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Stress Analysis of Maraging Steel Differential Gear using ANSYS

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Abstract: The main purpose of this project paper is to focus on stress analysis of differential gear. For power transmitted from the engine to the rear wheels the differential gear is used. In a Vehicles, the differential gear provides equal power to all drive wheels while allowing each driving wheel to turn at a different angle and different velocity. Basically, while turning around corners, wheels of an automobile spin at differing velocity. Differential gears fails when tooth tension exceeds its safety limit. Therefore, the maximum capacity at the specified load should be determined. Gears analysis is done to minimize stress on gear teeth and prevents the gear to failure. The purpose of this project is to compare the results obtained on different materials (i.e., Maraging steel, aluminium alloy, cast steel) and achieve a suitable material for Differential Gear without any failure using ANSYS and Solid Works software.
Keywords: Differential Gear, Stress Analysis, ANSYS, Maraging Steel, Solid Works.

I. INTRODUCTION

This project's motive directed towards determining the outcome of meshing gear tooth stresses and deformation by creating the virtual 3D model of a differential gear assembly. The analysis is done in ANSYS Work Bench and designed using Solid Works software. The differential gear permits each one of the driving roads wheels in automobiles to spin at different velocity, whereas for almost all vehicles providing equivalent rotational force to each one of them. Wheels of a vehicle rotate at various velocity, basically while turning around corners. To transfer the power from engine to the hind wheels, a differential gear is used. For running a set of two wheels with equivalent rotational force, a differential gear is specifically designed although letting them to spin at differing velocity. The differential gears are the part of the ultimate drive assembly. The purpose is to rotate the innermost wheels at differing velocity every time the automobile takes turn from straight track and as well to permit equivalent torques on every one of the wheels, even though when they revolving at dissimilar speeds.

The innermost wheel needs to travel less distance than the outermost wheel, while turning around corners, thus without differential, the outcome is the innermost wheel will be spinning and the outermost wheel will be hauling, and that arises in burdensome controlling and harm the tires on road and difficulty on whole driving systems.

For design analysis in mechanical engineering Ansys is an essential software. Ansys is a software which is used to design a parts and structure or component by analysis the design. It is automation application by this we can easily calculate the stresses generated in component and failure conditions as well as which is completely integrated with ProEngineer. The Finite Element Method (FEM) is utilized by this software to simulate the working circumstances of the designs and forecast their behaviour. Powered by instant solvers, Ansys makes it feasible for designers to instantaneously look over the probity of their designs and search for the best solution.

II. LITERATURE SURVEY

Ref. No.	Author Name	About Work	Outcome Of Work
1.	Ronak P Panchal & Pratik B Umrigar	I. Attributes of a bevel gear in dynamic condition involving meshing stiffness and stresses produced. II. Advanced the theoretical model of bevel gear by using numerical approach.	Resolved the consequences by grabbing material case hardened alloy steel for stresses generated during meshing of gear tooth.
2.	Rossinoa S V Khandagale	Inspection to resolute the failure of case-hardened pinion and causes of surface contact fatigue.	Found out the pinion teeth favored surface crack and cyclic loading leading to spallation with counterpart gear.
3.	S H Gawande & Luciana Sgarbi	I. Customized the differential gear using pro-e software. II. And the impact analysis for cast steel & aluminum alloy.	Contrast and analyzed the composite gear with functioning cast iron gear using ANSYS 13.0.

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4.	Gregory Antony	I. Introduced an analytical model for evaluating and forecasting the frictional losses arising in differential gearbox. II. Elaborated specifications in this model that can be decisive (geometric parameters).	Sensitive Analysis was counseled, to examine the effect of these parameters and to determine the potential of the model and to forecasting some mechanical deprivations.

III. RESEARCH GAP

1) The study shows that differential gear fails due to spalling, abrasive wear, excessive wear, pitting, frosting breakage.
2) So far, the material used in manufacturing of differential gears is grey cast iron (having elongation 0.1 - 0.5% & tensile strength 410 – 560 MPa), aluminium alloy (having elongation 12 - 25% & tensile strength 690 – 910 MPa) with respective properties eventually it also fails in certain condition.
3) Hence in this project we make a virtual model of the differential gear and does the analysis by compare the material i.e., cast iron & aluminium alloy with maraging steel (having elongation 5 – 12%, tensile strength 1500 – 2500 MPa and value at 0.2% proof stress = 1900 MPa). The composition of maraging steel is 18% Ni, 12% Co, 3.5% Mo, 1.8% Ti, 0.15% Al and rest iron.

IV. PROBLEM STATEMENT

The following problems due to which Gear failures: -

1) Fatigue Fracture
2) Interference
3) Surface erosion

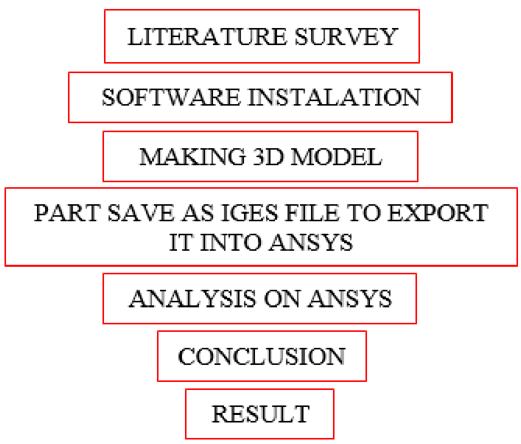
When the tooth tension exceeds the safety limit the gears break down occur. Therefore, the maximum capacity of gear at the specified load should be determined. To minimize the stresses on gear teeth and prevent from failure gears are inspected & analysis should be done. When failures occur, they are costly in costs associated with machine downtime, but also in terms of replacement and repair costs, they belong to the system part.

