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Design Evaluation and Material Optimization of a Train Brake Shoe

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Abstract: The moving train having the kinetic energy. The train will be stopping by using brakes. When the brakes will apply on the train wheels the friction will be creates in between the wheels and brake shoe. This energy dissipated on surrounding in the form of heat. Friction is created heat; if the brake gets too hot they will cease to work because they cannot dissipate enough heat. The train brake is exposing the massive thermal traces throughout routing braking and extraordinary thermal traces throughout laborious braking. The major drawback in exciting train brake shoes is due to high thermal stresses, crakes create on the surface of brake shoe. The life of the brake shoe also decreased.

The aim of the project is to reduce the thermal stresses, crakes and increase the life of the brake shoe. Static, Modal analysis are to be done on the train brake. In static analysis, ultimate stress limit for the design is found. In modal analysis, mode shapes of the train brake for number of modes can be analysed. Presently the train brake material high carbon alloy we modified the material nickel chromium alloy, malleable cast iron. The modelling we are using SOLID WORKS and analysis is done using COSMOS.

Keywords: Train brake shoe, static analysis, High carbon steel, Malleable cast iron, Nickel chromium alloy, Modal analysis

I. INTRODUCTION

A Brake is a mechanical device which inhibits motion, slowing or stopping a moving object or preventing its motion. Most commonly brakes use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat though other methods of energy conversion may be employed.

A. Principles Of Braking System

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

II. DIMENSIONS AND PROPERTIES

According to RDSO (Research and Development Standard (Organization), Lucknow, the following are standard designed values for Railway air brake system.

1) Brake cylinder diameter: 355.6 mm (14 inches)
2) Effective piston force of brake cylinder: 3.6 tons.
3) Number of brake cylinder per coach: 2.
4) Number of brake bogie levers per coach :4.
5) Mechanical efficiency of brake rigging: 0.9.
6) Brake rigging ratio: 0.9.
7) Number of brake shoes per one coach: 16

A. Suggest Modification

The suggested modification is to reduce the excessive brake force on the brake by changing the existing horizontal leverage ratio 420: 280 to modified value 372: 328 which in turn reduces the excessive brake force.

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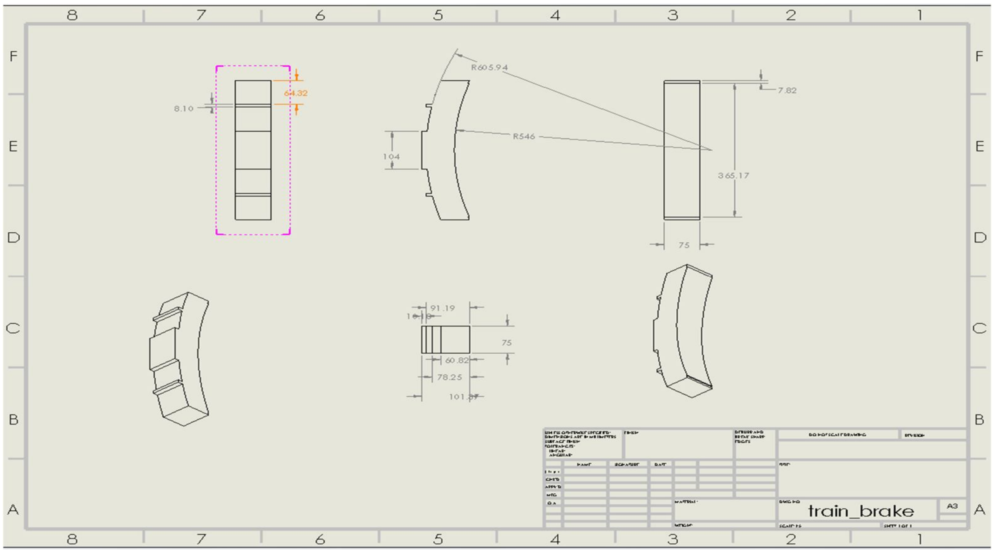

2D View of Brake Shoe

B. Properties of Material

Property	High carbon steel	Malleable cast iron	Nickel chromium alloy
Density (Kg/m^3)	8260	7450	8195
Poisson's ratio	0.32	0.27	0.32
Yield strength (MPa)	330	483	2300
Thermal conductivity (W/m.K)	30	22	17
Specific heat (J/Kg.K)	500	510	500
Ultimate tensile strength (MPa)	760	586	760

III. ANALYSIS

1) Static analysis for 1.653 ton
2) Applied pressure 0.55 N/mm^2

A. High carbon steel:
1) Stress:

Name	Type	Minimum	Maximum
Stress	Von Mises Stresses	1.807e-008 N/mm^2 (MPa) Node: 679	4.980e+000 N/mm^2 (MPa) Node: 8377

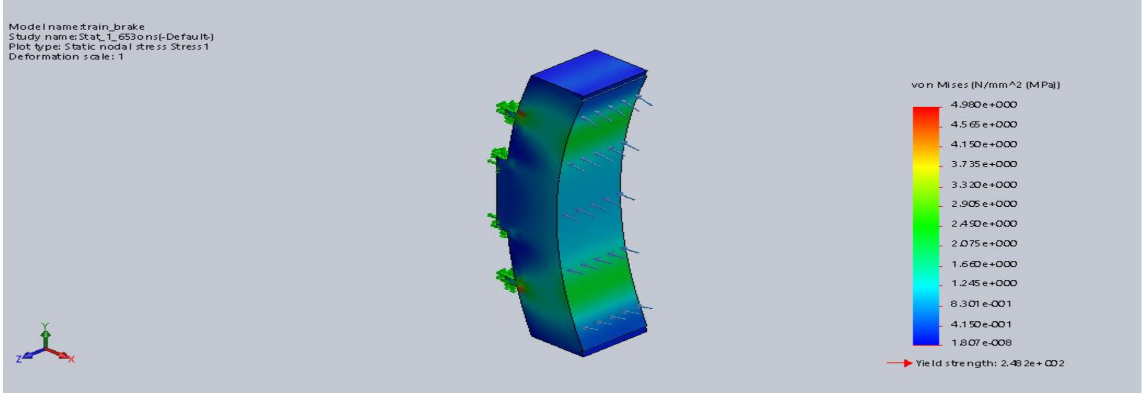

Fig.1 stress Results for High Carbon Steel

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2) Displacement

Name	Type	Minimum	Maximum
Displacement	Resultant Displacement	0.000e+000mm Node: 275	2.463e-003mm Node: 227

