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RESEARCH ARTICLE
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DESIGN & ANALYSIS OF LIGHT WEIGHT COMPOSITE DIFFERENTIAL GEAR BOX

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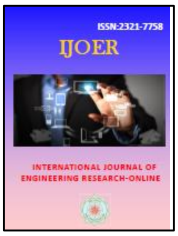

ABSTRACT
A Gear box is one of the important mechanical components of transmission system used in variety of machines. Differential Gear box increases effective weight of vehicle which in turn directly affects the performance and efficiency of the vehicle. So there is a requirement to make light and effective gears .Therefore, in the present work composite materials are used to make light weight gears in order to perform such duty efficiently. Comparisons of various stress and deformation, shear stress results have been done using ANSYS-14.5 with Glass filled polyamide composite and grey cast iron.
Key Words: gray cast iron , Glass filled polyamide, Gearbox Design, Assembly Analysis, Stresses and deformation, shear stresses, static Analysis

1. INTRODUCTION

A differential consists of one input, the drive shaft, and two outputs which are the two drive wheels, however the rotation of the drive wheels are coupled by their connection to the roadway. Under normal conditions, with small tyre slip, the ratio of the speeds of the two driving wheels is defined by the ratio of the radii of the paths around which the two wheels are rolling, which in turn is determined by the track-width of the vehicle (the distance between the driving wheels) and the radius of the turn.

2. CROWN GEAR AND PINION

The main aim of the project is to verify the best material for the gears in the gear box at higher speeds by analyzing stress, displacement and shear stress and also by considering weight reduction focus on the mechanical design with assembly of gears in gear box when they transmit power at 200N.m. Analysis is also conducted by varying the materials. Differential gear is modeled in CATIA. The ANSYS 14.5 software was used as the analysis tool for determining the structural behavior of various composite and conventional under the given loading conditions.

2.1 HEAVY VEHICLE SPECIFICATION

Property	Assumption Quantity	Taken Quantity
Gear profile	20^0	-
pressure angle (α)	20^0	-
bevel gear arrangement	90^0	-

Pitch cone Angle (ϕ)	45^0	Diameter of sun gear =DG=150mm
Back cone Angle (β)	45^0	Diameter of pinion =Dp=70mm
Module (M)	10	M=D/T=6.66=7 D=DG+DP=220 T= ZG+ ZP= 33
Number of teeth on gear (ZG)	50	18
Number of teeth on pinion (Zp)	8	15
Velocity Ratio (V.R)	50/8=6.25	150/70=2.142
Pinion speed(NP)	2400RPM	2400RPM
Gear speed(NG)	384rpm	1120.448rpm
Pitch angle for pinion = θP1=tan-1(1/v.r)	tan-1(1/6.25)	25.025
Pitch angle for gear θp2	=90°-9=81	90°-25.025 =64.974
Formative teeths on pinion (Zep)=	Zpsecθp1 =8sec90 =8	16.554
Formative teeths on gear(Zeg=Zgsec θp2	=50sec81 =319.622	42.55
Pitch Cone Distance (AO)	$=((d_1/2)^2+(d_2/2)^2)1/2$ =250mm	82.7mm
Face width (b)=	AO/3=b=83.3	27.5 mm

2.2 MATERIAL PROPERTIES

Engineering data imparts the material properties. Composite materials made from two or more constituent materials with significantly different physical or chemical properties. These constituent materials combined to produce a material with characteristics different from the individual components. The composite material selection for gearbox is done using if –then approach, using product design specification sheet Table 3.

Glass filled polyamide in particulate form is used for differential gear box(bevel and spur gears)having better tensile strength (38.1 Mpa), recyclability, low density (840 Kg/m 3), high creep resistance, fatigue strength, high impact strength, low Von-Misses Stress, less friction and low cost. Table 4 gives the properties of glass filled polyamide

2.2.1 POLYMIDE PROPERTIES

S.NO	MATERIAL PROPERTIES	VALUES
1	Density	840 Kg/m^3
2	Young's modulus	76 GPa
3	Poisson's ratio	0.314
4	Bulk modulus	8.33×10^{10} Pa
5	Shear modulus	3300 Pa
6	Tensile ultimate strength	38.1 Mpa

