic analysis has done by using ANSYS Workbench 15.0. Present used material for clutch is Alloy steel. In this project, it is replaced with Gray cast iron, En-Gjs-400 – 15Steel, E Glass Epoxy, Aluminium Alloy A360, Silicon Carbide and Kevlar 49.Has been selected for friction plate and static and dynamic analysis has been done to find the total deformation, equivalent (vonmises) stress and equivalent elastic strain. By comparing the results it is clear that Aluminium Alloy A360 has less deformation than other materials. So using the materials is safe. By comparing the results between materials, Aluminium Alloy A360 is more advantageous than other materials due to its less weight and high strength.

H. MAY THIN GYAN

This paper explains the design of single plate clutch 2 drawing is drafted by using theoretical calculations. The strength of friction plate is done by using Solid Works. Friction materials used are cast iron, alloy steel and copper. By observing the analysis results are shown the stress, strain and displacement values of the three materials. When comparing the stress values of the three materials, the stress values of other two materials are greater than the stress value of cast iron. The result of this paper, using cast iron as

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friction material is advantageous than using alloy steel and copper as friction material. The cast iron using as friction material is the best for single plate clutch.

III. SCOPE OF PRESENT WORK

In this system, friction disc of single plate clutch will be studied by doing structural analysis on different materials. Previous research was done on cast iron and ceramics. In this research static structural analysis of Grey cast iron, Sintered iron, Kevlar, Aluminium metal matrix composite, C45 and Sialons for a friction disc will be done. The objectives of this study are:

1) To develop 3D CAD model of friction disc of Single Plate Clutch.
2) To study the behavior of different material (friction disc of single plate clutch) under static analysis.
3) To calculate the total deformation, stress, strain which is developed on a friction disc of cast iron, sintered iron, Kevlar, aluminium metal matrix composite, C45 and Sialons.
4) To compare all the Six results and conclude a best material for the selection of a friction disc.

IV. METHOD AND MATERIALS

A model is created with the help of computer aided drafting software, Ansys. Using Ansys software we can create 3D model of friction disc as per measurement data and can Import the Spaceclaim model in the Ansys Workbench for pre-processing and then the structural analysis is done on the friction disc. The Analysis involves the discretization called meshing, boundary conditions and loading. For analysis we take Cast iron, Sintered iron, Kevlar, aluminium metal matrix composite, C45 and Sialons.

A. Specifications of Friction Disc

Power = 52.5KW @ 3600 rpm

Torque = 195 N-m @1400-2200RPM

Material used is pressed asbestos on cast iron or steel μ = 0.35

Maximum operating temperature ℃ = 150 – 250

Maximum pressure N/mm^2 = 0.4

r_1 and r_2 outer and inner radius of friction faces r_1 =114.5mm and r_2 =80 mm

R = mean radius of friction surfaces

For uniform pressure

$$R = \frac{2}{3} \times \frac{{r_1}^3 - {r_2}^3}{{r_1}^2 - {r_2}^2} = \frac{2}{3} \times \frac{114.5^3 - 80^3}{114.5^2 - 80^2} = 98.26mm = 0.09826m$$

For Uniform Wear

$$R = \frac{r_1 + r_2}{2} = \frac{114.5 + 80}{2} = 97.25mm = 0.09725m$$

B. Considering Uniform Pressure

When the pressure is uniformly distributed over the entire area of the friction face then the intensity of pressure P

$$P = W / \{\pi ({r_1}^2 - {r_2}^2)\}$$

Where, W = axial thrust with which the friction surfaces are held together.

In general frictional torque acting on the friction surfaces or on the Clutch is given by-

$$T = n \times \mu \times W \times R$$

n = no. of pairs of friction surfaces for single plate clutch n = 2

R = mean radius of friction surfaces

μ = coefficient of friction

$$T = 195 = 2 \times 0.35 \times W \times 0.09826$$

$$W = 2835.04 N/m^2$$

$$P = \frac{W}{\pi({r_1}^2 - {r_2}^2)} = \frac{2835.04}{\pi(0.1145^2 - 0.80^2)} = 136.392 \times 10^3 N/mm^2$$

C. For Considering Uniform Axial Wear

Axial Force is required to engage the clutch

$$W = 2\pi C(r_1 - r_2)$$

$$C = P \times r \qquad \text{(C=constant)}$$

The maximum intensity pressure occurs at inner radius (r_2) of friction surface

$$C = P_{\max} \times r_2$$

$$C = W/(r_1 - r_2) = 2835.04/(.1145\text{-}.080) = 13078.58$$

$$P_{\max} = C/r_1 = 13078.58/0.08 = 164871 \text{ N/m2} = 0.165 \text{ MPa}$$

The minimum intensity pressure occurs at outer radius (r_1) of friction surface

$$P_{\min} = C/r_1 = 13277.79/0.1145 = 115963 \text{N/m2} = 0.115 \text{MPa}$$

The average pressure on the friction surface

P_{avg}= (Total force on friction surface) / (Cross -sectional area of friction surface)

$$P_{avg} = W/\pi(r_1{}^2 - r_2{}^2)$$

$$P_{avg} = 136392 \text{N}/m^2$$

D. Material Properties of friction plate

Properties / Materials	Density (kg/m3)	Poison Ratio (μ)	Young's Modulus (E)GPa
Grey Cast Iron	7200	0.27	110
Sintered Iron	6200	0.34	275.79
Kevlar	1440	0.36	112
Aluminium Metal Matrix Composite	2800	0.30	115
C45	7800	0.30	210
Sialons	3250	0.23	288

V. BOUNDARY CONDITION

From above literature review, pressure is applied on the outer surface of the friction disc.

The boundary condition of clutch system are given as follows,

Pressure applied on plate: 0.165 MPa
Ambient temperature: 22℃
Maximum temperature generated: 150-200℃