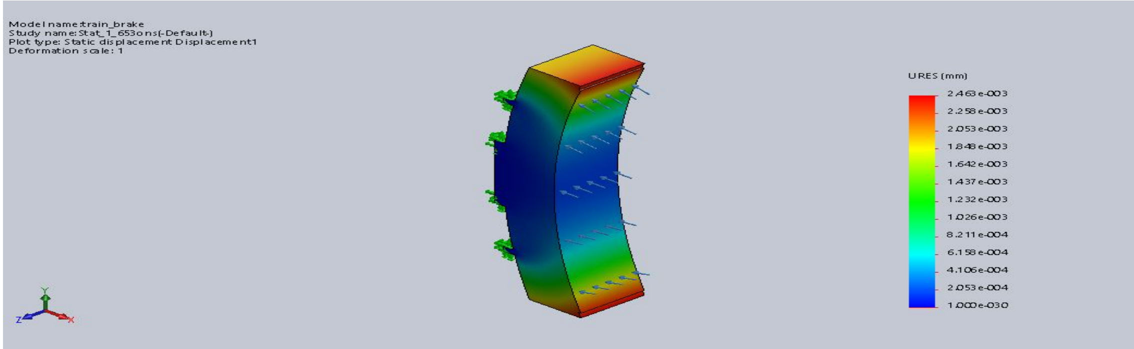

Fig.2 Displacement Results for High Carbon Steel

3) Strain

Name	***Type***	***Minimum***	***Maximum***
Strain	*Equivalent Strain*	*1.489e-007* *Element: 1662*	*2.198e-005* *Element: 1649*

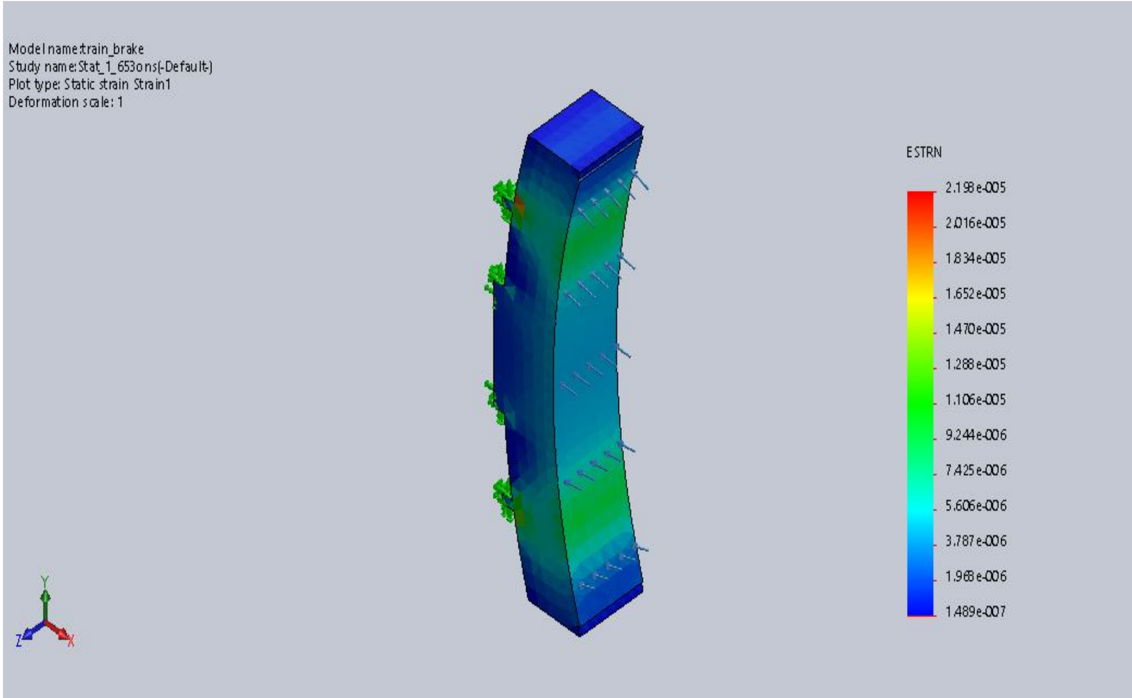

Fig. 3 Strain Results for High Carbon Steel

B. Malleable Cast Iron:

1) Stress

Name	Type	Minimum	Maximum
Stress	Von Mises Stress	1.813e-008 N/mm^2 (MPa) Node: 7260	5.109e+000 N/mm^2 (MPa) Node: 8377