2.2.2 GRAY CASTIRON PROPERTIES

S.NO	MATERIAL PROPERTIES	VALUES
1	Density	Kg/m^3
2	Young's modulus	110 GPa
3	Poisson's ratio	0.28
4	Bulk modulus	8.33×10^{10} Pa
5	Shear modulus	4.2969×10^{10} Pa
6	Tensile ultimate strength	2.4 ×108 Pa
7	Compressive ultimate strength	8.2×10^8 Pa
8	Thermal conductivity	52 W/m-k
9	Specific heat	447 J/kg-0C
10	Coefficient of thermal expansion	11×10^{-6} 1/k

3. PROCEDURE IN CATIA V5R20

Welcome to CATIA (Computer Aided Three Dimensional Interactive Application). As a new user of this software package, you will join hands with thousands of users of this high-end

CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade

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your designing skills with the tremendous improvement in this latest release.

Go to the assembly workbench after go to the new part and select xy plane create the half rectangle portion distance is 75mm overall length create the 15 mm offset distance apply chamfer after go to the shaft option apply angle 3600 option now go to the yz plane create the line after apply plane in part design work bench create the tooth profile in sketcher workbench apply rib option in part design workbench again go to circular pattern apply around 50 instances apply rib as well as same pattern create remaining parts also axle shaft gear, bevel gear, inner gear, ring main gear(sun gear). This figure represents the modeling of first side gear in CATIA.

It is created by drawing the bevel gear profile from prerequisites and removing the faces of bevel gear tooth for 45 0mating of other gears for assembly. And adding extruded stub axles rods to it.It is the second bevel side gear. This figure represents the modeling of second side gear in CATIA. It is created by drawing the bevel gear profile from prerequisites and removing the faces of bevel gear tooth for 450 mating of other gears for assembly.

And adding an extrude stub axles to it. This figure represents the modeling of ring gear in catia. It is created by drawing the bevel gear profile from prerequisites and removing the faces of bevel gear tooth for 450 mating of other gears for assembly. And adding an extrude stub axles to it. The ring rotates while the vehicle is taking turn. It rotates in it's own axis. This figure represents the modeling of sun gear in catia. It is created by drawing the bevel gear profile from prerequisites and removing the faces of bevel gear tooth for 45 0 mating of other gears for assembly.

