Design And Analysis Of Differential Of LMV Using Composite Materials

Study of forces on Differential

[1]Prathamesh Patil, [2]Abhishek Pathak, [3]Omkar Nikam, [4]Pravin Alone
[1]B.Tech Mechanical, [2]B.Tech Mechanical, [3]B.Tech Mechanical,
[4]Assistant Professor,
Department of Mechanical Engineering, New Horizon Institute Of Technology And Management
Kavesar, Thane.

Abstract: The main aim of this paper is to focus on the design and analysis of the assembly of gears in the differential gearbox of LMV. when they transmit power at a speed of 2000 RPM and 4400 RPM. The analysis is also conducted by different materials for gears i.e Cast Iron, Cast Steels and Aluminum Alloy. Generally, materials used for gears and gear shafts are Cast Iron, Cast steel. This paper testing different materials like Aluminum alloy and Nickel Chromium Alloy material for reducing the weight of the differential gearbox. Stress and displacement are analyzed by considering weight reduction in the gearbox at a higher speed. The analysis is done in Ansys software. All the parts of the differential are designed under static condition. The required data is taken from a journal paper. Modelling and assembly are done in SolidWorks. The detailed drawings of all parts are to be equipped.

KEYWORDS: Differential Gearbox Design, Assembly Analysis, Model Analysis, Weight Reduction.

I. INTRODUCTION

The differential gearbox is used to transfer power from the engine to a pair of driving wheels. Its gear arrangement helps dividing power equally to both wheels. But allowing them to follow the path of different length while turning a corner.

In vehicles without a differential, such as karts, both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain-drive mechanism. When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the entire drive train.

II. OBJECTIVES OF OUR WORK

The main objective of our work is to design differential for LMV and to do a structural analysis of the differential Providing torque to sun gear to find the stress development and deformation in gear using different composite material

III. CALCULATIONS, MODELLING AND ANALYSIS

1. Design Concept (Calculatiom)
   Firs t Determine standard size of Differential for car and note down all the the design parameter
   Designing For
   A. Car Model : Maruti Suzuki swift LXI
   B. Engine : 4cylinder-4stroke disel Engine 1.2L
   C. Max power : 88.50 bhp@6000RPM
   D. Max torqur : 115 Nm@4400 RPM
   E. Max speed : 121mph/180 kmph

Assumptions:

Gear profile-20 Degree full depth involute profile
pressure angle (α)=20

bevel gear arrangement=90

Pitch cone Angle (φ) =45

Back cone Angle (β) =45

CALCULATION Of CROWN GEAR AND PINION

Module =5
Number of teeth on Crown gear(Zp)=42
Number of teeth on gear(Zg)=17
V.R=Zp/Zg= DG/DP=NP/NG
V.R=Zp/Zg=42/17= 2.48
Minimum no. of teeth on Crown pinion (Zp) For satisfactory operation of bevel gears the number of teeth in the pinion must not be less than= $\frac{48}{(\sqrt{1}+(v.r)^2}=\frac{48}{(\sqrt{1}+(2.48)^2}$ =6.75
hence the assumed value of the pinion is in a safe condition
Pitch circle diameter (D)

Pitch circle diameter for the gear (Dg) = M*Zg = 5*17 = 85 mm
Pitch circle diameter for the Crown (Dp) = M*Zp = 5 * 42 = 210mm
Pitch angle (θ) Since the shafts are at the right angles
the pitch angle were given as: For the pinion = θp1=tan-1(1/v.r) =tan-1(1/2.48) =22.07
Pitch angle of gear θp2=90°- 22.07=67.90
formative number of teeth (Te)
for the gear Zep= Zpsecθp1=17sec22.07 =18
for the crown gear = Zeg=Zgsecθp2=42sec67.90 =111.63
Pitch Cone Distance (AO):

$$AO = \sqrt{(\frac{PDg}{2})^2 + (\frac{PDp}{2})^2} = \sqrt{(\frac{85}{2})^2 + (\frac{210}{2})^2} = 113.27$$