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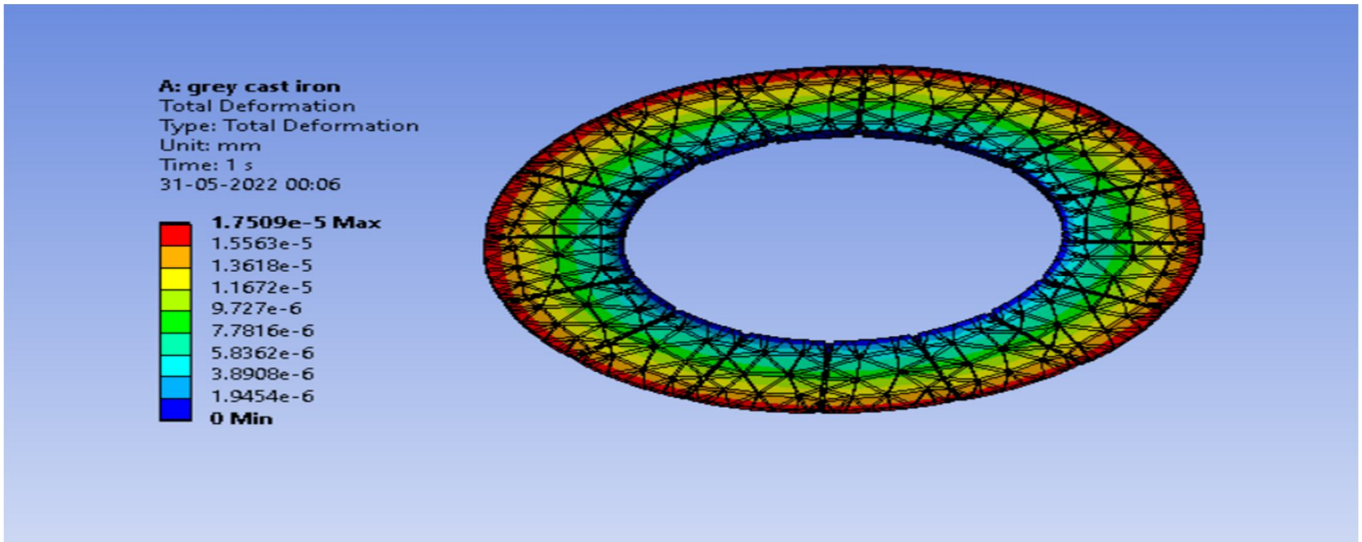
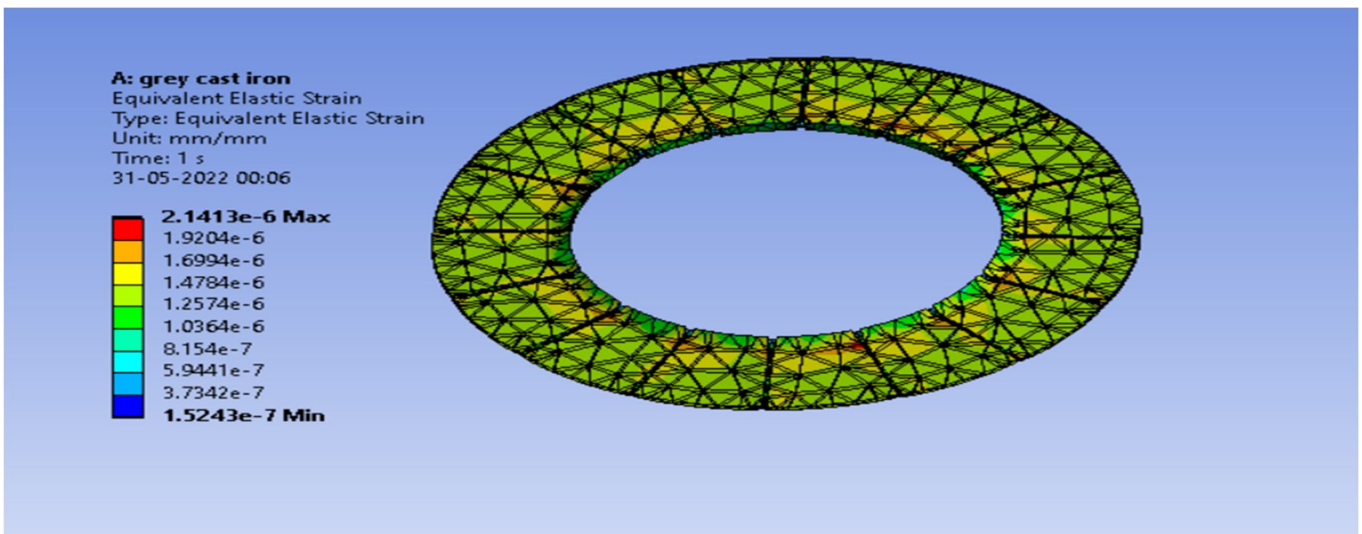
VI. ANALYSIS OF FRICTION PLATE

Finite element analysis of friction disc of single plate clutch is done with the help of Ansys workbench.
Static stress analysis is done for different materials and same operating conditions.
Static Structural Analysis
For Stress analysis, pressure is applied on the friction pad of friction disc which is 0.165MPa

Materials on which Analysis will be done are
1) Grey Cast Iron
2) Sintered Iron
3) Kevlar
4) Aluminium Metal Matrix Composite
5) C45
6) Sialons