We have taken following materials for performing the analysis i.e., Maraging steel, aluminium alloy, cast steel. For manufacturing of gears and gears shafts currently Grey Cast Iron, Cast Steel material is used. Therefore, in this project we are checking as the other material for the differential gear box.

V. OBJECTIVE OF THE WORK

The main purpose of the project is to make a virtual 3D model of Differential Gear using SolidWorks and analysis the design model using Ansys Workbench 17.2. To compare the results obtained on different materials (i.e., Maraging steel, aluminium alloy, cast steel) and achieve a suitable material for Differential Gear without any failure.

VI. METHODOLOGY



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VII. DESIGN AND ANALYSIS

A. Design

1) Design Parameters

Part	Diameter	Teeth
Ring gear	160mm	60
Differential Pinion gear	25mm	20
Drive Pinion gear	75mm	40
Differential Side gear	25mm	20

2) Exploded Detailed View

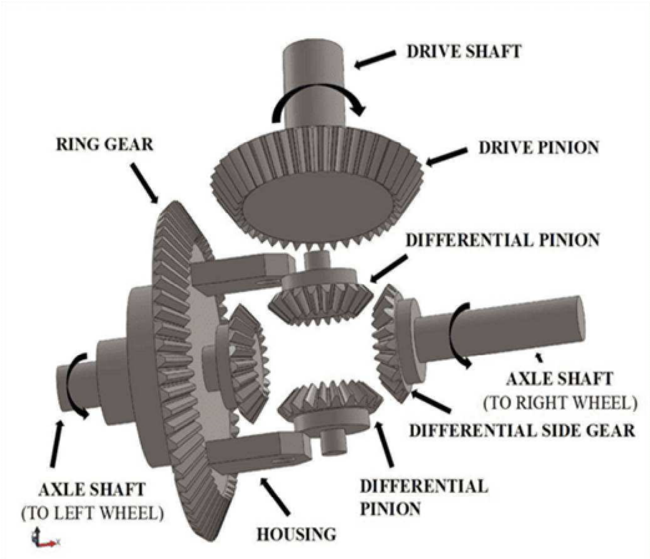

Fig.1.1

3) Assembly Of Differential Gear

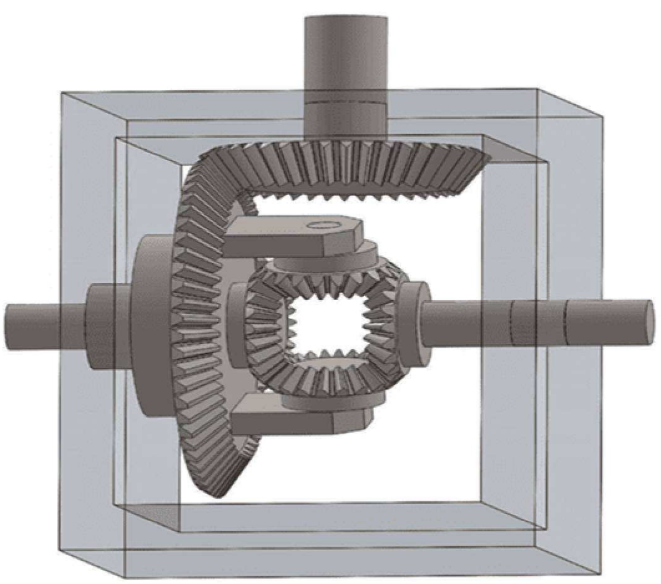

Fig.1.2

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B. Analysis

Engineering Analysis with ANSYS Software, provides a widespread adoption of CAE approach to design, finite element analysis became integrated with the procedure for design and analysis. Analysis of parts and assemblies, Structural (Static) analysis is used to determine,

- Maximum Stresses generate
- Deformation occurs in Component

1) Analysis In Ansys Workbench 17.2

a) Geometry Importing

The model is done in Solid Works 2020 is saved as in .iges file format and then it is imported in ANSYS Workbench software.

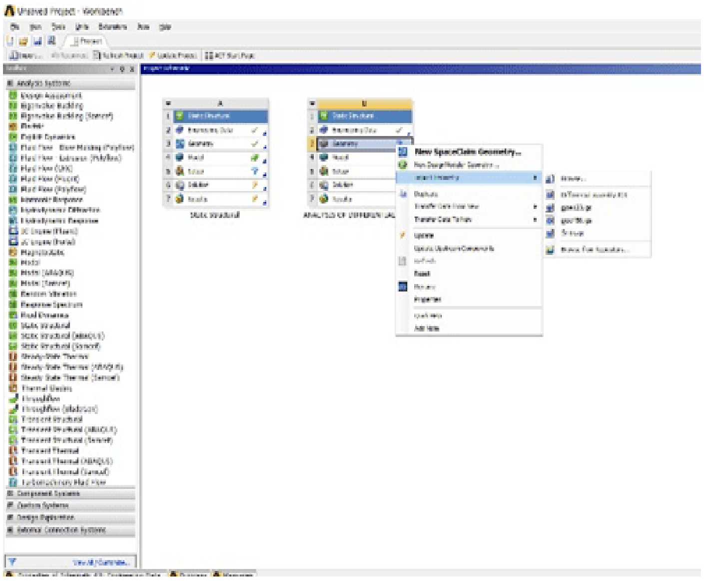

Fig.2.1

b) Meshing Generation

Meshing is a process of generating a three-dimensional grid which works is to divide the intricate geometries into elements that can be used to detach an area. It has a significant role when it comes to the engineering simulation process. It impacts the accuracy & speed of simulation and the resources required to perform the analysis. To balance these requirements ANSYS Meshing technology facilitate a way and obtain the right mesh for each simulation in the most automated way possible.