Face Width (b): b = AO/3 =113.27/3 = 37.16 ≅ 38

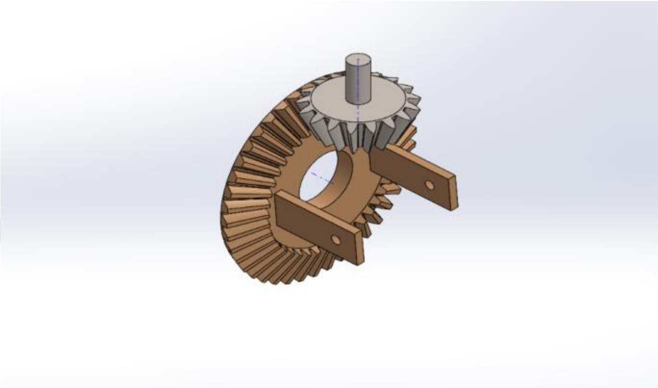

FIG 1.1 CROWN AND PINION

CALCULATION Of SIDE GEAR AND BEVEL PINION

Module =4
Number of teeth on bevel gear(Zp)21
Number of teeth on side gear(Zg)=16
V.R=Zp/Zg= DG/DP=NP/NG
V.R=Zp/Zg=21/16= 1.3126
Minimum no. of teeth on pinion (Zp) For satisfactory operation of bevel gears the number of teeth in the pinion must not be less than= $\frac{48}{(\sqrt{1+(v.r)^2}}$ = $\frac{48}{(\sqrt{1+(1.3126)^2}}$ =17.62
hence the assumed value of the pinion is in a safe condition
Pitch circle diameter (D)
Pitch circle diameter for the side gear (Dg) = M*Zg = 4*16 = 64mm
Pitch circle diameter for the bevel gear(Dp) = M*Zp = 4* 21 = 84mm
Pitch angle (θ) Since the shafts are at the right angles
the pitch angle were given as: For the pinion = θp1=tan-1(1/v.r) =tan-1(1/1.31) =37.20
Pitch angle of gear θp2=90°- 37.20=52.8
formative number of teeth (Te)
for the side gear =Zep= Zpsecθp1=16sec37.20 =20
for the bevel gear = Zeg=Zgsecθp2=21sec52.82 =34.74
Pitch Cone Distance (AO):

$$AO = \sqrt{(\frac{PDg}{2})^2 + (\frac{PDp}{2})^2} = \sqrt{(\frac{64}{2})^2 + (\frac{84}{2})^2} = 52.80$$

Face Width (b): b = AO/3 =52.80/3 = 17.60 ≅ 18

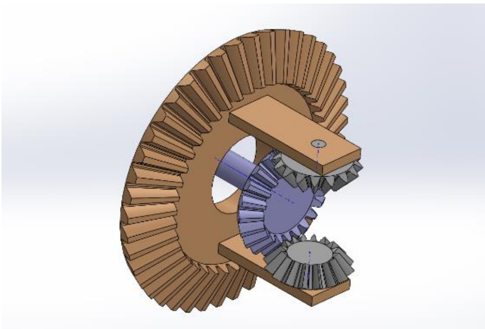

FIG 1.2

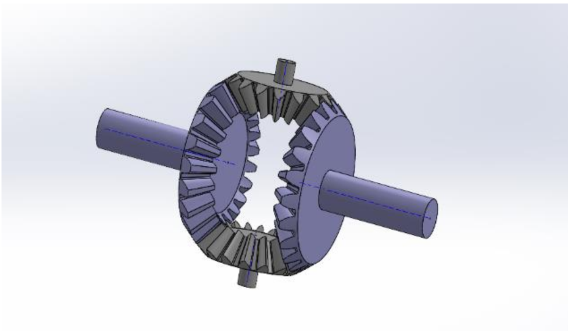

FIG 1.3

2. Modelling

To determine the structural Analysis of differential Gearbox. First, we have to create the Differential model using modelling software. here we used Solidworks for Constructing our 3D geometry of Differential Assembly. The assembly consists of 1 Driving gear to sun gear,2 side gear,2 bevel gear and sun gear. Save the assembly as an IGES file for further Analysis on Ansys software

