



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 7, July 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Design and Analysis of Differential Gearbox

Amarewar Reddy.V , M.Mallikarjuna

P.G. Scholar, Department of Mechanical Engineering (CAD CAM), Tadipatri Engineering College,
Andhra Pradesh, India

Assistant Professor, Department of Mechanical Engineering (CAD CAM), Tadipatri Engineering College, Andhra
Pradesh, India

ABSTRACT: With a identify like "Design and Analysis of Differential Gearbox," you could possibly bet that I'll be working usually with mechanical layout and evaluation of the gearbox used in power transmission. This turned into my ultimate assignment, and I voluntarily undertook it to research more approximately the technique with the aid of which successful firms take an idea from concept to crowning glory. My ideas consist of the transmission for a extensive style of powertrain sorts, as well as many aesthetic and upholstery choices. Boosting the electrical energy of the gearbox may also drastically improve productiveness.

The fundamental consciousness of this research is on analysing device boxes and growing a mechanical method for production a differential tool field. The grey cast-iron and aluminium alloys from a number of special producers were tested. Gears and device shafts are commonplace packages for forged iron or solid metal. To that cease, we look at the viability of the usage of aluminium in place of conventional steel inside the differential device container of software program-primarily based light-weight automobiles.

KEYWORDS: Differential Gearbox, Von-Misesstress values, catia, ansys.

I. INTRODUCTION

1.1 Differential (mechanical device)

A differential is a tool that lets in torque to be transmitted among three shafts without the want of gears. It operates like most motors in that it takes in one input and spits out some of effects, however it may also soak up a massive quantity of inputs and output the sum, distinction, or average of those effects. A differential is part of maximum present day engines that lets in the wheels to rotate at various speeds at the same time as still distributing torque uniformly.

1.2 Differential Gear Working

When it comes to strength training, differentiation is the biggest problem. It's what gets the pressure teach from the returned to the wheels. When a automobile is in motion, the outdoor wheels have extra momentum than the inner ones. Torque supplied to each of the rear wheels will regularly be the same if the propeller shaft is connected without delay to the axle, removing the need for differential gears. Therefore, each units of rear wheels may be rotating concurrently whilst the vehicle turns; this is obviously quite risky. One piece of machinery that could fix this problem is called a differential. The differential gearing device permits the outer wheel to transport at a better price of velocity than the internal wheel, which is mainly beneficial for turning or traversing tough terrain. Differential, rear axles, wheels, and bearings are all a part of the electricity axle housing assembly. The different torques are sent to the decrease back wheels thru a gadget this is firmly connected to the propeller shaft and the axle.

1.3 Purpose

To make turns, a vehicle's wheels rotate at specific prices. The differential lets in for a fixed of wheels to be circled at distinctive speeds whilst being propelled by using the same quantity of torque. Pass-karts and different cars without differentials frequently have their driving wheels and passenger wheels set up on a unmarried axle and pushed by means of a series. In the absence of a differential, the interior wheel may spin, resulting in premature wear on the tyres and pavement, whilst the outdoor wheel may want to drag, setting stress on (and possibly breaking) the whole drivetrain. Even whilst revolving, the inner wheel has a shorter distance to journey than the outer wheel.

II. RELATED WORK

Here, with the assist of numerous specialists, we take a close observe the studies which have been undertaken on differential gearbox layout and performance. A essential factor, the differential gearbox transmits varying speeds to all four wheels whilst maintaining a steady torque output.

Gears are used often (but no longer always) in a differential to convert torque and rotation, as explained via Muhammad Safuan Bin MdSalleh et al. It accepts two numbers as input and outputs the multiplicative, differential, or common fee. A differential lets in the wheels of a car, or a automobile with wheels, to spin at extraordinary speeds. As a car navigates bends, its wheels journey at one of a kind charges. Thanks to the differential, the equal quantity of torque may additionally make a fixed of wheels spin at very high velocities. The differential of the UTeM FV car has been in rate of shifting power from the engine to the wheels. While there are a ramification of differentials in the marketplace, nearly they all are bulky adjustments that might prevent the engine from accomplishing its most velocity and torque. The UTeM FV car can't use this differential because it wasn't designed for racing. This is completed primarily to provide a cushty in shape among the tool's mechanical parts. Solid Work Simulation is used to analyse forged iron and aluminium alloy gears. In area of cast-iron, aluminium alloy was employed to lessen the take a look at trouble's general weight.