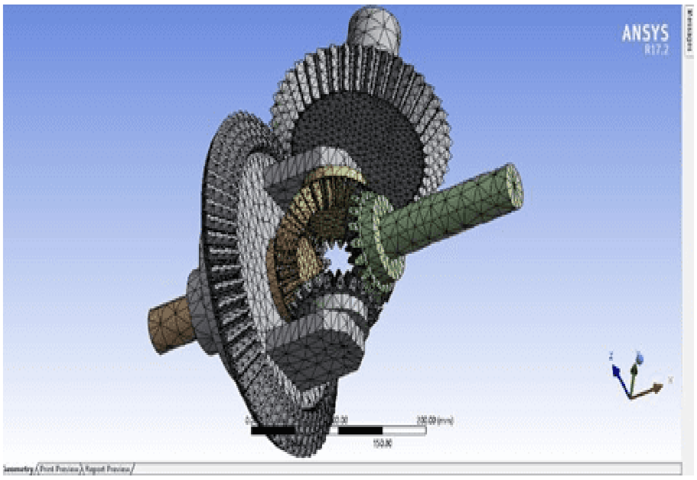

Fig.2.2

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2) Properties Of Selective Materials

In engineering data tab, we select the required material and fill the properties of maraging steel. The properties of materials are as follow: -

TABLE -1 PROPERTIES OF CAST IRON

Name	Grey Cast Iron
Model type	Linear Elastic Isotropic
Default Failure Criterion	Max von Mises Stress
Shear Modulus	8.6e+10 N/m2
Tensile Strength	4.13613e+8 N/m2
Elongation	0.1 – 0.5%
Elastic Modulus	1.9e+11 N/m2
Mass Density	7.3 g/cm3
Yield Strength	2.75742e+8 N/m2

TABLE -2 PROPERTIES OF ALUMINUM ALLOY

Name	Aluminum alloy
Model type	Linear Elastic Isotropic
Default Failure Criterion	Max von Mises Stress
Shear Modulus	3.189e+10 N/m2
Tensile Strength	3.0e+8 N/m2
Elongation	12 – 25%
Elastic Modulus	7e+11 N/m2
Mass Density	2.6 g/cm3
Yield Strength	1.65e+8 N/m2

TABLE -3 PROPERTIES OF MARAGING STEEL

Name	[18Ni(250)]
Model type	Linear Elastic Isotropic
Default Failure Criterion	Max von Mises Stress
Shear Modulus	7.7e+10
Tensile Strength	1.9e+9 N/m2
Elongation	5 – 12%
Elastic Modulus	2.1e+11 N/m2
Mass Density	8.1 g/cm3
Yield Strength	1.835e+9 N/m2

3) Applying Boundry Condition For Analysis

For calculation in finite element in ANSYS applying of the boundary condition is most essential. Accordingly, here I have considered on input gear as a frictionless support which allows the tangential rotation in pinion gear. After that applying a moment which is in counter clockwise direction, hence it is used as a driving torque. Further we select the criteria in which solution is form.

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We applying different – different torque on selected material and get solution as follow: -