A. Grey Cast Iron





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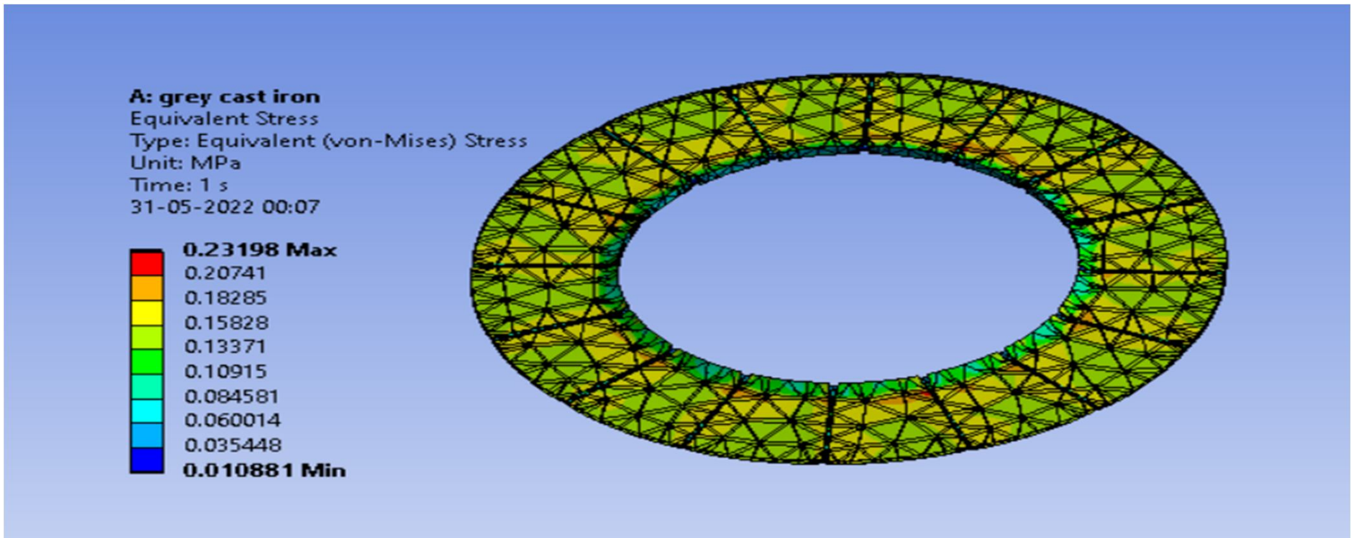
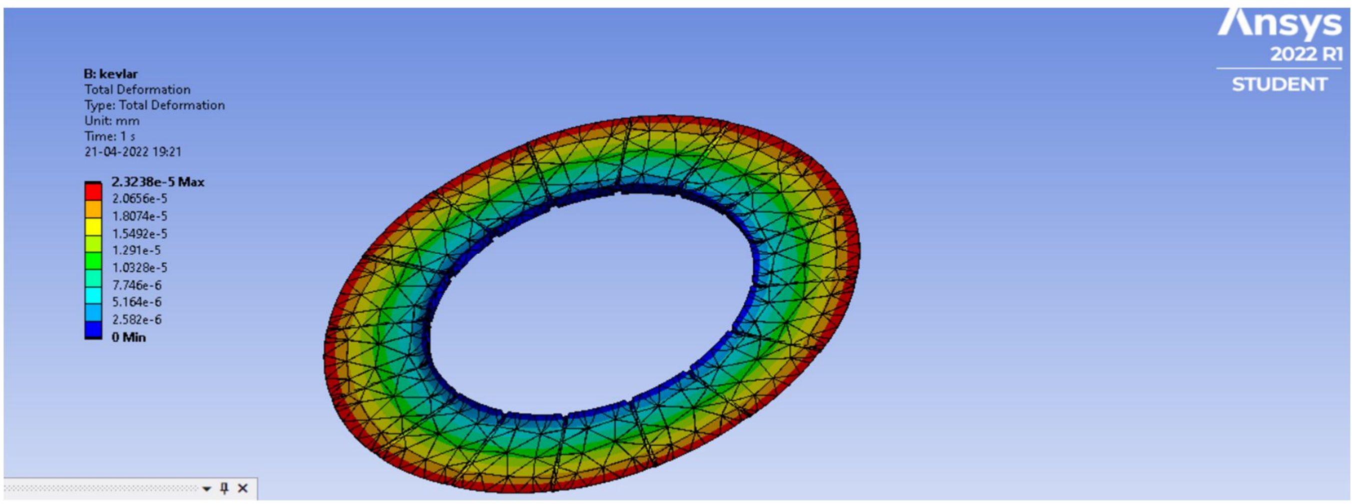
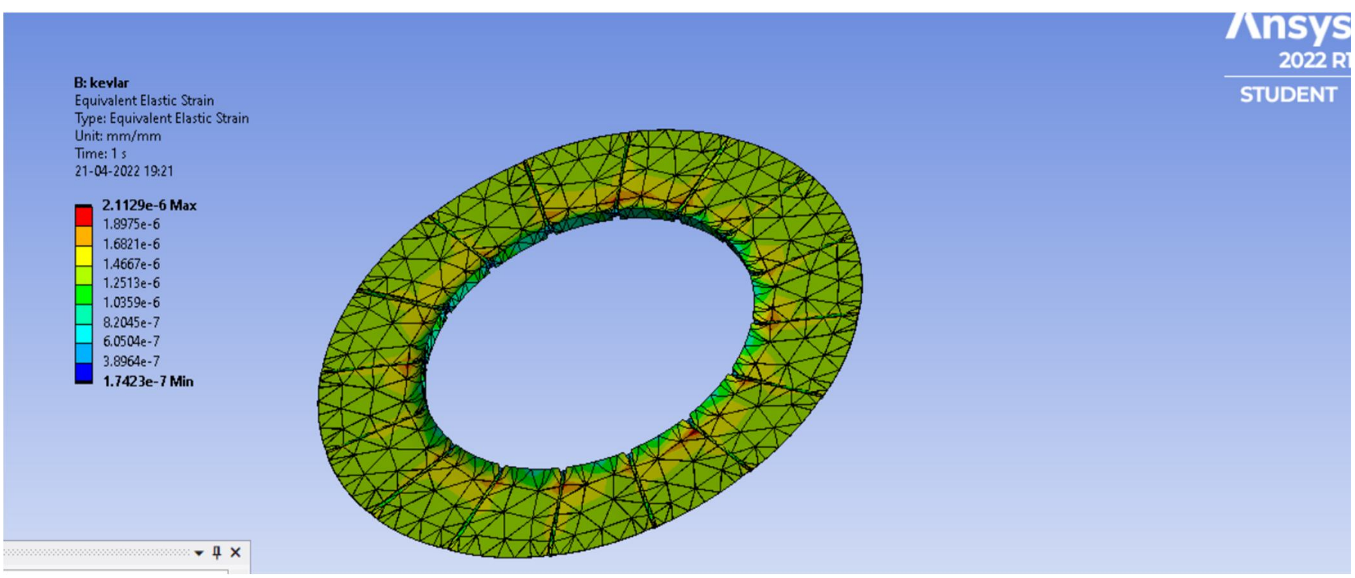
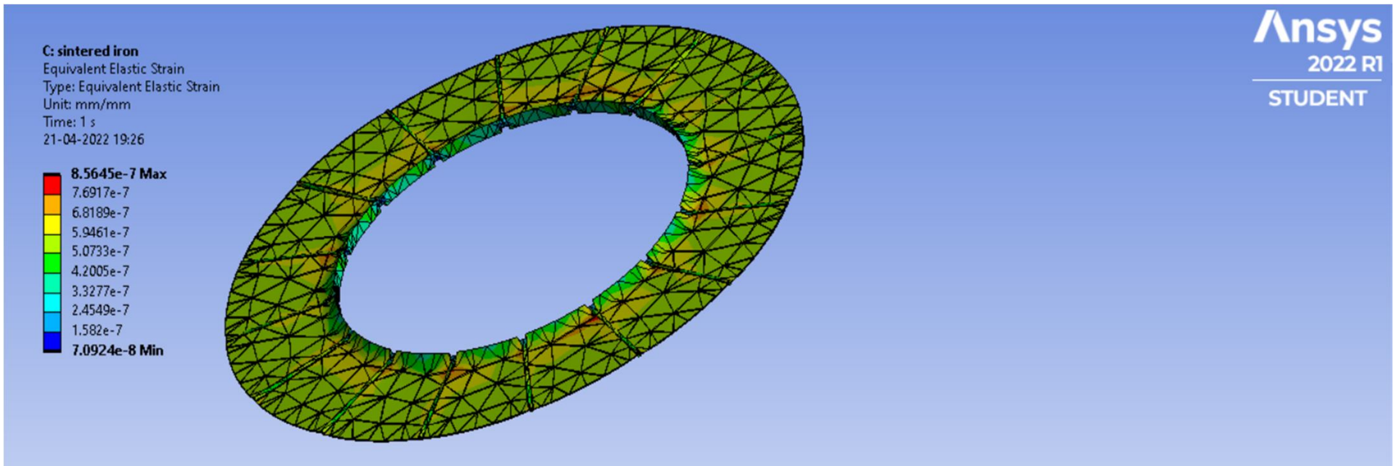
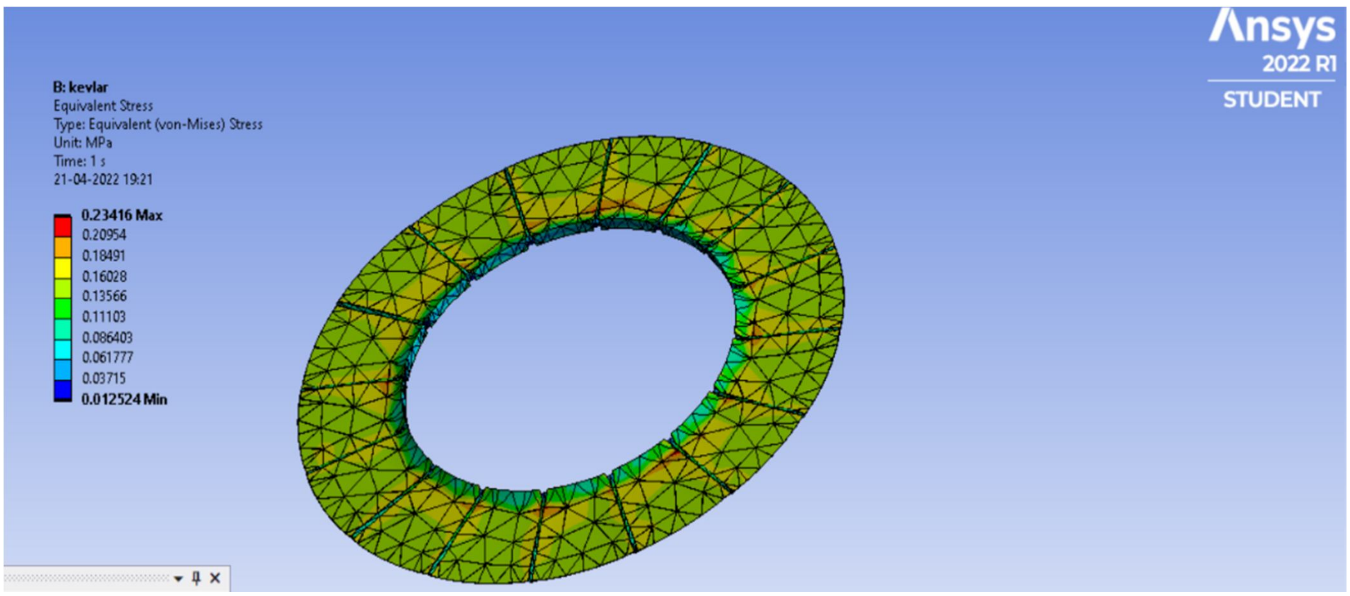