T. Recent research via Loknadh et al. [2] uses structural examples to construct and simulate a crown wheel tool for the differential gadget container. The number one objective of this contest is to enhance the structural evaluation and design of the crown wheel device utilised in system packing containers to trade energy at maximum speed of 7200 rpm. The test verifies the wonderful cloth (metal and aluminium alloys) used inside the crown wheel gear by way of analysing static and dynamic activities within the device subject at higher speeds. The dynamic behaviour of gears should be saved in mind even when doing a static analysis. NX-CAD become used in the layout meeting, and ANSYS changed into used inside the structural evaluation, each of their customised bureaucracy.

Shoji Haizuka et al. [3] investigated the impact of load and rotating velocity on the absence of friction in helical gears with seven particular helix angles. These consequences were discussed:

1. As the helix angle and teeth pinnacle of a helical gear get larger, the gear's friction decreases. Alterations of as much as forty six tiers and zero.Five tiers may occur in the helix angles.
2. The amount of friction lost even as using helical gears is unaffected via either the applied load or the helix mind-set. This fashion can be defined by using a fixed of standards which can be all based totally on empirical research.

III. METHODOLOGY

Exemplar based Inpainting technique is used for inpainting of text regions, which takes structure synthesis and texturesynthesis together. The inpainting is done in such a manner, that it fills the damagedregion or holes in an image, with surrounding colour and texture. The algorithm isbased on patch based filling procedure. First find target region using mask image and then find boundary of target region. For all the boundary points it defined patch andfind the priority of these patches. It starts filling the target region from the highestpriority patch by finding the best match patch. Thisprocedure is repeated until entire target region is inpainted.

The algorithm automatically generates mask image without user interaction that contains only text regions to be inpainted.

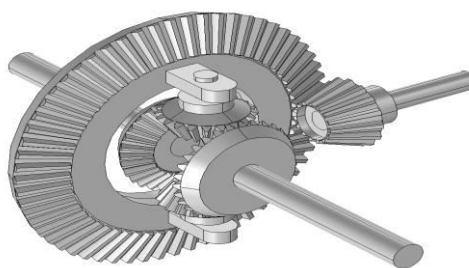


Figure 3.1: Geometry of a differential mechanism.



3.2 GEOMETRY AND CONNECTIONS

The additives of a differential encompass a ring gear, spider gear, and a pressure shaft with a pinion.

Gears are connected to both the right and left axles.

The rider's shaft is hooked up to the hoop mechanism thru a pinion. In hoop tools, the spider gears may also freely spin on their personal axes because of the manner they're linked. The spider gears join the inner ends of the 2 axles to the aspect attachments.

The wheels can not stay put with out the axles, that have vanished. In this version, the right wheel is anticipated to touch down following the flip.

3.3 WORKING OF A DIFFERENTIAL

You may additionally specify your excellent duties the use of the provided examples.

Under standard situations with negligible tyre slip, the ratio of the speeds of the 2 driving wheels is decided by means of the song-width (the gap among the employing wheels) and the radius of the turn.

If you hold going in the identical course, your value in keeping with revolution of the wheels won't change. The spider gears orbit like planets rather than spin on their own axes due to the fact their axles all rotate at the identical pace.

The protection area created by way of the outer wheel is crucial on winding roads. It favours going quicker than the inner tyre to save you you from sliding. All gears within the field might revolve on the identical pace without the differential, that can motive the wheels to slip.

In addition to differentials, the gearbox can be set up such that each wheel receives its most viable acceleration independently. Because of this, the spider gears preserve a steady charge of rotation, much like the planets. Variation in wheel rotation speed is due to spider gears.

3.4 MODEL PARAMETERS

- Permits the left and right axles to spin at diverse prices.

Power is transferred at.

- Lowers wheel speed in evaluation to the driving shaft.

3.5 Straight Path Curved Path

- The ring tools and pinion have a equipment ratio of four.
- The spider tools and aspect tools have a 1.5 gear ratio.
- The outer wheel's pace should be six instances greater than the internal wheel's so that you can save you any slipping on a curved direction.
- The automobile actions into a curved path after one power shaft revolution and exits the curve after three pressure shaft revolutions.

3.6 CONSTRAINTS AND LOADS

As the automobile turns, an outside torque is delivered to both axles. The two wheels are pressured to revolve at the specified speed ratio through the torque, which simulates the friction among the wheels and the floor.