a) Grey Cast Iron

- *At 380 N.m Torque*

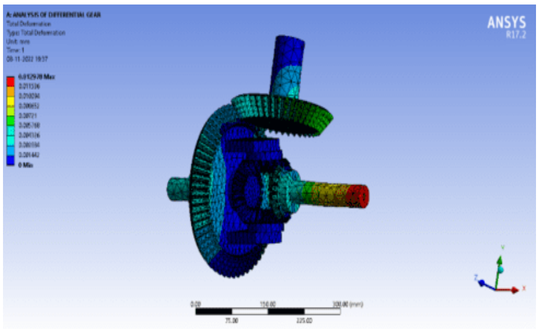

Fig.2.3.1 Total Deformation

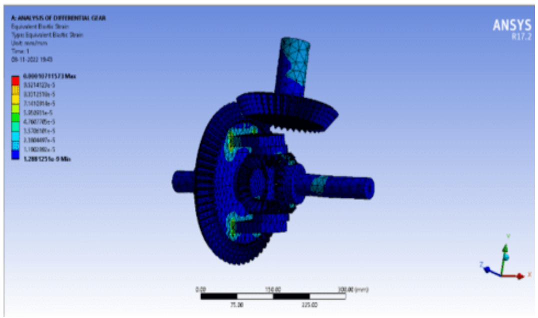

Fig.2.3.2 Equivalent Elastic Strain

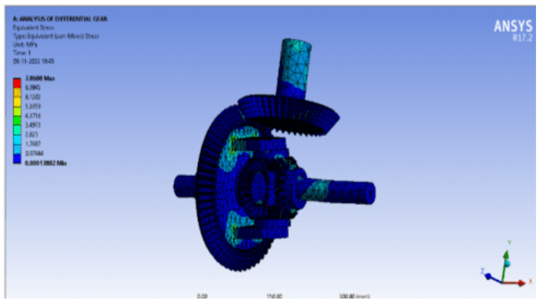

Fig.2.3.3 Von-Mises Stresses

- *At 545 N.m Torque*

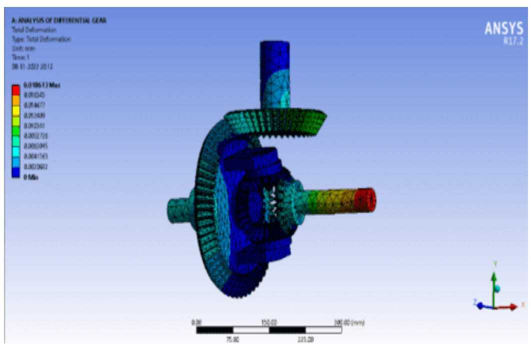

Fig.2.3.4 Total Deformation

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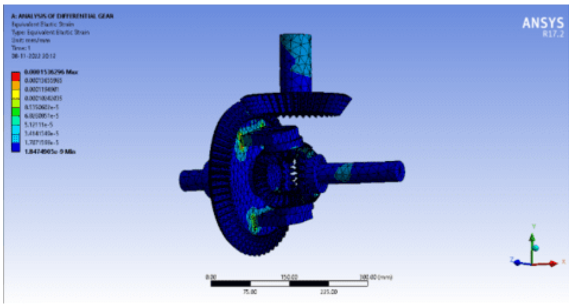