B. Kevlar

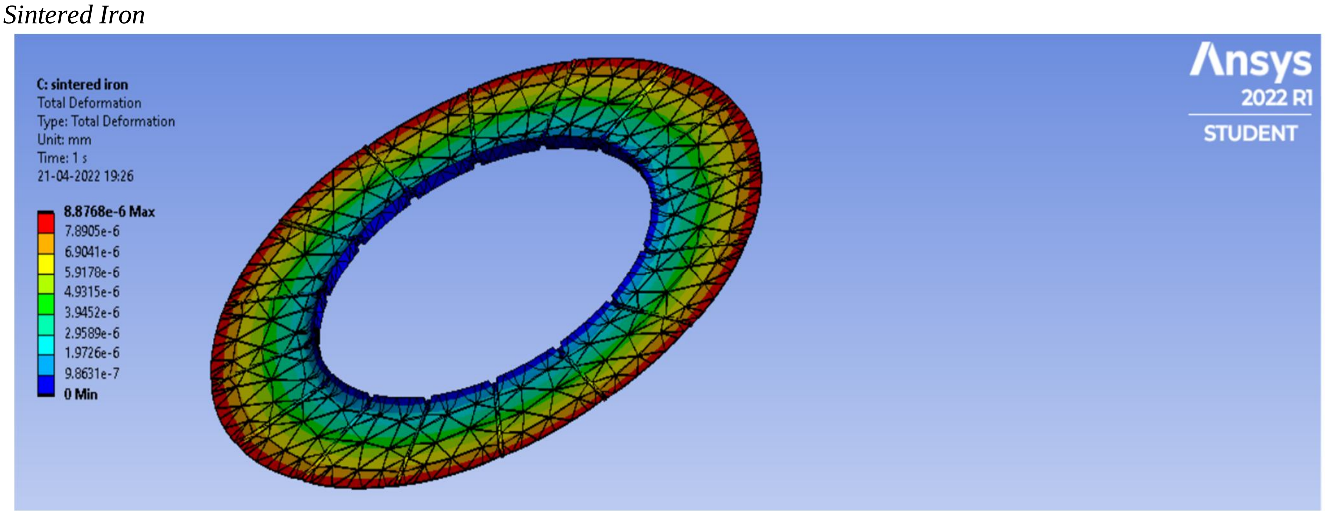


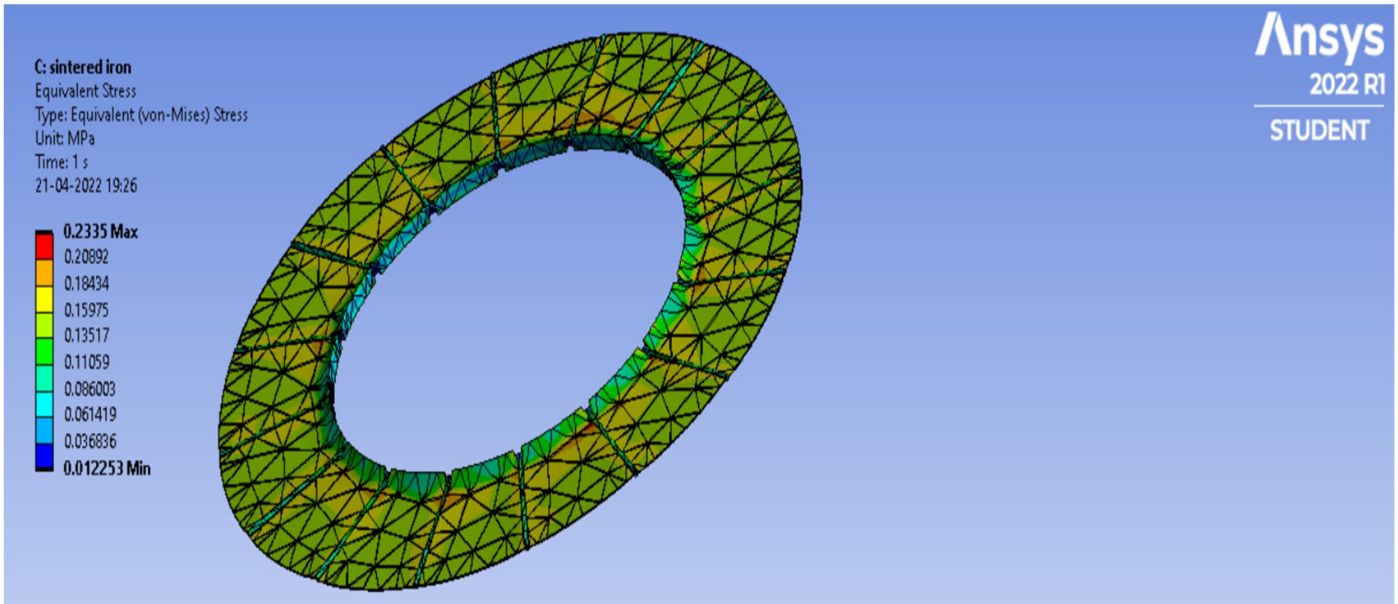




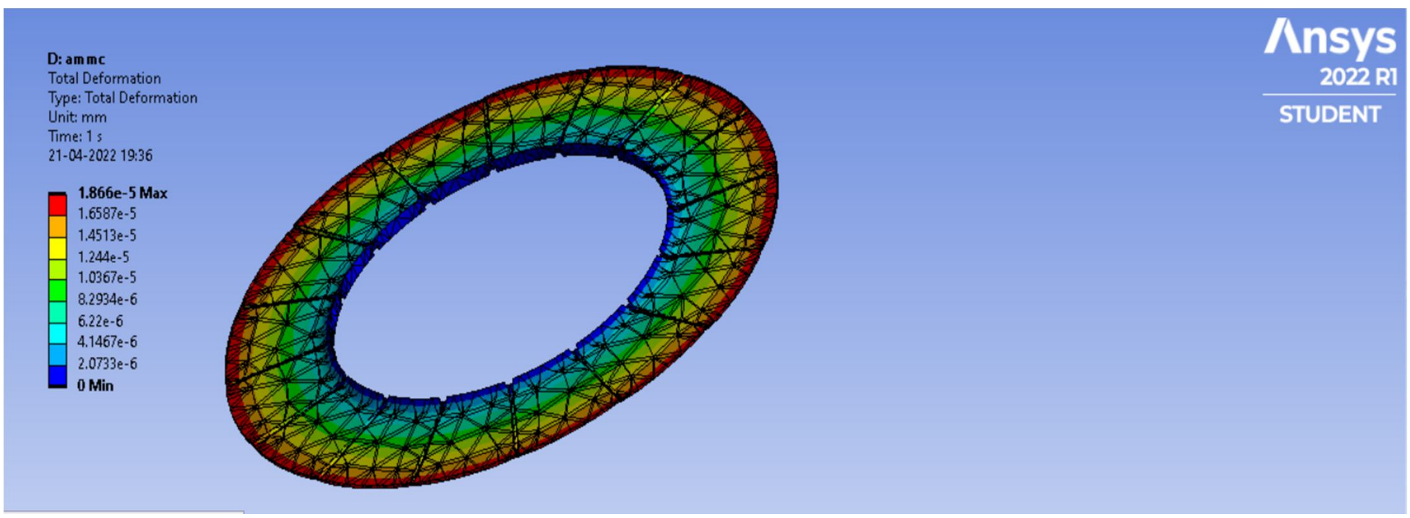


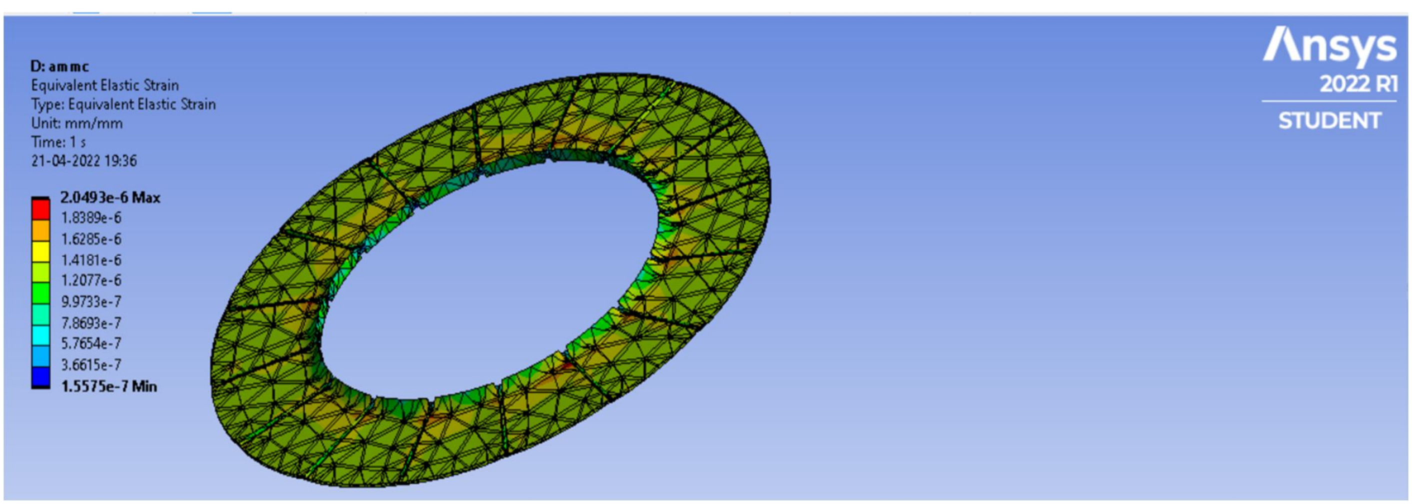
C. Sintered Iron

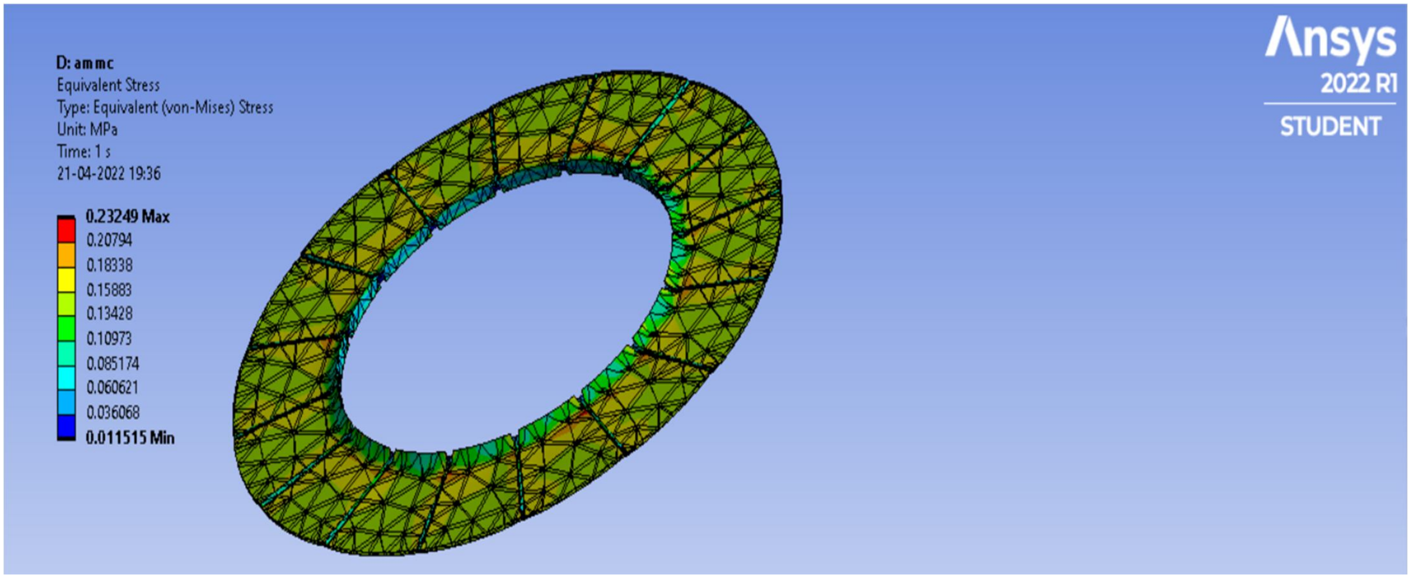



C: sintered iron
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1 s
21-04-2022 19:26
0.2335 Max
0.20892
0.18434
0.15975
0.13517
0.11059
0.086003
0.061419
0.036836
0.012253 Min
Ansys
2022 R1
STUDENT