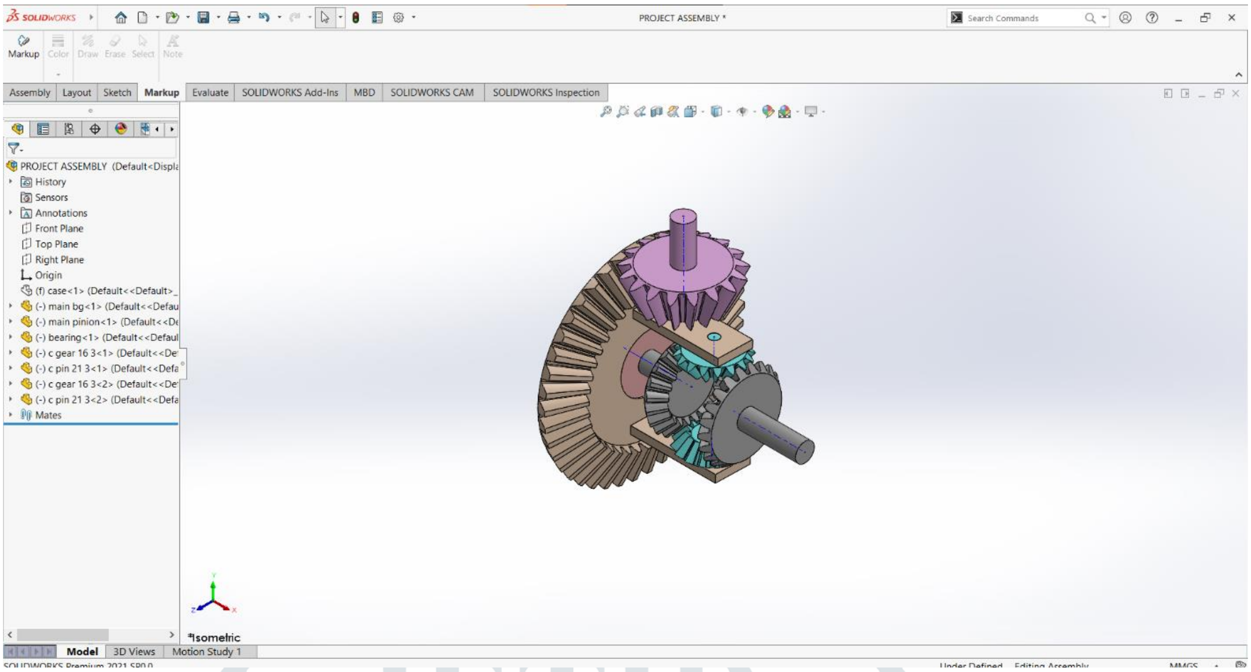

FIG 2.0

3. Analysis

For the Analysis, we import the 3D Model Geometry in Ansys. Imports the geometry as IGES format. after importing in Ansys the material is defined for 3D Geometry and then meshing is done to divide the whole geometry into small parts constructed by nodes.

Material

The commonly used material for gears is nickel-chromium steel. The material chosen for analysis is aluminium alloy and Sic reinforced ZrB2. For FEA analysis of gear manufactured from composite Young's modulus is calculated theoretically and Young's Modulus and Poisson's ratio for alloy steel has been taken from the design data book. The various Property of Material is given in below table.