Fig.2.3.5 Equivalent Elastic Strain

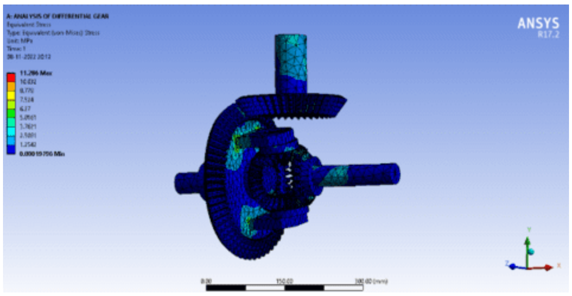

Fig.2.3.6 Von-Mises Stresses

- *At 610 N.m Torque*

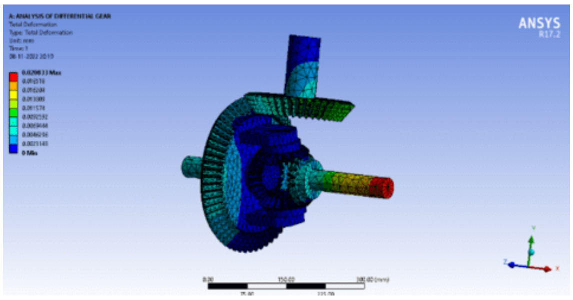

Fig.2.3.7 Total Deformation

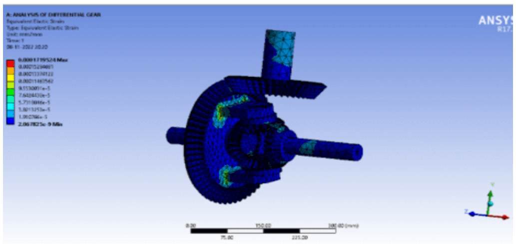

Fig.2.3.8 Equivalent Elastic Strain

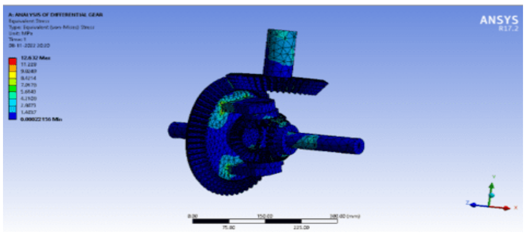

Fig.2.3.9 Von-Mises Stresses

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b) Aluminium Alloy

- *At 380 N.m Torque*

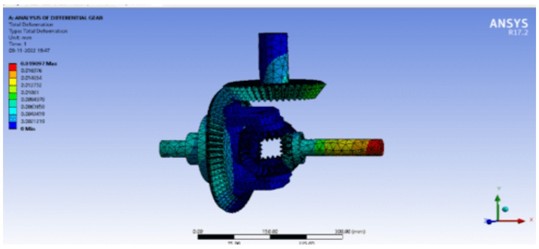

Fig.2.4.1 Total Deformation

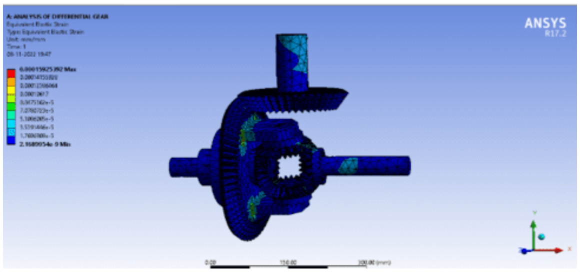

Fig.2.4.2 Equivalent Elastic Strain

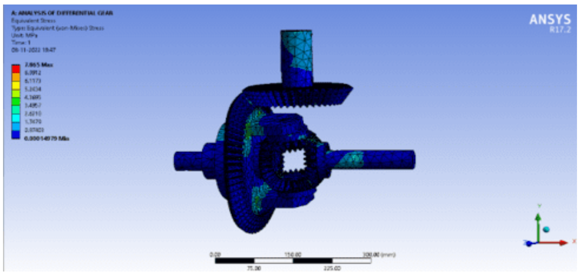

Fig.2.4.3 Von-Mises Stresses

- *At 545 N.m Torque*

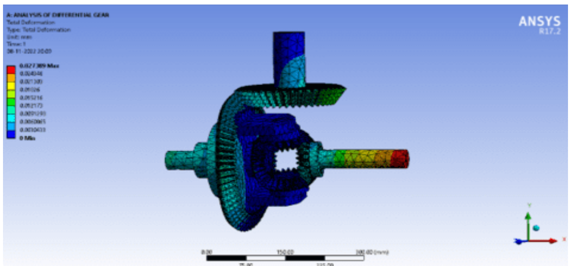

Fig.2.4.4 Total Deformation

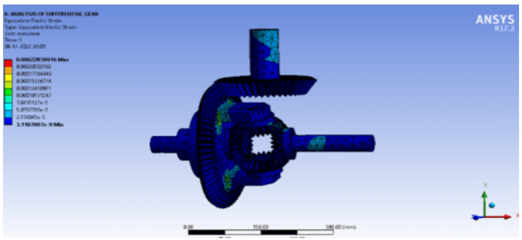

Fig.2.4.5 Equivalent Elastic Strain

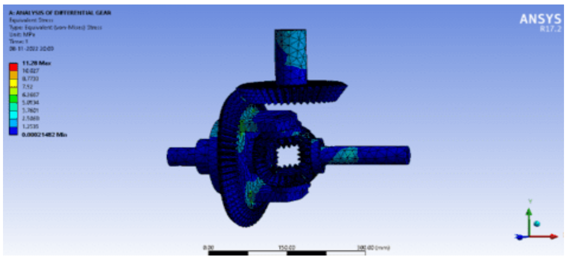

Fig.2.4.6 Von-Mises Stresses

- *At 610 N.m Torque*

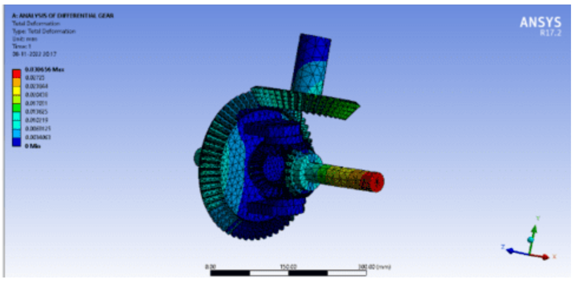

Fig.2.4.7 Total Deformation

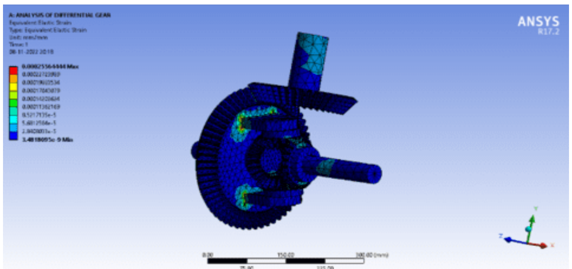

Fig.2.4.8 Equivalent Elastic Strain

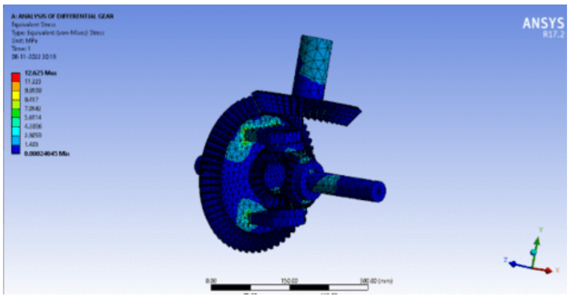

Fig.2.4.9 Von-Mises Stresses

c) *Maraging Steel*

- *At 380 N.m Torque*

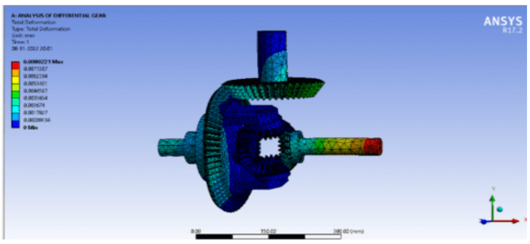

Fig.2.5.1 Total Deformation

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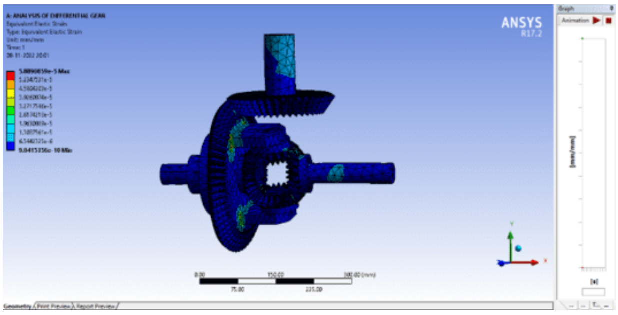