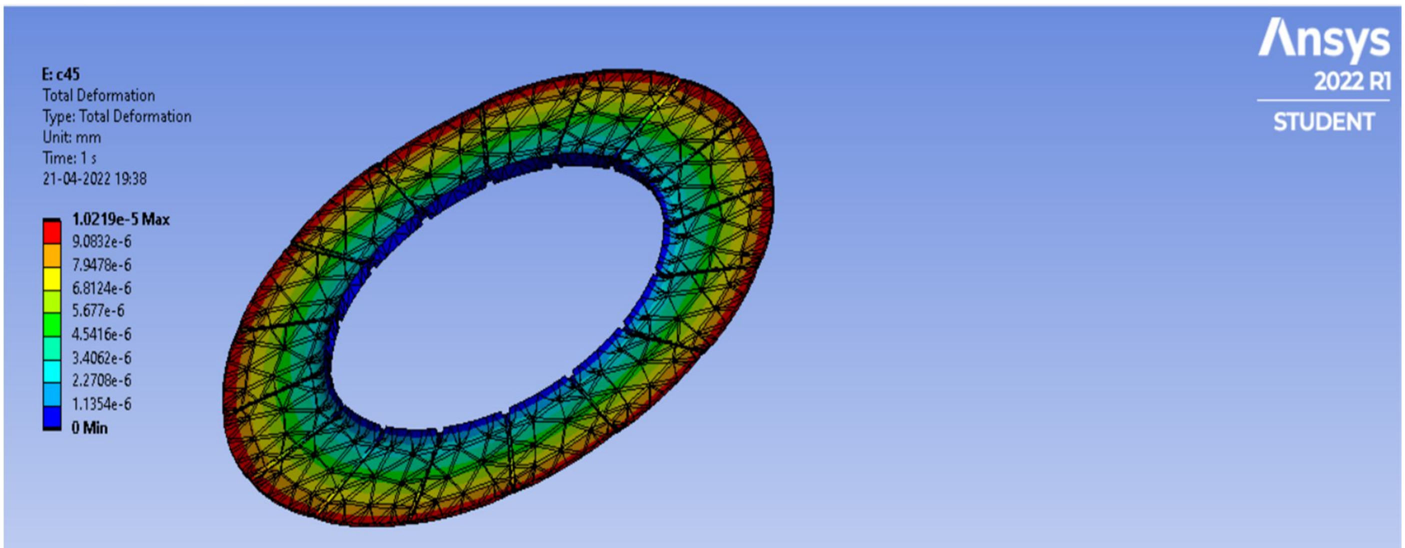
D. Ammc

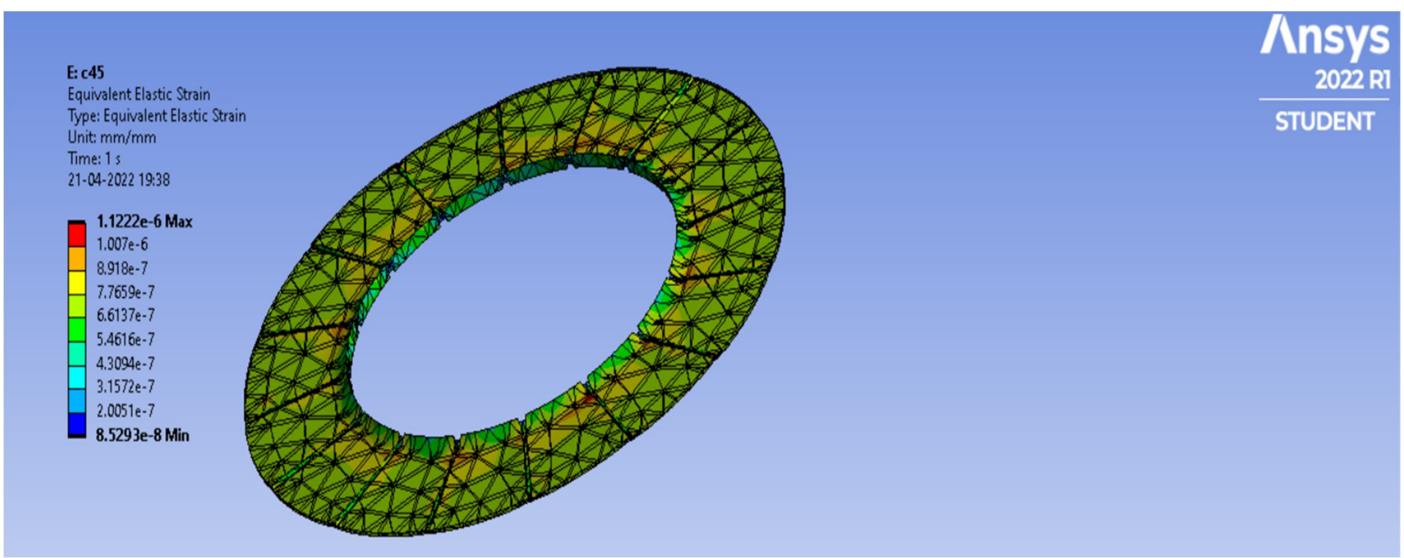

D: ammc
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
21-04-2022 19:36
1.866e-5 Max
1.6587e-5
1.4513e-5
1.244e-5
1.0367e-5
8.2934e-6
6.22e-6
4.1467e-6
2.0733e-6
0 Min
Ansys
2022 R1
STUDENT


D: ammc
Equivalent Elastic Strain
Type: Equivalent Elastic Strain
Unit: mm/mm
Time: 1 s
21-04-2022 19:36
2.0493e-6 Max
1.8389e-6
1.6285e-6
1.4181e-6
1.2077e-6
9.9733e-7
7.8693e-7
5.7654e-7
3.6615e-7
1.5575e-7 Min
Ansys
2022 R1
STUDENT


D: ammc
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1 s
21-04-2022 19:36
0.23249 Max
0.20794
0.18338
0.15883
0.13428
0.10973
0.085174
0.060621
0.036068
0.011515 Min
Ansys
2022 R1
STUDENT

E. C45


E: c45
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
21-04-2022 19:38
1.0219e-5 Max
9.0832e-6
7.9478e-6
6.8124e-6
5.677e-6
4.5416e-6
3.4062e-6
2.2708e-6
1.1354e-6
0 Min
Ansys
2022 R1
STUDENT