Material	Nickel chromium steel	aluminium alloy	Sic reinforced ZrB2
Density	7750 kg/m3	2770 kg/m3	2060 kg/m3
Coefficient of thermal expansion	9e-10 k-1	1e-06 k-1	8.9e-06 k-1
Youngs modulus	150	71e3 mpa	4.86e5 mpa
Poisons ratio	0.28	0.33	0.11
Ultimate strength	330 mpa	310 mpa	1070 mpa
Thermal conductivity	17 w/mk	174w/mk	93.7w/mk
Specific heat	380 j/kgk	0.13j/kgk	500j/kgk
Yield strength	330 mpa	280mpa	930mpa

Mesh Generation

Finite element mesh is generated in the Ansys workbench. The von mises stress is checked for convergence. An automatic method is used to generate the mesh in the present work. The meshing of assembly is shown in figure

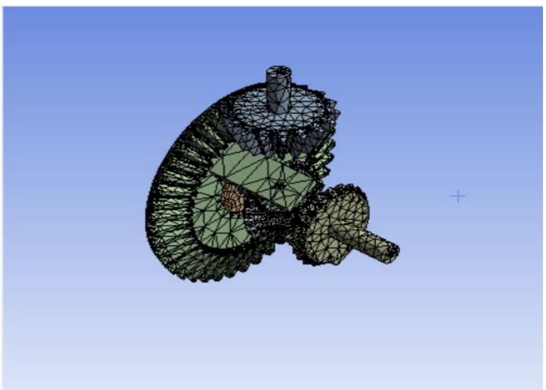

FIG 3.1.0

AT Torque = 115Nm

1.Nickel chromium steel