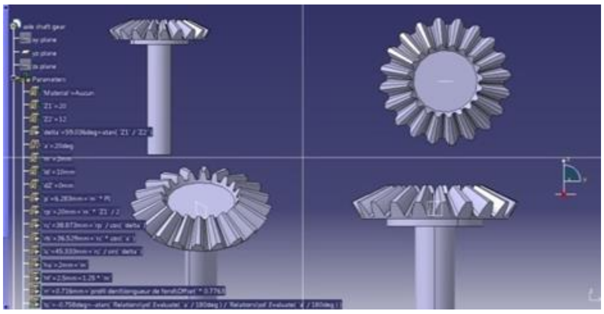


Fig (3.1): AXLE SIDE SHAFT GEAR

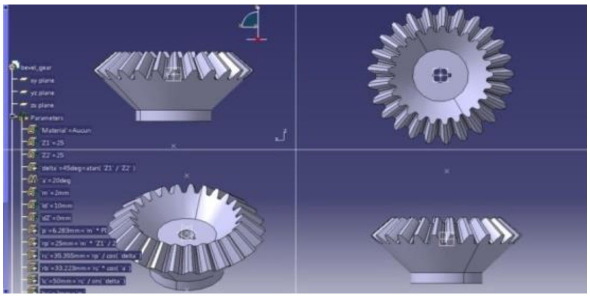


Fig (3.2): FBEVEL GEAR

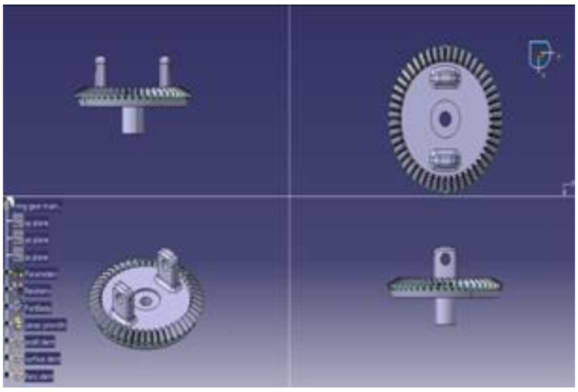


Fig (3.3): RING MAIN GEAR

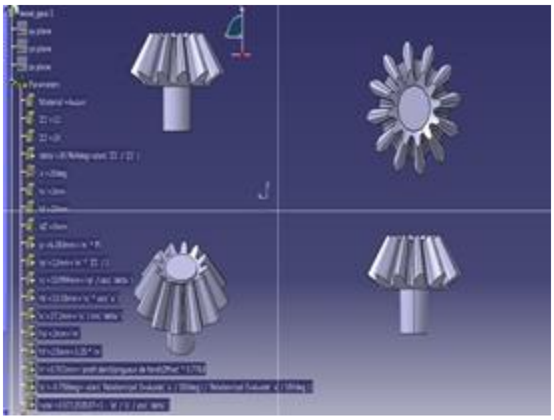


Fig (3.4): Inner GEAR

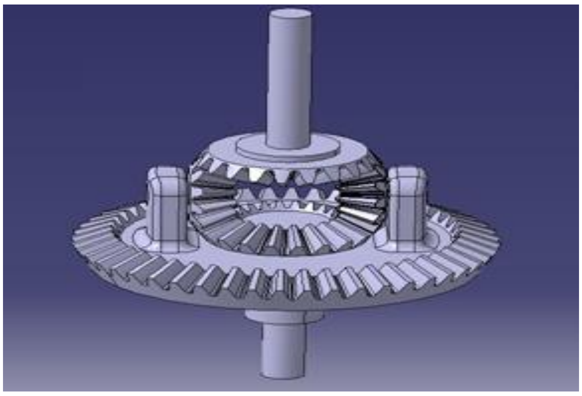


Fig (3.5): MAIN ASSEMBLY

4. **ANSYS**:

ANSYS is a large-scale multipurpose finite element program developed and maintained by ANSYS Inc. to analyze a wide spectrum of problems encountered in engineering mechanics. In the present work, the computational numerical analysis is done using ANSYS version 15.0. Designed component in CATIA workbench after imported into ANSYS workbench now select the steady state thermal analysis.

The static structural analysis calculates the stresses, displacements, shear stress and forces in structures caused by a load that does not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that the loads and the structure's response are assumed to change slowly with respect to time. A static structural load can be performed using the ANSYS WORKBENCH solver. The types of loading that can be applied in a static analysis include:

Meshing and boundary conditions:

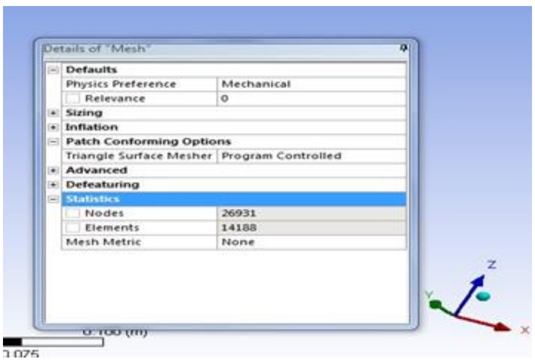


Fig (4.1): Number of nodes and elements

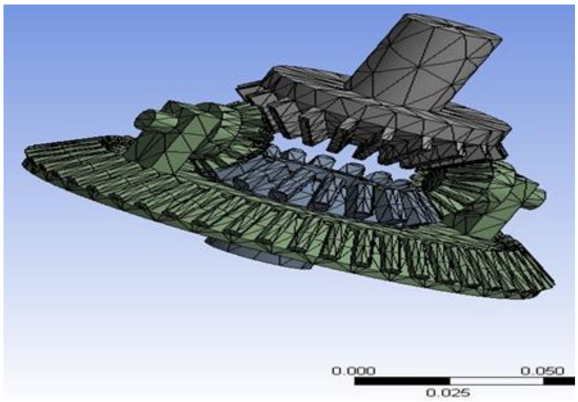


Fig (4.2): GEAR BOX MESHING

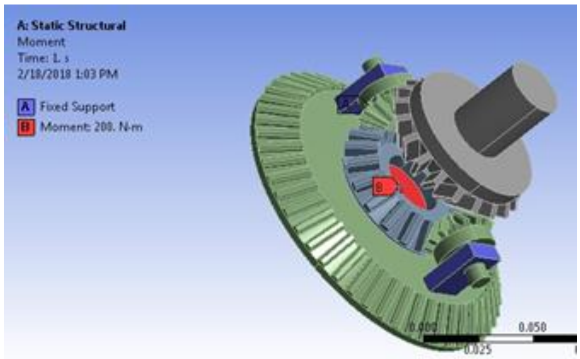


Fig (4.3): BOUNDARY CONDITION

5. **RESULTS AND DISCUSSION**

7 This analysis is performed to find Structural parameters such as Stresses shear stresses, Deformation, Here we observed results on two materials namely grey cast iron and polymide

5.1 Grey cast-iron:

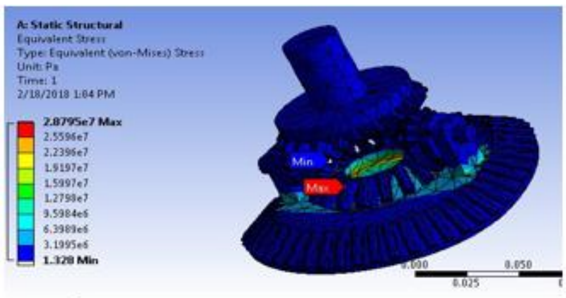


Fig (5.1): STRESS ON GREY CAST IRON

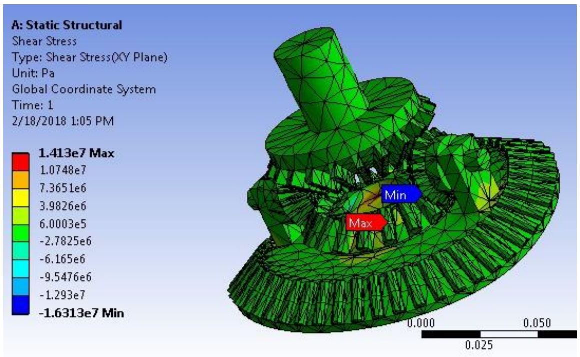
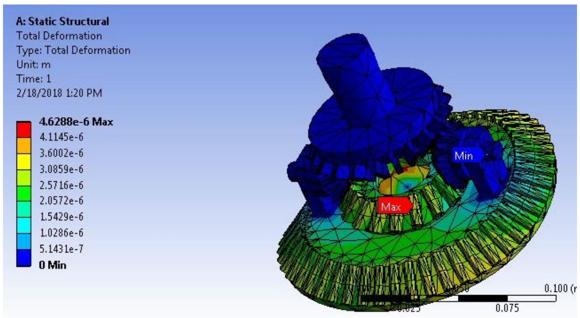