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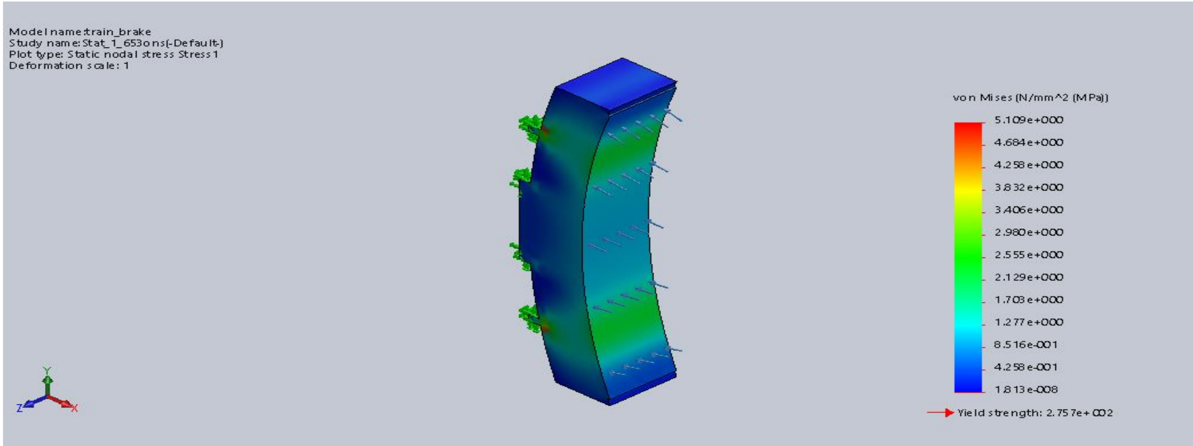

Fig.4 Stress Results for Malleable Cast Iron

2) Displacement

Name	Type	Minimum	Maximum
Displacement	Resultant Displacement	0.000e+000 mm Node: 275	2.585e-003 mm Node: 227

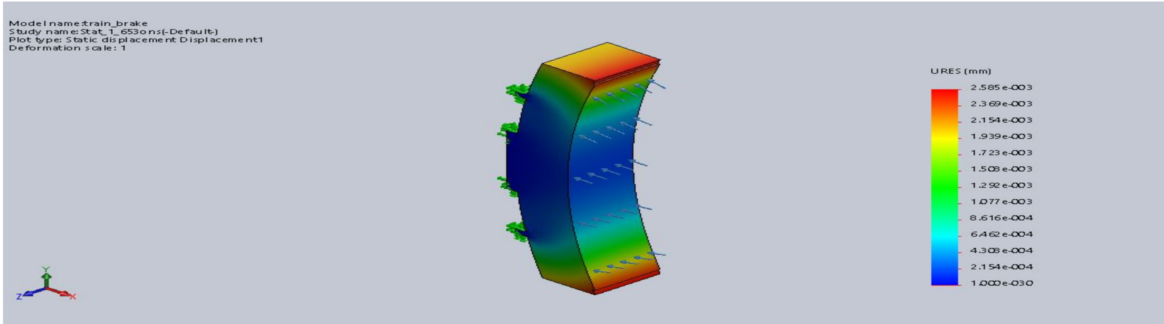

Fig.5 Displacement Results for Malleable Cast Iron

3) Strain

Name	Type	Minimum	Maximum
Strain	Equivalent Strain	1.697e-007 Element: 4507	2.320e-005 Element: 1767

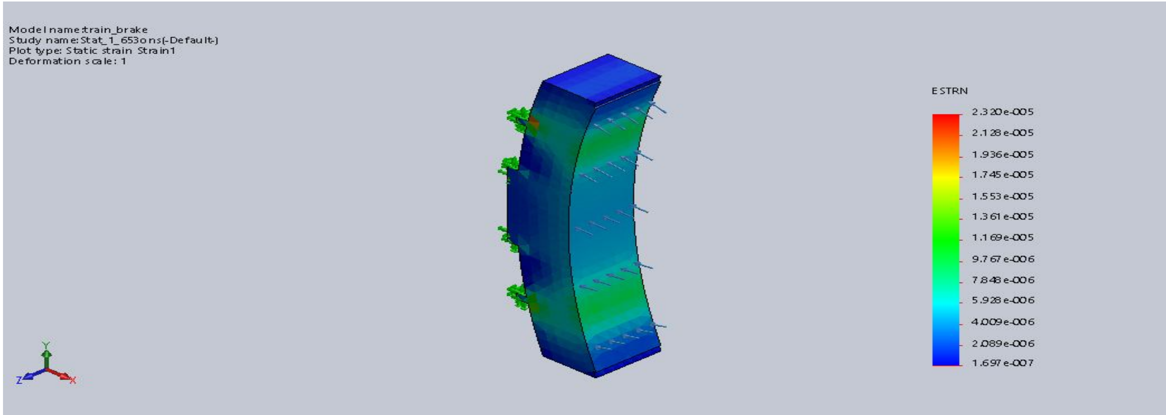

Fig. 6 Strain Results for Malleable Cast Iron

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C. Nickel Chromium

1) Stress

Name	Type	Minimum	Maximum
Stress	Von Mises Stress	1.812e-008 N/mm^2 (MPa) Node: 7260	5.133e+000 N/mm^2 (MPa) Node: 8377

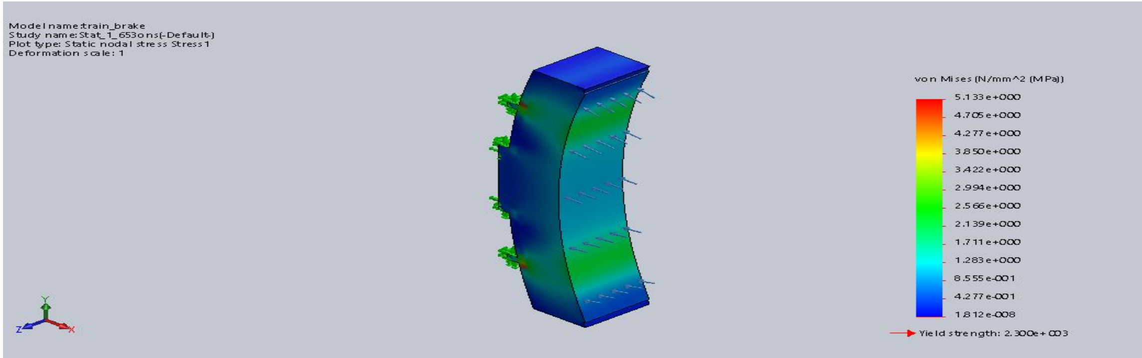

Fig.7 Stress Results for Nickel Chromium

2) Displacement

Name	***Type***	***Minimum***	***Maximum***
Displacement	*Resultant Displacement*	*0.000e+000 mm* *Node: 275*	*2.003e-003 mm* *Node: 227*