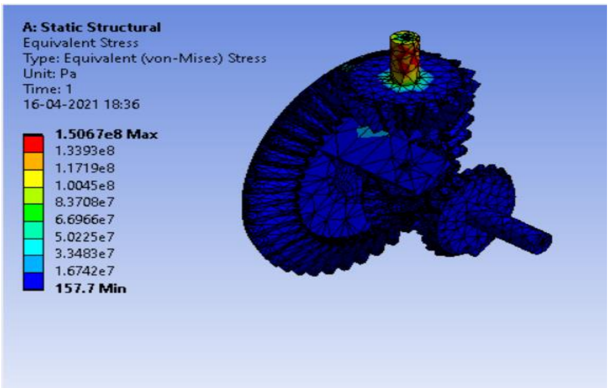

FIG 3.1.1 STRESS

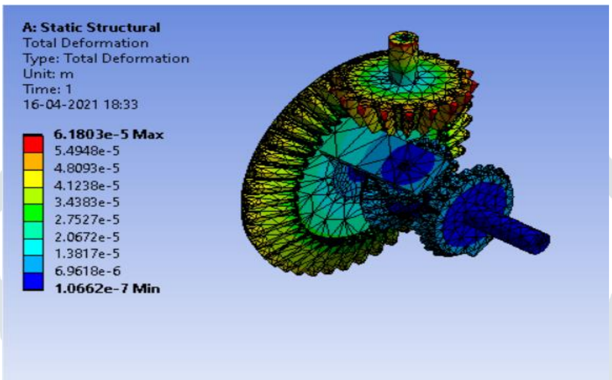

FIG 3.1.2TOTAL DEFORMATION

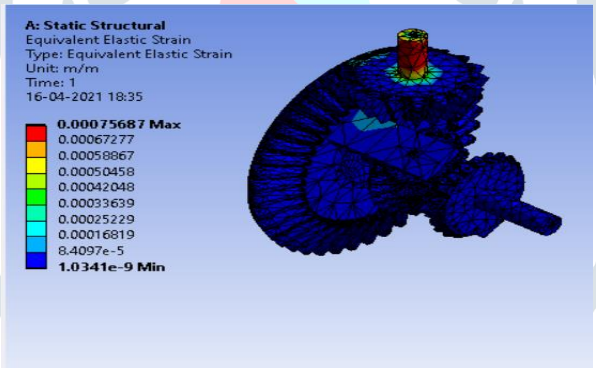

FIG 3.1.3 STRAIN

2. aluminium alloy

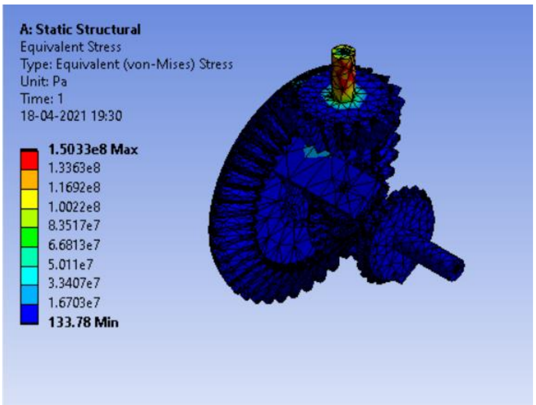

FIG 3.2.1 STRESS

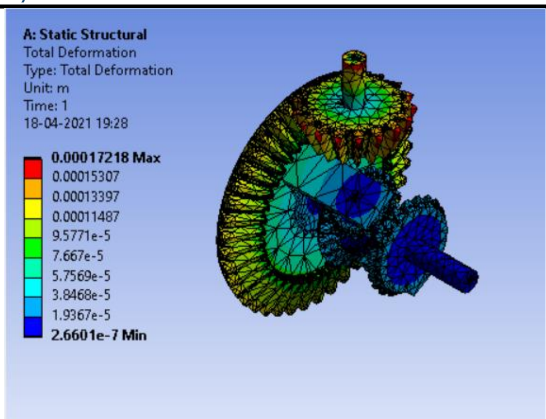

FIG 3.2.2 TOTAL DEFORMATION

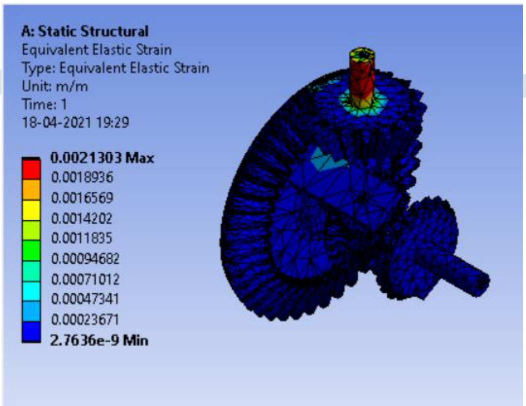

FIG 3.2.3 STRAIN

3. Sic reinforced ZrB2

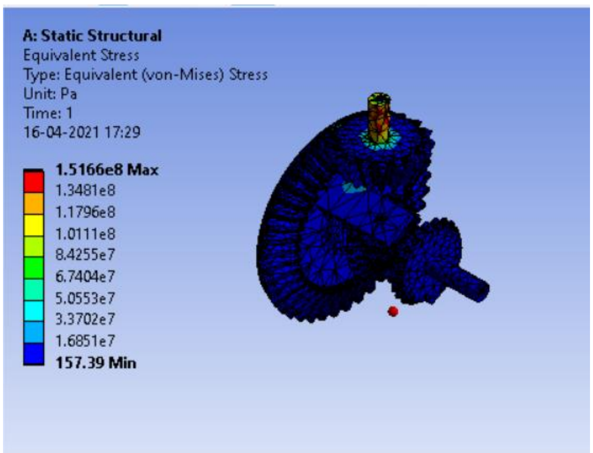

FIG 3.3.1 STRESS

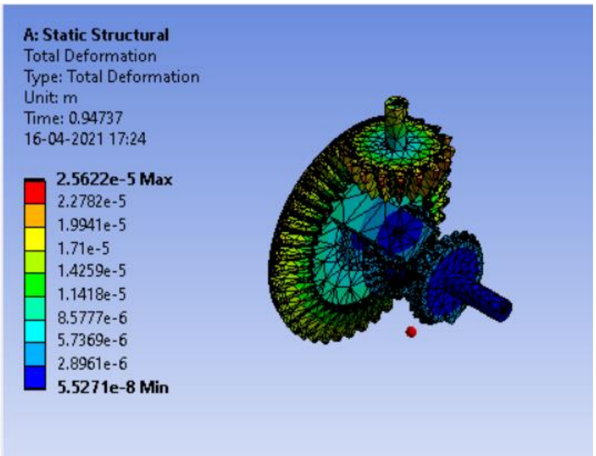

FIG 3.3.2 TOTAL DEFORMATION

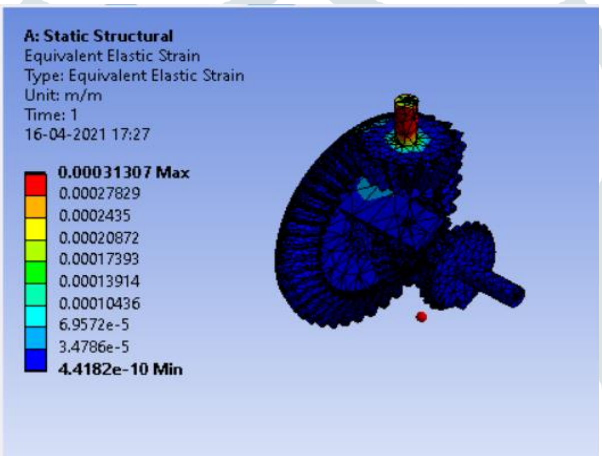

FIG 3.3.3 STRAIN

AT Torque = 190 Nm

4.Nickel chromium steel

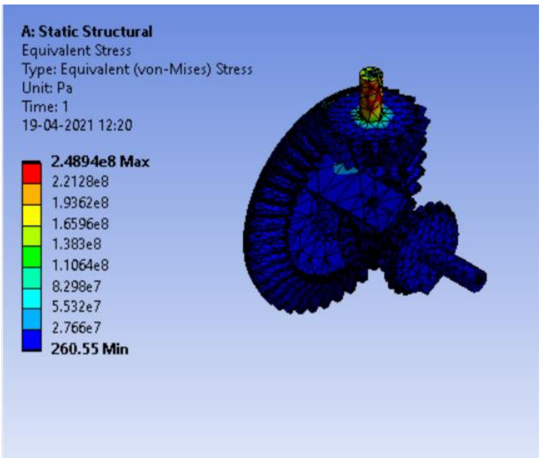

FIG 3.4.1 STRESS

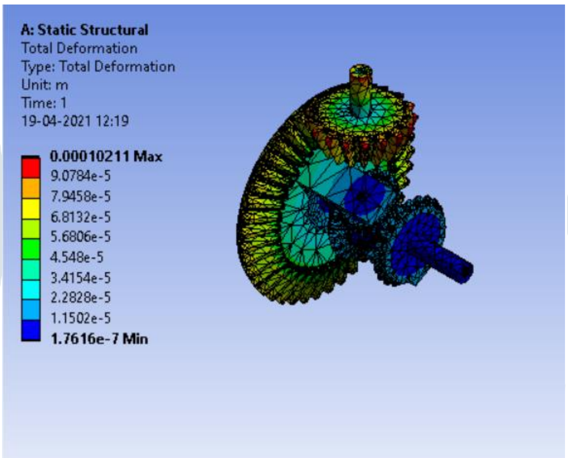