Fig (5.2): HEAR STRESS ON GREYCAST IRON

Fig (5.3): TOTAL DEFORMATION GREYCAST IRON



5.2 Glass gilled polyamide:

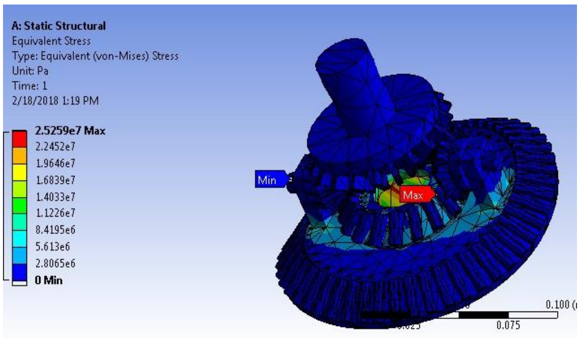


Fig (5.4): STRESS ON POLYAMIDE

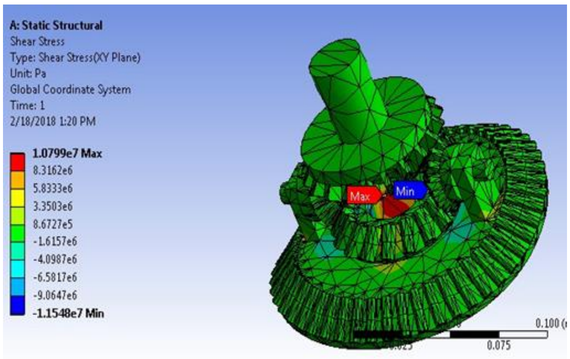


Fig (5.5): SHEAR STRESS ON POLYAMIDE

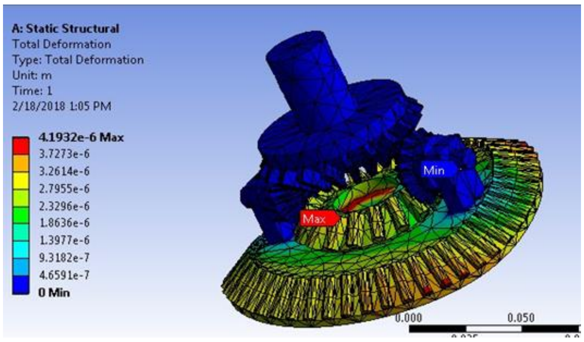
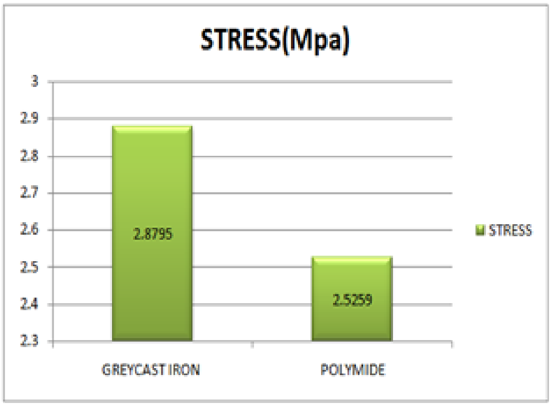


Fig (5.6): TOTAL DEFORMATION ON POLYAMIDE

6. GRAPHS

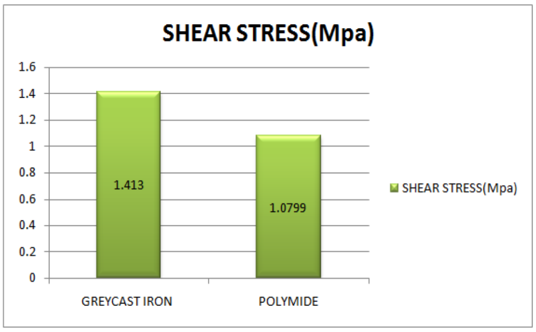
6.1 Stress graph:

This graph shows the different maximum stress values in different materials, polymaide (2.5256 Mpa) material has least stress value compared to another materials as shown in the graph 1



6.2 Shear stress graph

This graph shows the different maximum shear stress values in different materials, polyamide 1.0799 Mpa material has least shear stress value compared to another materials as shown in the graph2



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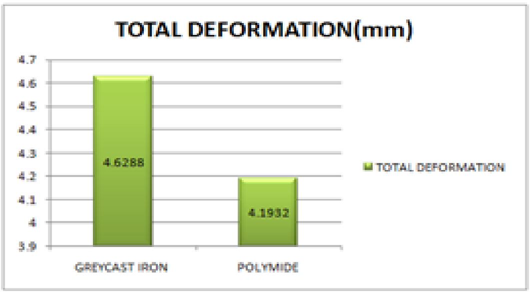
6.3 Total deformation graph

This graph shows the different total deformation values in different materials, polymaide 4.1932 material has least deformation value compared to another materials as shown in the graph3



7. CONCLUSIONS

- Glass filled polyamide composite material is used for gears and are analyzed using ANSYS for equivalent (Von-Misses) stress, displacement (total deformation) and maximum shear stress under static conditions.
- Comparisons of various stress and strain results with Glass filled polyamide composite and metallic materials like grey cast iron and glass filled composite polyimide are also being performed and found to be lower for composite material.

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