E: c45
Equivalent Elastic Strain
Type: Equivalent Elastic Strain
Unit: mm/mm
Time: 1 s
21-04-2022 19:38
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1.007e-6
8.918e-7
7.7659e-7
6.6137e-7
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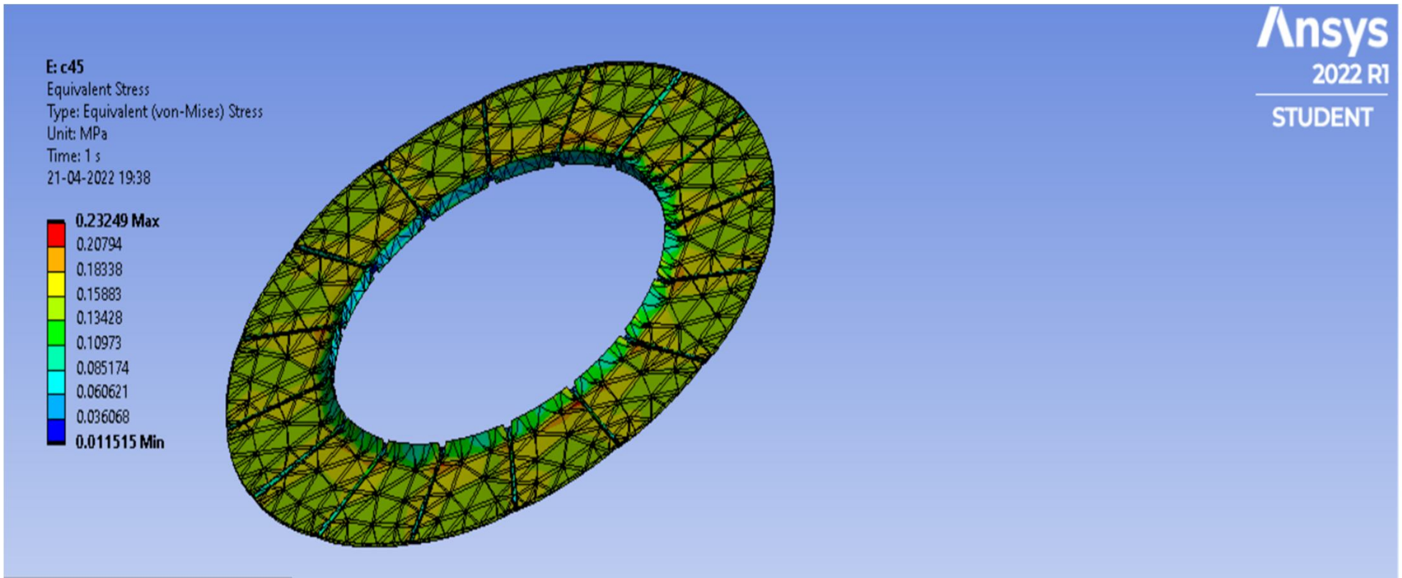
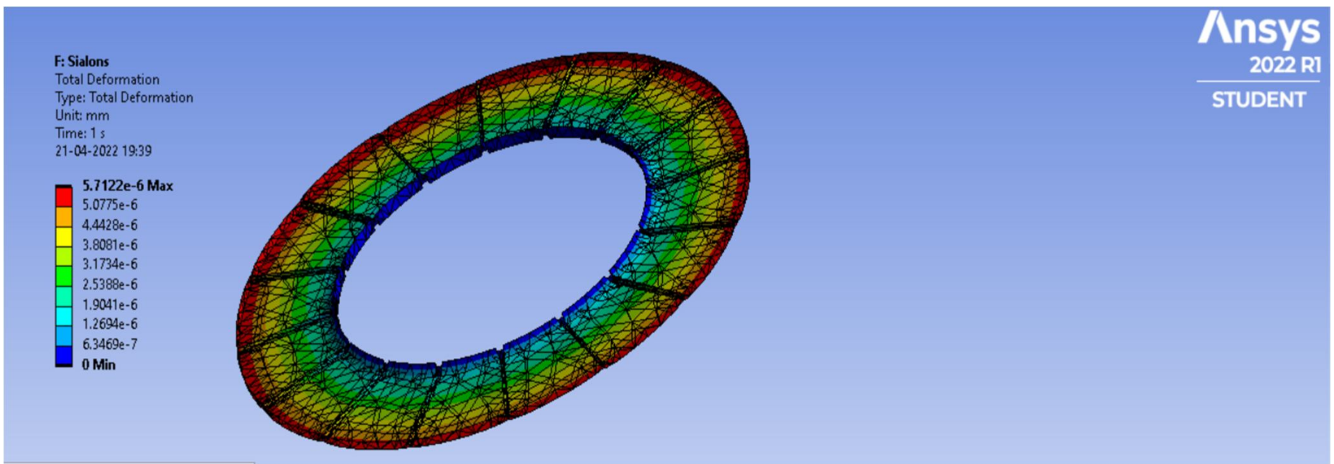
3.1572e-7
2.0051e-7
8.5293e-8 Min
Ansys
2022 R1
STUDENT


E: c45
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1 s
21-04-2022 19:38
0.23249 Max
0.20794
0.18338
0.15883
0.13428
0.10973
0.085174
0.060621
0.036068
0.011515 Min
Ansys
2022 R1
STUDENT

F. Sialons


F: Sialons
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
21-04-2022 19:39
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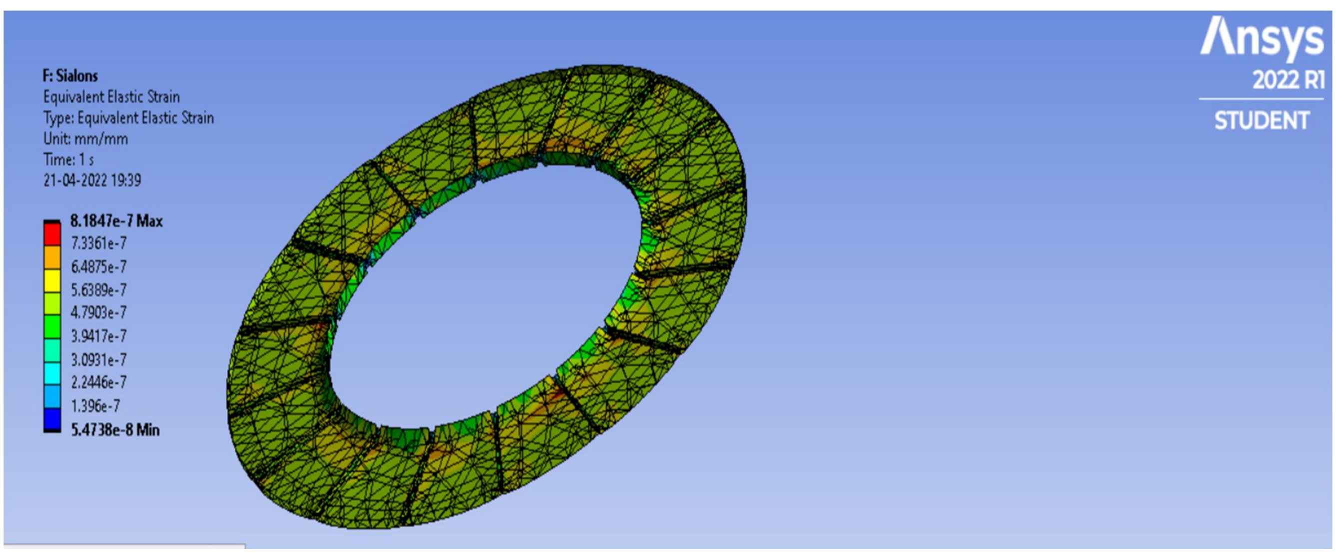
5.0775e-6
4.4428e-6
3.8081e-6
3.1734e-6
2.5388e-6
1.9041e-6
1.2694e-6
6.3469e-7
0 Min
Ansys
2022 R1
STUDENT