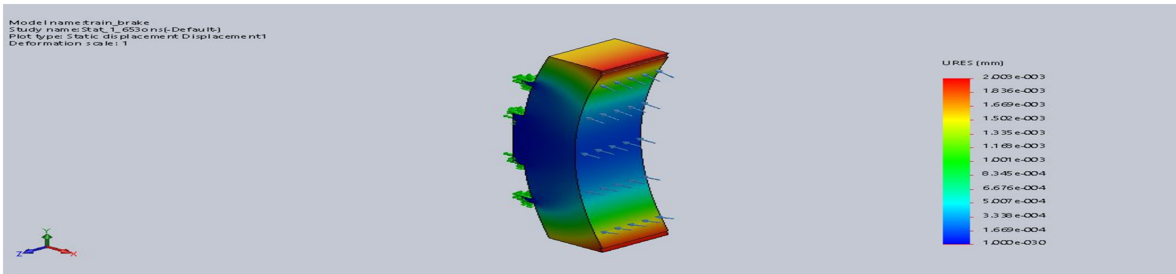

Fig.8 Displacement Results for Nickel Chromium

3) Strain

Name	Type	Minimum	Maximum
Strain	Equivalent Strain	1.233e-007 Element: 2486	1.801e-005 Element: 1767

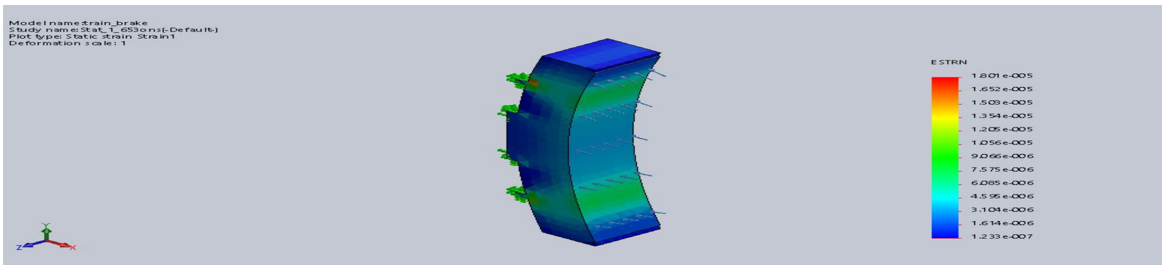

Fig.9 Strain Results for Nickel chromium

Static Analysis for 2.187 ton , Applied Pressure 0.73 N/mm^2

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D. High Carbon Steel

1) Stress

Name	Type	Minimum	Maximum
Stress	Von Mises Stress	2.399e-008 N/mm^2 (MPa) Node: 679	6.610e+000 N/mm^2(MPa) Node: 8377

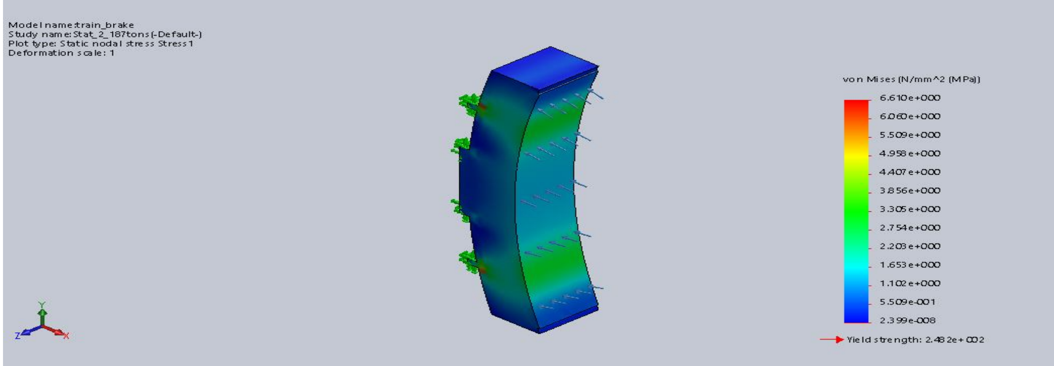

Fig.10 Stress Results for High Carbon Steel

2) Displacement

Name	Type	Minimum	Maximum
Displacement	Resultant Displacement	0.000e+000 mm Node: 275	3.270e-003 mm Node: 227

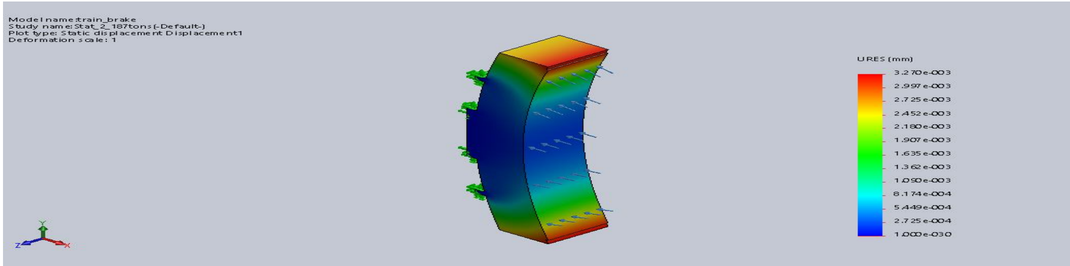

Fig.11 Displacement Results for High Carbon Steel

3) Strain

Name	Type	Minimum	Maximum
Strain	Resultant Strain	1.976e-007 Element: 1662	2.917e-005 Element: 1649