FIG 3.4.2 TOTAL DEFORMATION

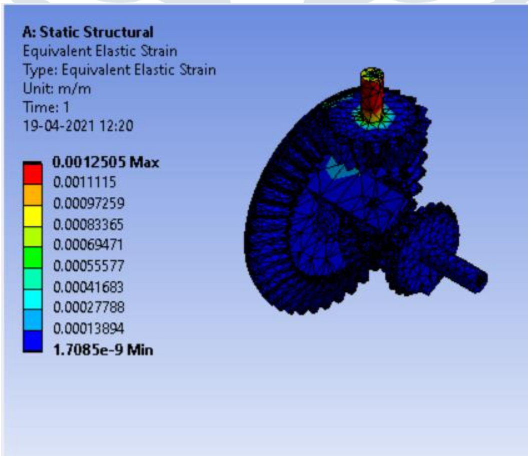

FIG 3.4.3 STRAIN

5. aluminium alloy

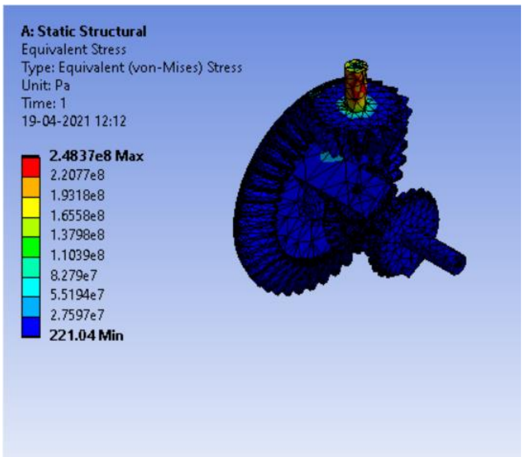

FIG 3.5.1 STRESS

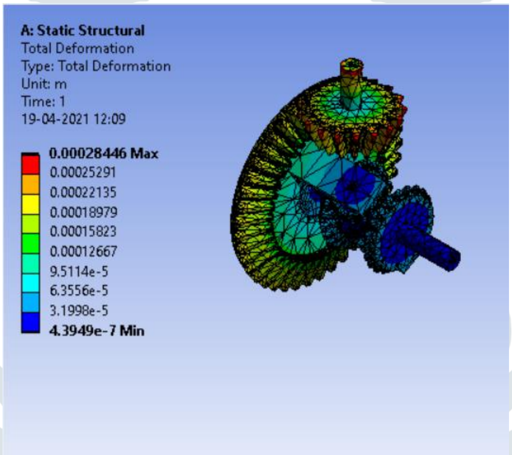

FIG 3.5.2 TOTAL DEFORMATION

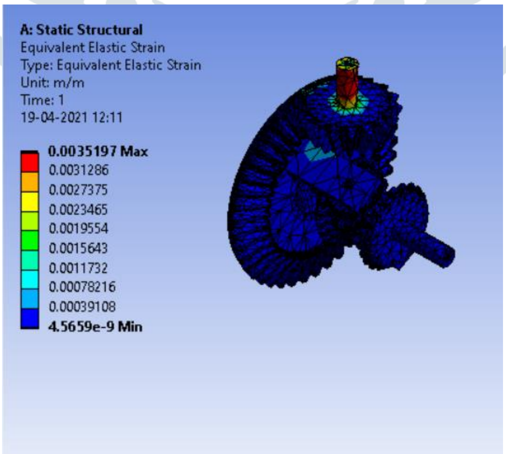

FIG 3.5.3 STRAIN

6. Sic reinforced ZrB2

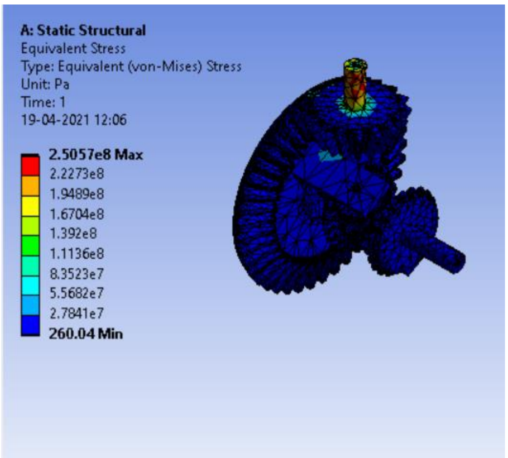

FIG 3.6.1 STRESS

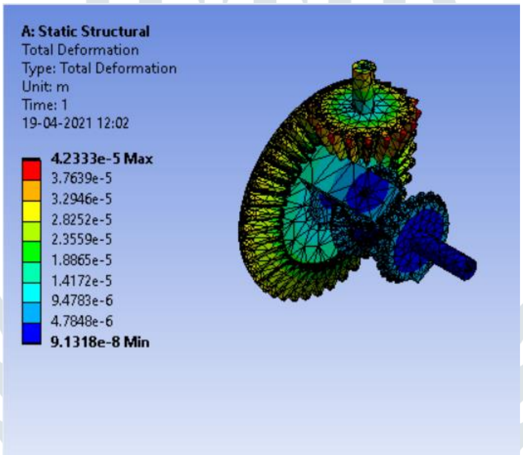

FIG 3.6.2 TOTAL DEFORMATION

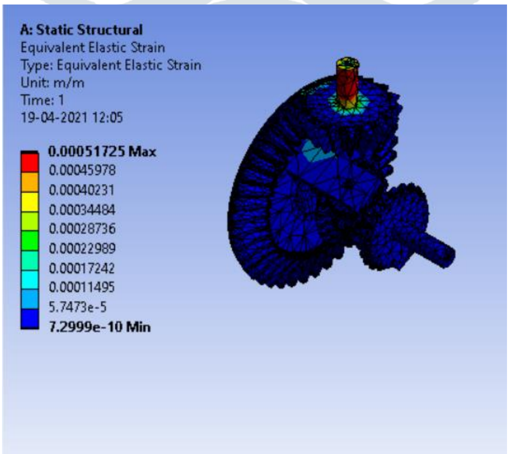

FIG 3.6.3 STRAIN

IV. RESULTS AND DISCUSSION

Torque Consideration	Torque 115Nm @4400 rpm			Torque 190N.m @2000rpm		
	Nickel chromium steel	alluminium alloy	Sic reinforced ZrB2	Nickel chromium steel	alluminium alloy	Sic reinforced ZrB2