Fig.2.5.2 Equivalent Elastic Strain

- *At 545 N.m Torque*

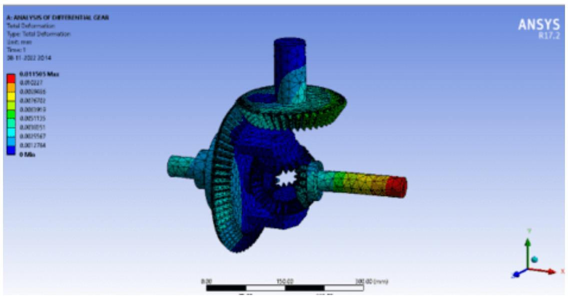

Fig.2.5.3 Total Deformation

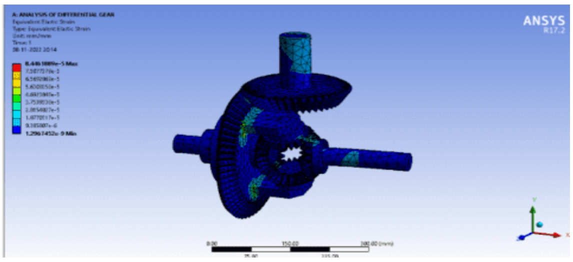

Fig.2.5.4 Equivalent Elastic Strain

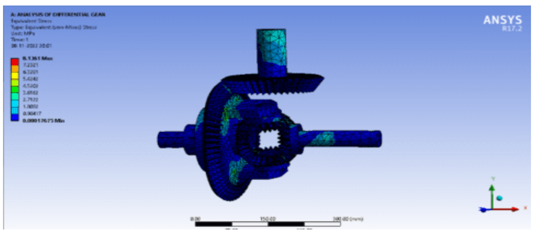

Fig.2.5.5 Von-Mises Stresses

- *At 610 N.m Torque*

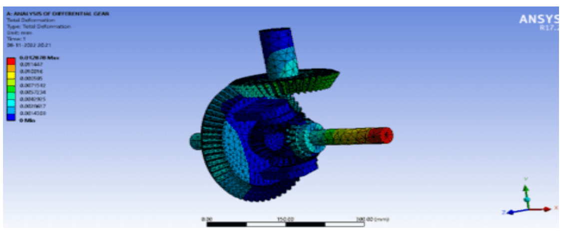

Fig.2.5.6 Total Deformation

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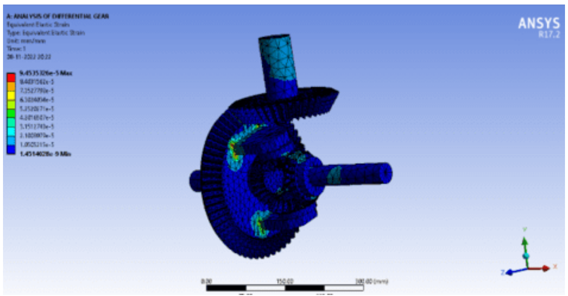


Fig.2.5.7 Equivalent Elastic Strain

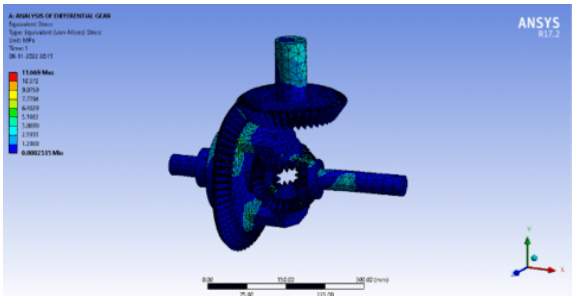


Fig.2.5.8 Von-Mises Stresses

VIII. COMPARISON OF RESULTS

TABLE - 4 FOR GRAY CAST IRON

S. No	Torque	Total Deformation	Equivalent Elastic Strain	Von-Mises Stresses
1	380 N.m	0.012978 mm	1.0712e-4	7.868 MPa
2	545 N.m	0.018613 mm	1.5363e-4	11.286 MPa
3	610 N.m	0.020833 mm	1.7195e-4	12.632 MPa

TABLE - 5 FOR ALUMINUM ALLOY

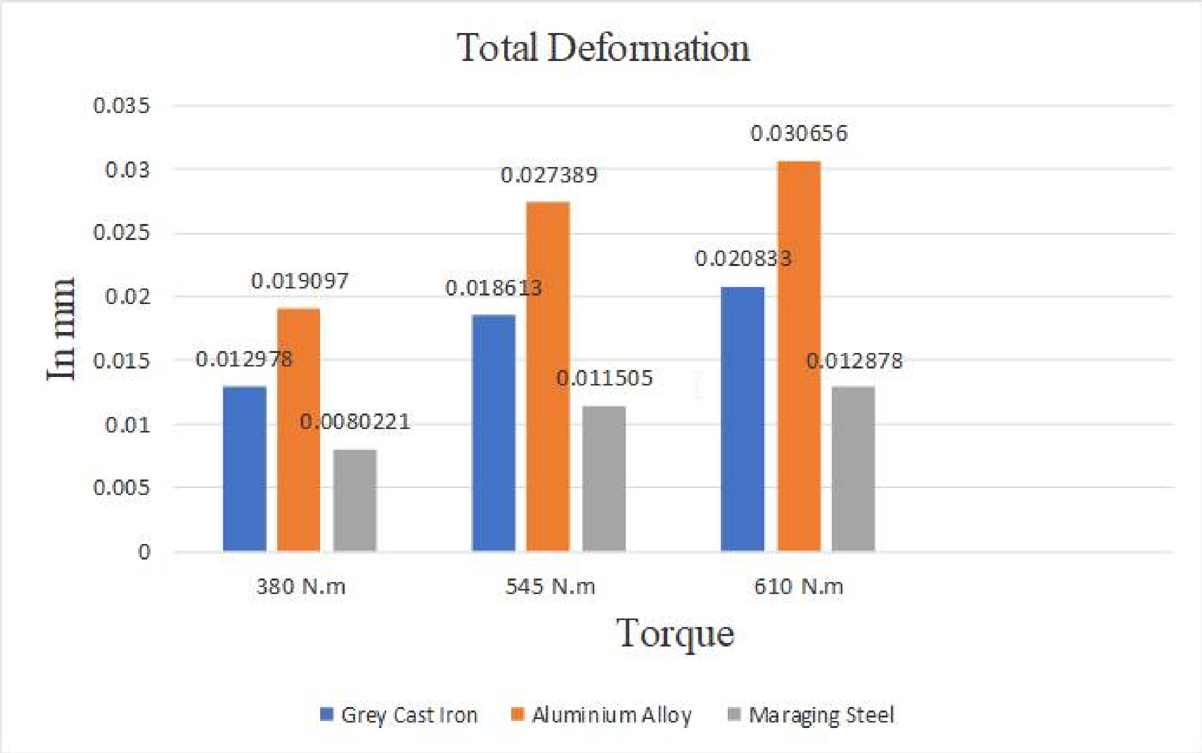
S. No	Torque	Total Deformation	Equivalent Elastic Strain	Von-Mises Stresses
1	380 N.m	0.019097 mm	1.5925e-4	7.865 MPa
2	545 N.m	0.027389 mm	2.2839e-4	11.28 MPa
3	610 N.m	0.030656 mm	2.5564e-4	12.625 MPa