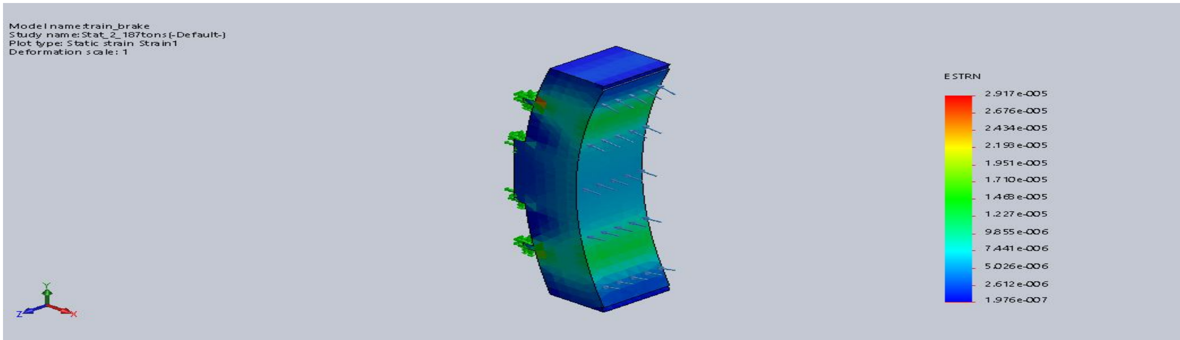

Fig.12 Strain Results for High Carbon Steel

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E. Malleable Cast Iron

1) Stress

Name	Type	Minimum	Maximum
Stress	Von Mises Stress	2.406e-008 N/mm^2 (MPa) Node: 7260	6.782e+000 N/mm^2 (MPa) Node: 8377

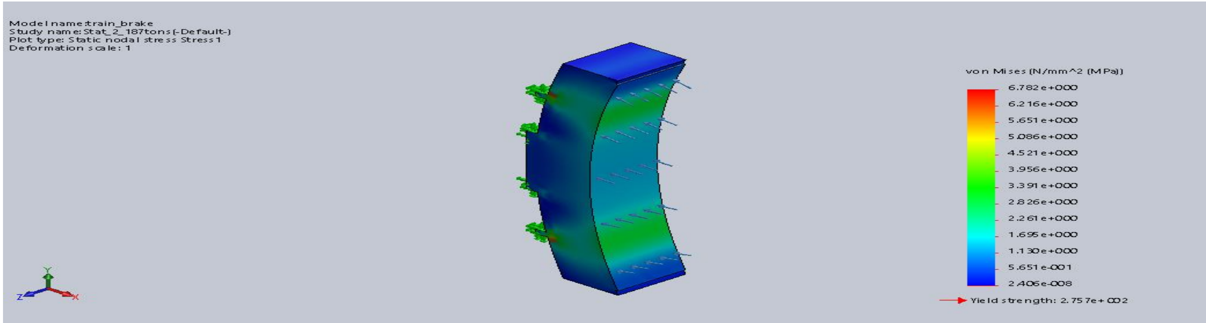

Fig.13 Maximum Stress Results for Malleable Cast Iron

2) Displacement

Name	Type	Minimum	Maximum
Displacement	Resultant Displacement	0.000e+000 mm Node: 275	3.431e-003 mm Node: 227

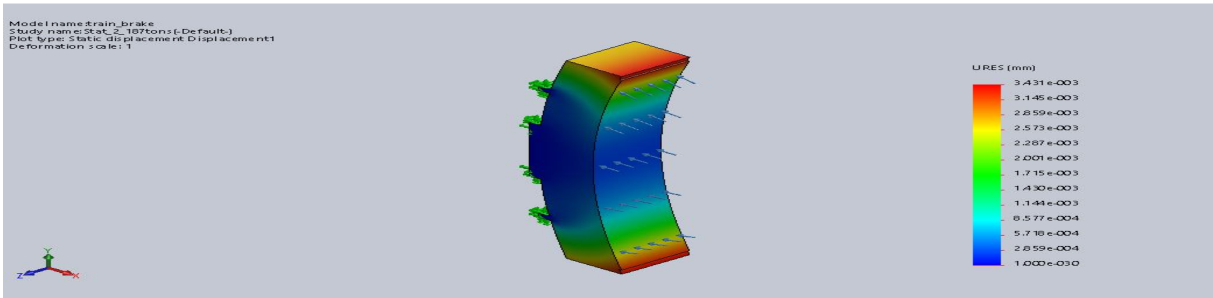

Fig.14 Displacement Results for Malleable Cast Iron

3) Strain

Name	Type	Minimum	Maximum
Strain	Resultant Strain	2.252e-007 Element: 4507	3.080e-005 Element: 1767

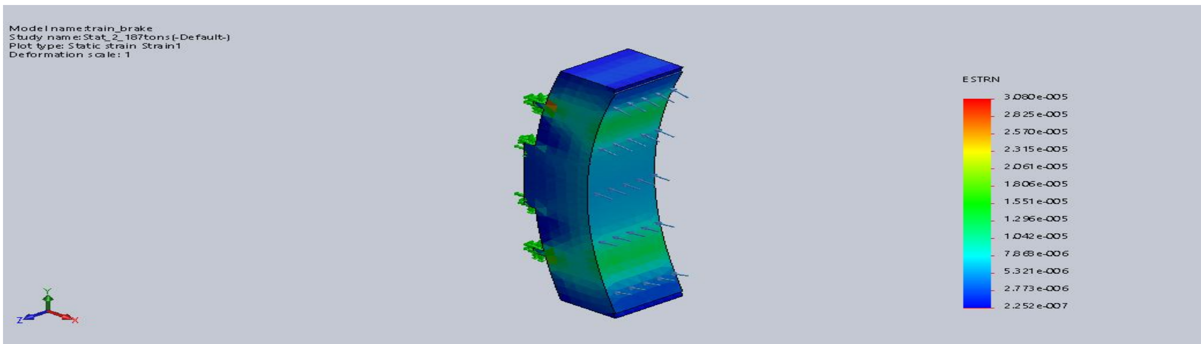

Fig.15 Strain Results for Malleable Cast Iron

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F. Nickel Chromium

1) Stress

Name	***Type***	***Minimum***	***Maximum***
Stress	*Von Mises Stress*	*2.405e-008 N/mm^2 (MPa)* *Node: 7260*	*6.813e+000 N/mm^2 (MPa)* *Node: 8377*