Deformation (mm)	6.1803e-005	1.7218e-004	2.5622e-005	1.021e-004	2.8446e-007	4.2233e-005
Stress (n/m2)	1.5067+008	1.5033e+008	1.5166e+008	2.4805e+008	2.4837+008	2.5057e+008
Strain	7.5687-004	2.130e-003	3.1307e-004	1.2505e-003	3.5197e-003	5.1725e-004

V. Acknowledgement

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VI. Conclusion

The following conclusion can be drawn from the analysis conducted in this study

1. In our Project, we have successfully done analysis on differential with varying Torque 115 Nm @4400Rpm and 190Nm @2000Rpm.Analysis is done to verify the best material for the Differential taking into account stress development, strain and deformation.
2. In our Analysis, We Observe that All Three material are Good for the gear design but when its come to weight reduction The aluminium alloys perform the as the best Option.

REFERENCES

[1] F. K. Choy, H. Chen & J. Zhou, 2006, 'Identification of Single and Multiple Teeth Damage in a Gear Transmission System', Tribology Transactions, Vol. 49.

[2] B.Venkatesh, V.Kamala, A.M.K.Prasad, 2010, 'Modelling and Analysis of Aluminium A360 Alloy Helical Gear for Marine Applications', International Journal Of Applied Engineering Research, Dindigul Volume 1.

[3] J.O.Nordiana, S.O.Ogbeide, N.N.Ehigiamusoe and F.I.Anyasi., 2007," Computer-aided design of a spur gear, "Journal of Engineering and Applied Sciences 2 (12); pp 17431747.

[4] EATON PERFORMANCE DIFFERENTIAL PRODUCT OWNER'S MANUAL

[5] PSG, 2008."Design data," KalaikathirAchchagam publishers, Coimbatore, India