TABLE - 6 FOR MARAGING STEEL [18NI(250)]

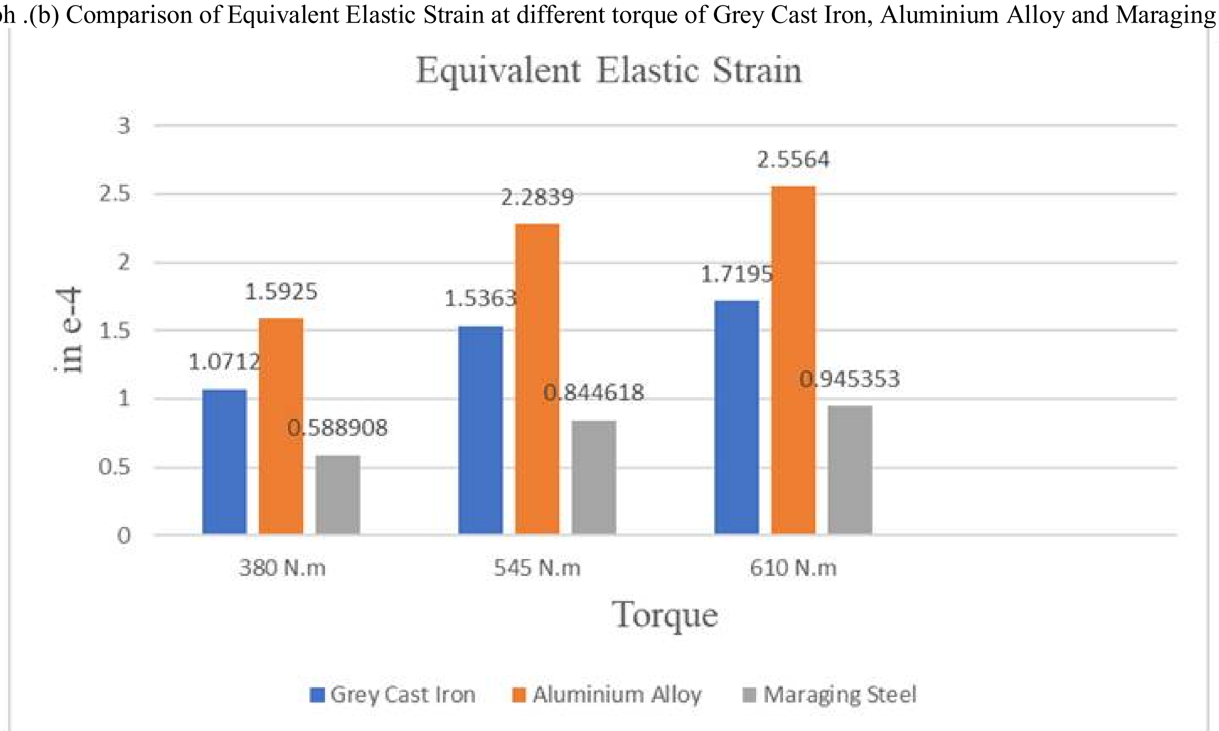
S. No.	Torque	Total Deformation	Equivalent Elastic Strain	Von-Mises Stresses
1	380 N.m	0.0080221 mm	5.88908e-5	6.1453 MPa
2	545 N.m	0.011505 mm	8.44618e-5	8.1361 MPa
3	610 N.m	0.012878 mm	9.45353e-5	11.669 MPa

GRAPHS

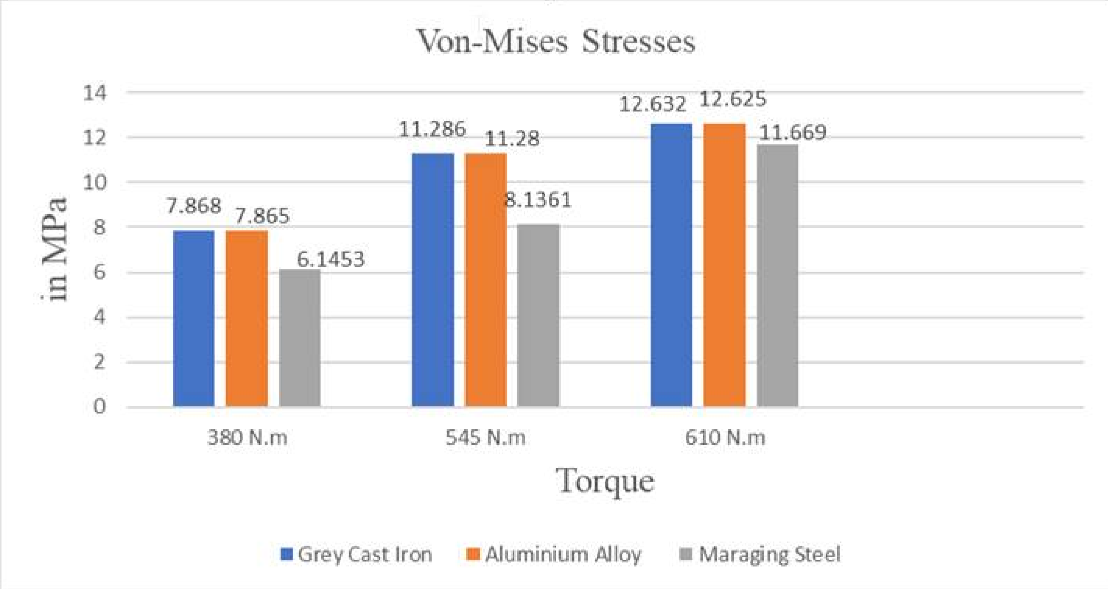
Graph. (a) Comparison of total deformation at different torque of Grey Cast Iron, Aluminium Alloy and Maraging Steel.