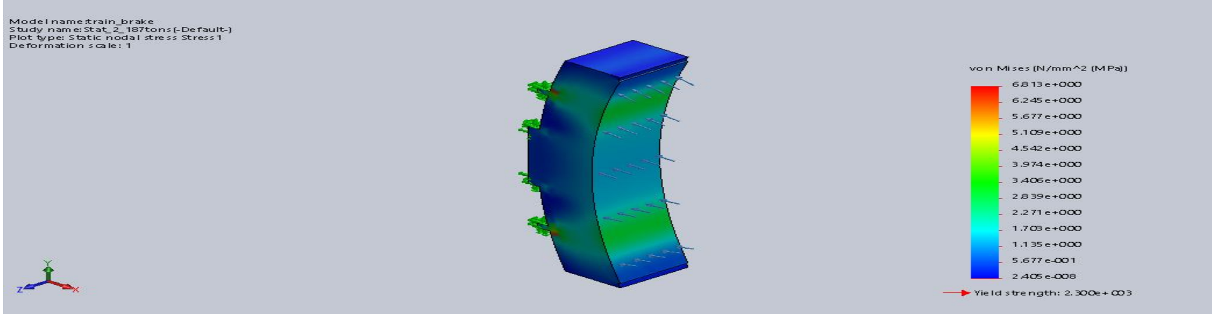

Fig.16 Stress Results for Nickel Chromium

2) Displacement

Name	Type	Minimum	Maximum
Displacement	Resultant Displacement	0.000e+000mm Node: 275	2.658e-003mm Node: 227

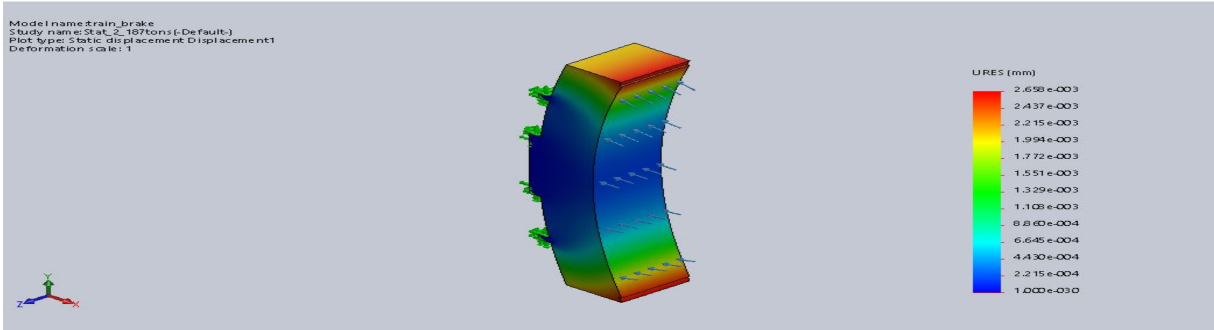

Fig.17 Displacement Results for Nickel Chromium

3) Strain

Name	Type	Minimum	Maximum
Strain	Resultant Strain	1.637e-007 Element: 2486	2.390e-005 Element: 1767

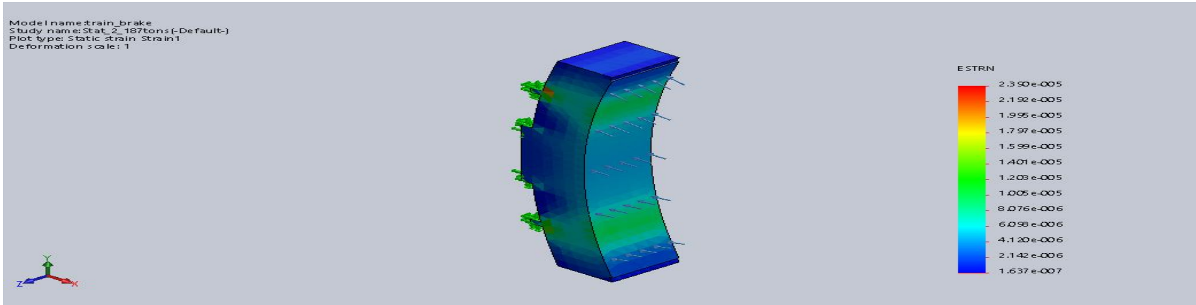

Fig.18 Strain Results for Nickel Chromium

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G. Modal Analysis

1) High Carbon Steel

Name	Type	Minimum	Maximum
Amplitude 1	AMPRES: Resultant Amplitude Plot for Mode Shape: 1(Value = 3933.73 Hz)	0.000e+000 Node: 275	8.027e-001 Node: 224