F: Sialons
Equivalent Elastic Strain
Type: Equivalent Elastic Strain
Unit: mm/mm
Time: 1 s
21-04-2022 19:39
8.1847e-7 Max
7.3361e-7
6.4875e-7
5.6389e-7
4.7903e-7
3.9417e-7
3.0931e-7
2.2446e-7
1.396e-7
5.4738e-8 Min
Ansys
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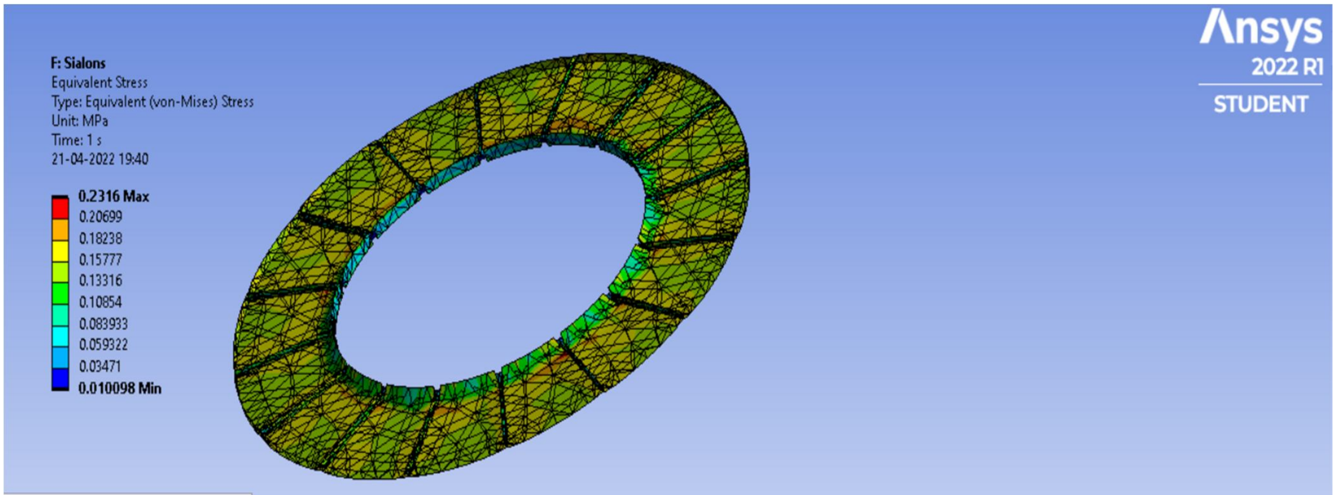

VII. RESULTS

Static Structural analysis

Materials \ Parameters	Total Deformation (mm)	Equivalent Strain (mm/mm)	Equivalent Sress (MPa)
Grey Cast Iron	1.7509×10^{-5}	2.1413×10^{-6}	0.23198
Sintered Iron	8.8768×10^{-6}	8.5645×10^{-7}	0.2335
Kevlar	2.3238×10^{-5}	2.1129×10^{-6}	0.23416
Aluminium Metal Matrix Composite	1.866×10^{-5}	2.0493×10^{-6}	0.23249
C45	1.0219×10^{-5}	1.1222×10^{-6}	0.23249
Sialons	5.7122×10^{-6}	8.1847×10^{-7}	0.2316

VIII. CONCLUSION

In our project we have designed a friction Disc of single plate clutch by using Ansys SpaceClaim. Structural analysis is done on the friction Disc to find out the Total Deformation, equivalent stress and equivalent Strain on the friction Disc by using different friction materials such as Grey cast iron, Sintered iron, Kevlar, Aluminium metal matrix composite, C45 and Sialons . From above results we can conclude that Sialons is giving the minimum value of Total Deformation, equivalent stress and equivalent Strain so it is the best suited material for the Friction Disc of Single Plate Clutch. On the other hand the various factors like Material is economically good, minimum temperature at the surface, high coefficient of friction and high wear resistance etc, if Sialons shows satisfactory results in these Parameters also then it may be used for Manufacturing process in future.

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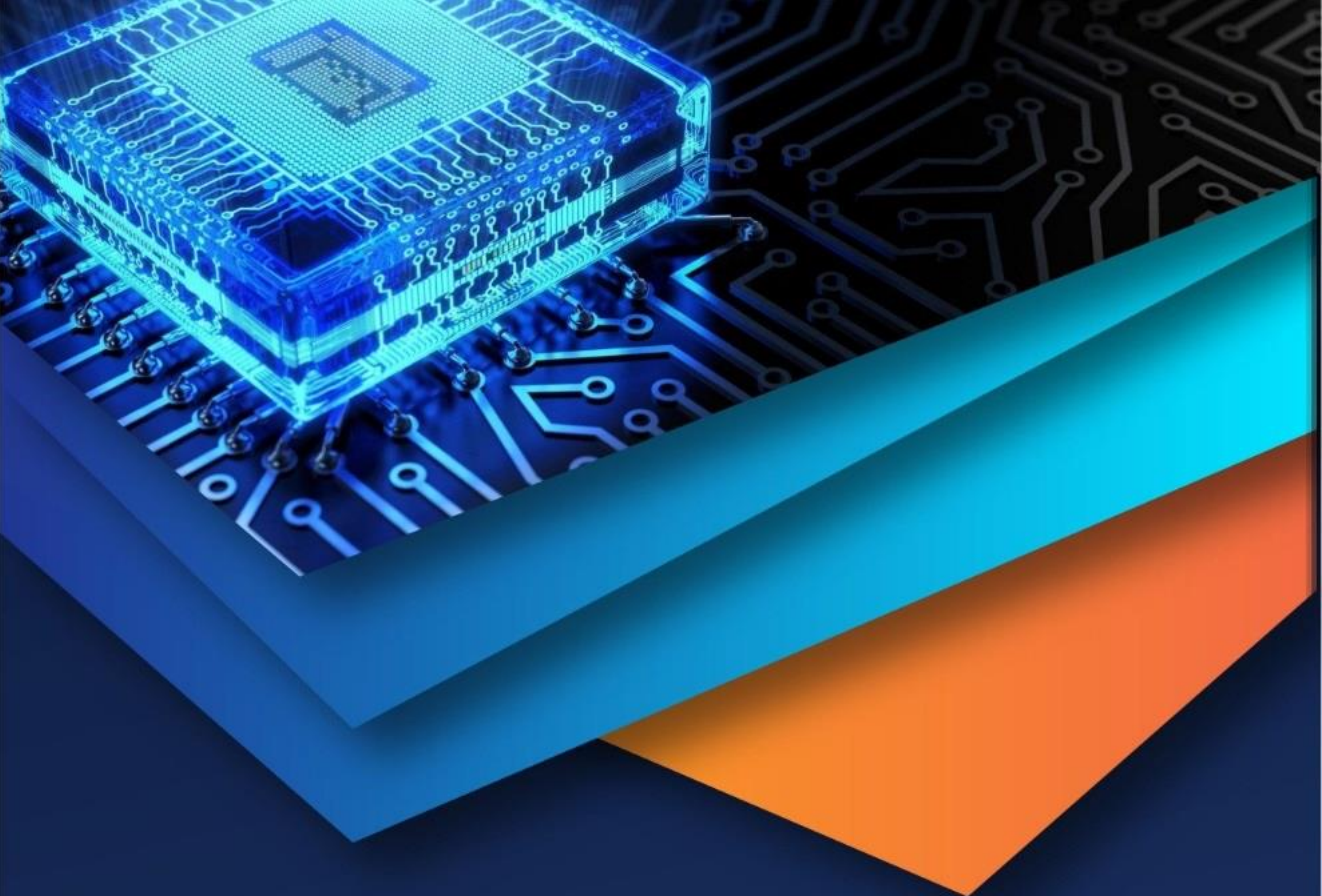

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