Graph .(b) Comparison of Equivalent Elastic Strain at different torque of Grey Cast Iron, Aluminium Alloy and Maraging Steel.



Graph. (c) Comparison of Von-Mises Stresses at different torque of Grey Cast Iron, Aluminium Alloy and Maraging Steel.



IX. CONCLUSION

1) By the comparison between Maraging steel and Cast iron, Aluminium Alloy; Maraging steel is superior material for manufacturing of gears in differential gearbox due to its excellent strength.
2) From a result we conclude that maraging steel have less deformation and bear more stress in comparison to other material.
3) So that we achieve a suitable material for Differential Gear without any failure.
4) We use this material in manufacturing of Differential Gear.

X. ACKNOWLEDGMENT

Cooperation & coordination helps in completion of any work, and together efforts of some sources of knowledge. We would like to express our special thanks of gratitude to our guide Mr. Puneet Bhatia, who helped us in making of the virtual 3D model. And also, we are thankful for the assist contributed by Mechanical Engineering Department of Buddha Institute of Technology, GIDA (Gorakhpur) in terms of computer and software's. Without their active guidance, help, cooperation and encouragement we would not have made headway in this paper.

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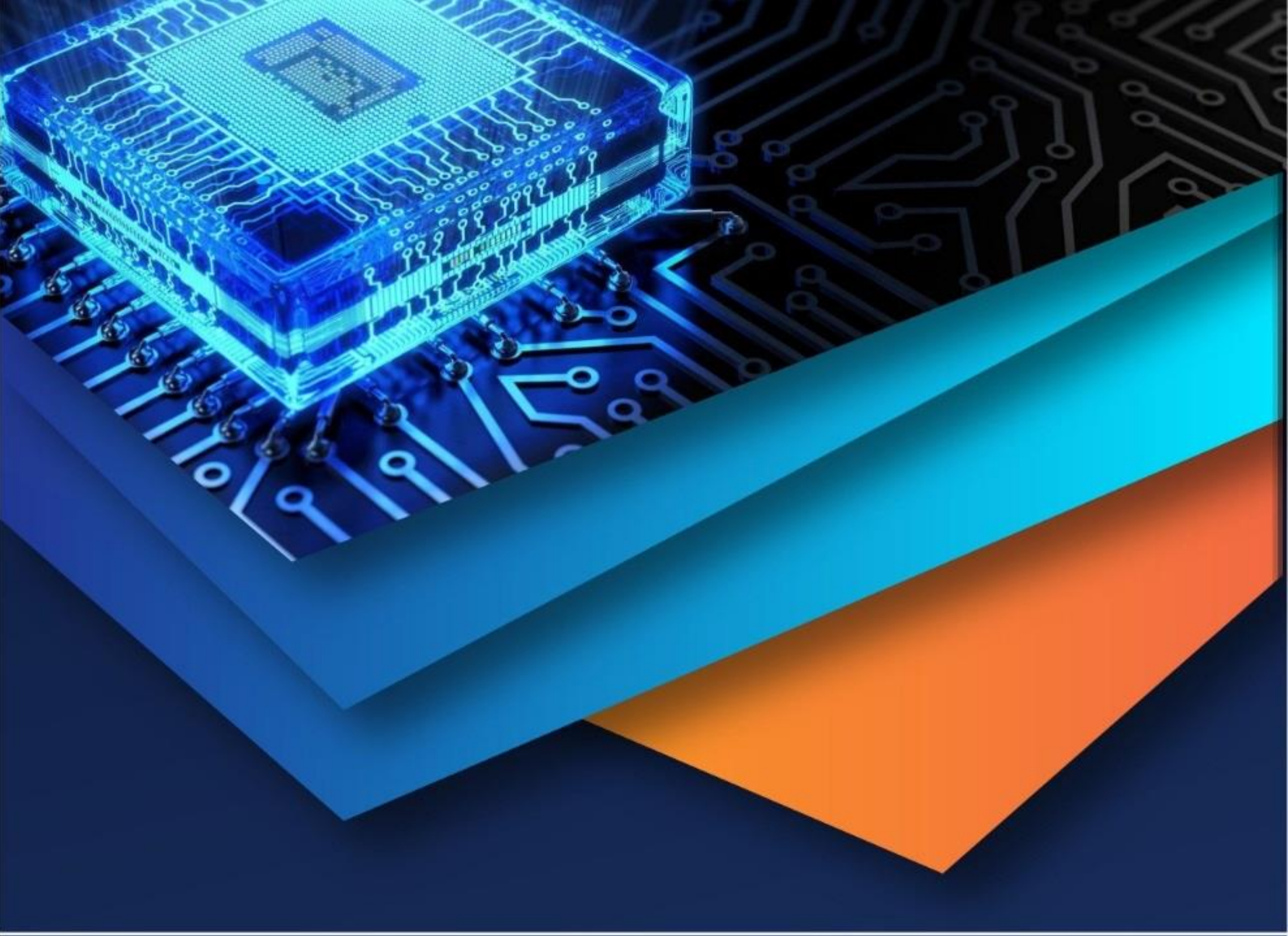

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