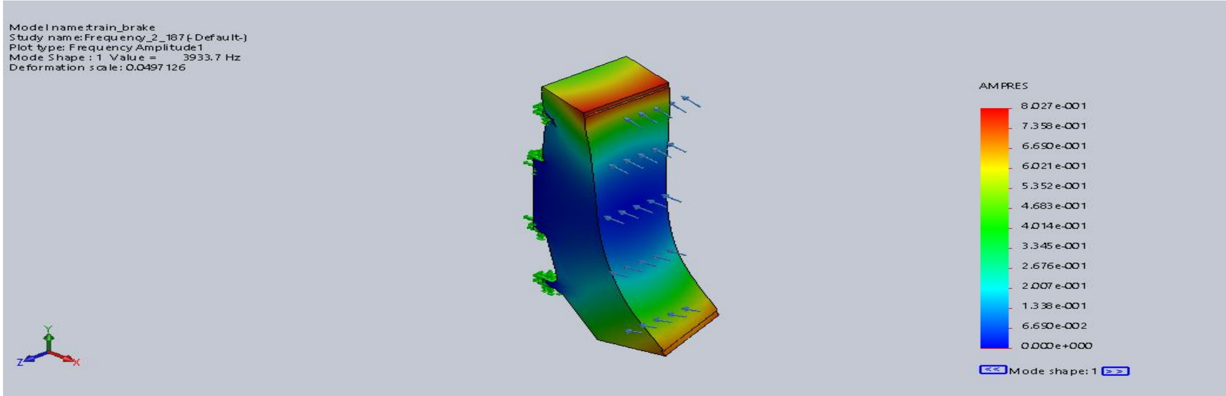

Fig.19 Amplitude 1 Results for High Carbon Steel

2) Malleable Cast Iron

Name	Type	Minimum	Maximum
Amplitude 1	AMPRES: Resultant Amplitude Plot for Mode Shape: 1(Value = 3970.78 Hz)	0.000e+000 Node: 275	8.481e-001 Node: 224

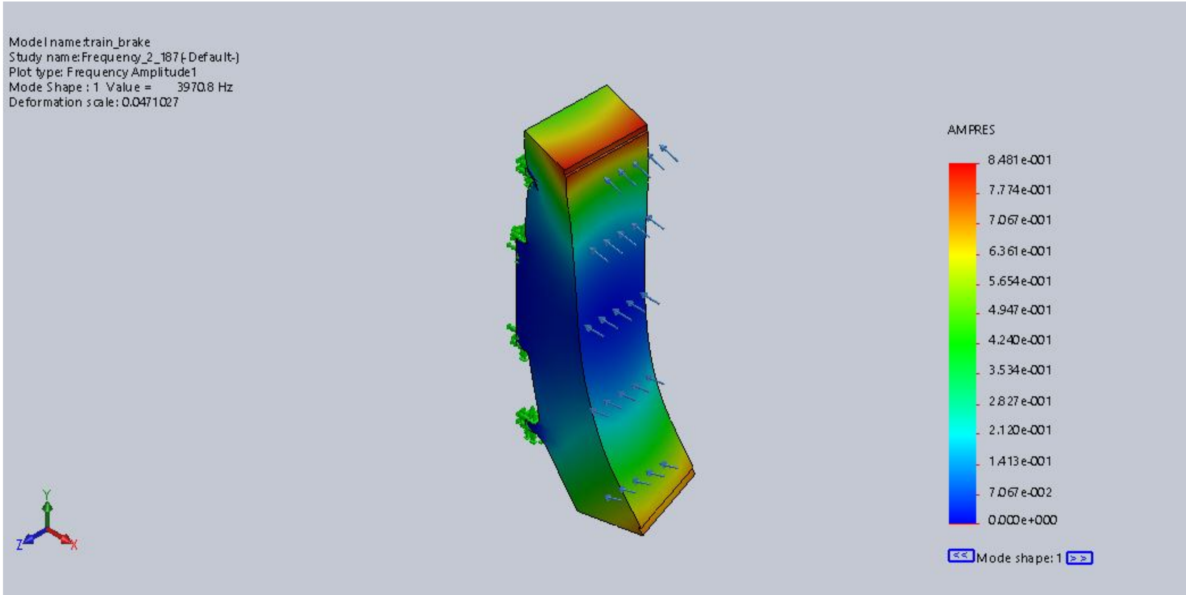

Fig.20 Amplitude 1 Results for Malleable Cast Iron

3) Nickel Chromium

Name	Type	Minimum	Maximum
Amplitude 1	AMPRES: Resultant Amplitude Plot for Mode Shape: 1(Value = 4144.7 Hz)	0.000e+000 Node: 275	7.834e-001 Node: 224

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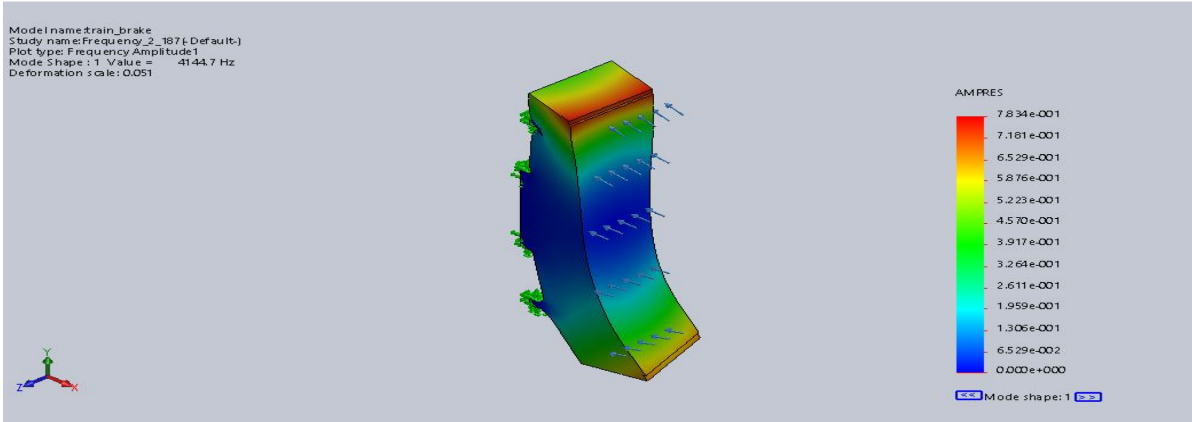

Fig.21 Amplitude 1 Results for Nickel Chromium

IV. RESULTS TABLE

A. For load 1.653-ton pressure 0.55 N/mm²

S.No	Material	Stress (N/mm^2)	Displacement (mm)	Strain
1.	High Carbon Steel	4.9805	2.463e-3	2.198e-5
2.	Malleable Cast Iron	5.109	2.585e-3	2.320e-5
3.	Nickel Chromium	5.133	2.003e-3	1.801e-5

B. For load 2.187-ton pressure 0.73 N/mm²

S.No	Material	Stress (N/mm^2)	Displacement (mm)	Strain
1.	High Carbon Steel	6.610	3.270e-3	2.917e-5
2.	Malleable Cast Iron	6.782	3.431e-3	3.080e-5
3.	Nickel Chromium	6.813	2.658e-3	2.390e-5

S.No	Material	Amplitude 1 (Hz)	Amplitude 2 (Hz)	Amplitude 3 (Hz)	Amplitude 4 (Hz)	Amplitude 5 (Hz)
1.	High Carbon Steel	0.8027	0.8055	0.8001	0.8147	0.7663
2.	Malleable Cast Iron	0.8481	0.8498	0.8278	0.8422	0.7821
3.	Nickel Chromium	0.7834	0.7848	0.7607	0.7738	0.7168

V. CONCLUSION

In this project we are calculated the von mises stress, displacement, strain for the High carbon steel, Malleable cast iron and Nickel chromium. Thus we are prepared the 3D models by solid works software. Presently using material for manufacturing of train brake shoe is High carbon steel we modify that material to Malleable cast iron and Nickel chromium. By the comparing the static results the Malleable cast iron has little more than the High carbon steel and less than the Nickel chromium materials. By comparing the modal analysis from the above tables we got less frequency for Nickel Chromium than other two materials, the malleable cast iron was more frequency than other materials and possess high strength Finally, we are concluding that present material high carbon steel will be replacing with the Malleable cast iron is good for future.

VI. FUTURE SCOPE

From the study this clear that there is huge scope of designing of train brake shoe for trains. This can be improving the life of brake shoe, heat dissipation from in between the wheels and brake shoe and reducing the thermal cracks on the brake shoe that can be achieved by changing the material. Changing the suitable material for train brake shoe easily we are increasing the life of brake shoe and reducing the cracks on the surface of the brake shoe. So doing more experiments on the materials we are easily selecting good material.

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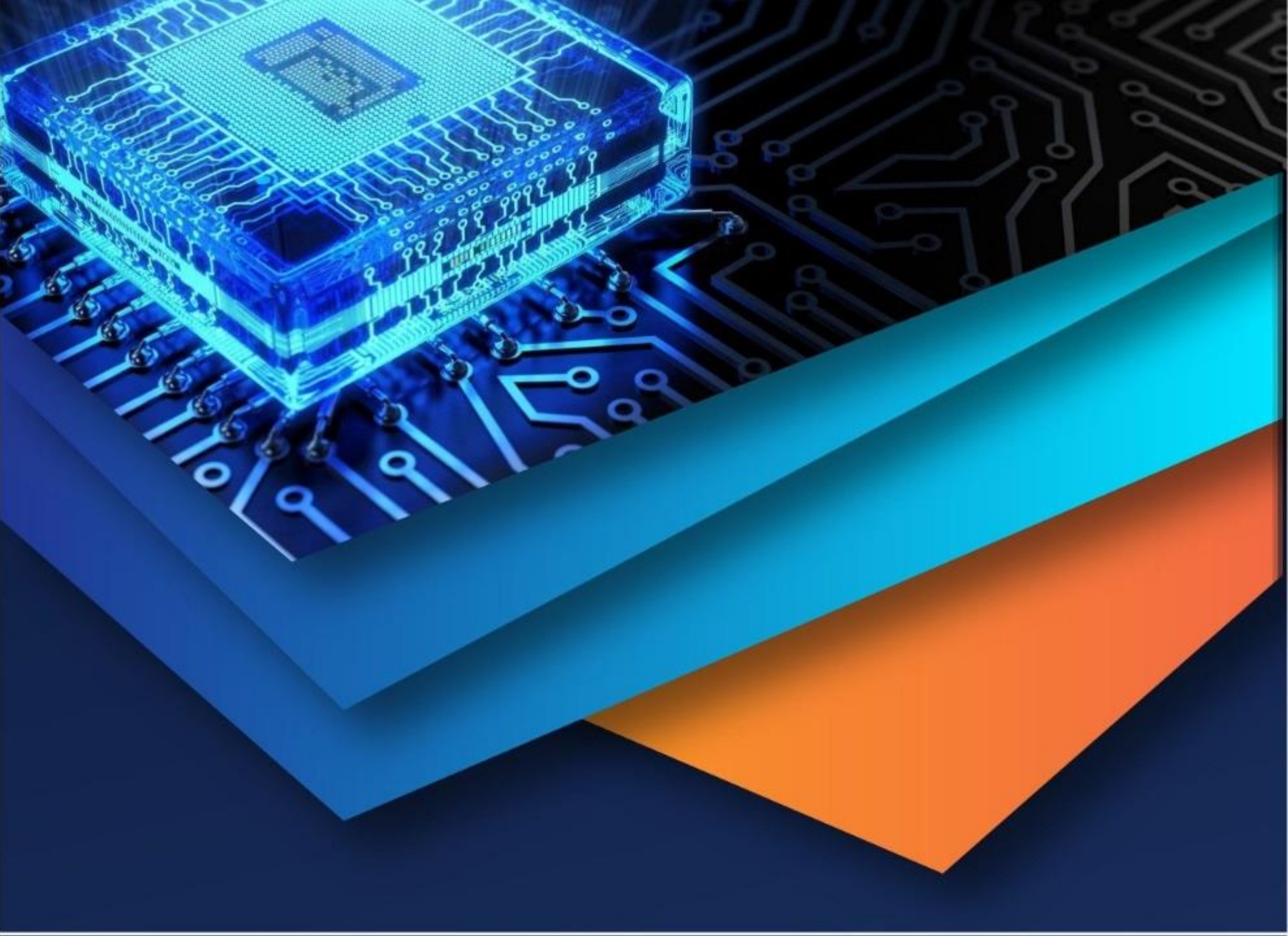

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