The definition of this external torque (T) is as follows:

- The ring equipment is hinged across the y-axis and the riding shaft rotates with an angular speed of 2 hundred rad/s about the x-axis.
- The side gears (or axles) are hinged about the y-axis.

$$T = c_f(\omega_o - \omega_r\omega_i) \tag{1}$$

$$\omega_r = 1 + 5 \cdot \text{rect1}(\omega t)$$

- c_f is the frictional damping coefficient,
- ω_o and ω_i are the angular velocities of the outer and the inner wheels,
- ω_r is the velocity ratio between the outer and the inner wheels (set to 1 on a straight path and assumed to be 6 on a curved path), and

• ω is the angular velocity of the drive shaft

3.7 BEVEL GEAR TERMINOLOGY

Fig.7 shows the bevel gear terminology used in this work.

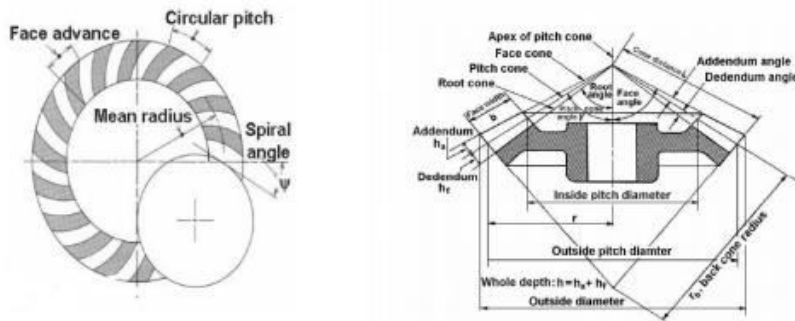


Fig.7 Bevel gear terminology

3.8 PROBLEM FORMULATION AND OBJECTIVE

Problem statement:

TABLE I TECHNICAL DETAILS

Vehicle Data	Front Axle	Rear Axle
Laden Weight Distribution		
(Road Transfer)	2500kg	3500kg
Wheel Tread (Min-Max)	1470-1870(mm)	-
Max.Load (Breakout) :	4500kg	-
Engine Data		
Power gross/Engine Speed	71.6kw/2200 rpm	-
Max.torque/Engine speed	402Nm/1400rpm	
Tyres Data		
Index Radius	0.65m	
Front Axle Specification		
Bevel Set ratio	2.9	
Final Drive Ratio(epicyclic)	6	Total Ratio=22.44

Design manufacturing and FE analysis of Differential Crown Gear and Pinion for MFWD Axle's for TAFE MF 455 with specifications as shown in Table I.

3.8 MODELING OF GEAR

Three-dimensional solids can be modelled mathematically and computationally using a steady set of rules called modelling. The attention on physical authenticity in stable modelling units it other than adjoining fields like geometric modelling and computer graphics. The ideas of geometric and solid modelling, which form the basis of laptop-aided design, facilitate the development, interchange, visualisation, animation, interrogation, and annotation of digital representations of actual-international gadgets.

3.9 CALCULATIONS OF A 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 also by considering weight reduction focus on the mechanical design and contact analysis on assembly of gears in gear box when they transmit power at different speeds at 2400 rpm, 5000 rpm and 6400 rpm. Analysis is also conducted by varying the frequencies. Differential gear is modeled in Solidwork . The ANSYS 14.0 fem software were used as the analysis tool for determining the structural behaviour of various composites under the given loading conditions.

Specifications Of Used Heavy Vehicle

3.10 ASSUMPTIONS:

- Gear profile: -20 degree full depth involute profile (standard)
- pressure angle (α):-20 degree
- bevel gear arrangement = 90 degree
- Pitch cone Angle (ϕ) = 45
- Back cone Angle (β) = 45
- Module (M) = 10
- Number of teeth on gear = $Z_g = 50$
- Number of teeth on pinion = $Z_p = 8$
- Velocity Ratio (V.R) $V.R = T_G/T_P = D_G/D_P = N_P/N_G$

$V.R = T_G/T_P = 50/8 = 6.25$

$V.R = N_P/N_G$

$6.25 = 2400/N_G$

- $N_G = 384$ rpm Minimum no. of teeth on pinion (Z_p)

For satisfactory operation of bevel gears the number of teeth in the pinion must not be less than hence the assumed value of the pinion is in safe condition

- Pitch circle diameter (D)
- Pitch circle diameter for the gear (D_g) = $M * Z_g$
- Pitch circle diameter for the pinion (D_p) = $M * Z_p$
- Pitch angle (θ)

Since the shafts are at the right angles ,the pitch angle were given as:

- For the pinion = $\theta_{p1} = \tan^{-1}(1/v.r)$
- Pitch angle of gear $\theta_{p2} = 90^\circ - \theta_{p1} = 81$
- formative number of teeth (T_e)
- for the pinion $Z_{ep} = Z_p \sec \theta_{p1} = 8 \sec 9 = 8$
- for the gear = $Z_{eg} = Z_g \sec \theta_{p2} = 50 \sec 81 = 319.622$

1. Pitch Cone Distance (AO): $AO = ((d_1/2)^2 + (d_2/2)^2)^{1/2}$ $AO = 250$ mm
2. Face width (b) $b = AO/3$ or } which is lesser $b = 10$

IV.INTRODUCTION TO CAD/CAM

4.1 COMPUTER AIDED DESIGN (CAD):

Computer-aided design (CAD) is an umbrella time period for a huge sort of computing technologies used to streamline the design system on a laptop in fields including engineering, architecture, and different layout professions. Incorporating geometry into product existence cycle control has evolved as a hot subject matter, even though it does need high-priced expert equipment and software program. New design drafting software program caters to the desires of designers via presenting each 3-D vector-based ground and panorama design fashions and 2D raster-based totally sketching options.

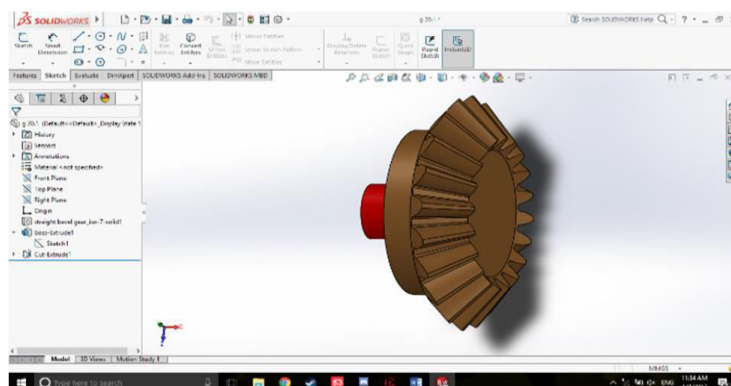


Fig4.1 Bevel gear1

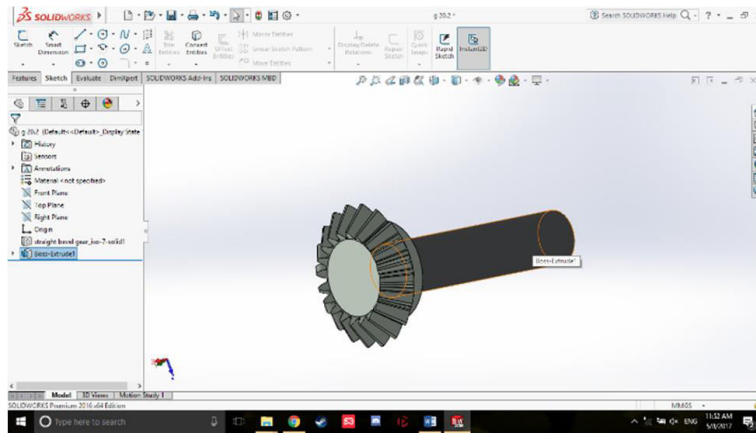


Fig4.2 Bevel gear 2

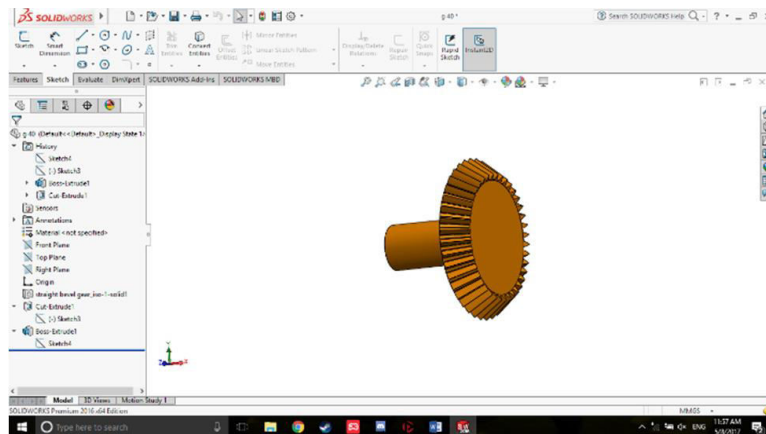


Fig4.3 Bevel gear3

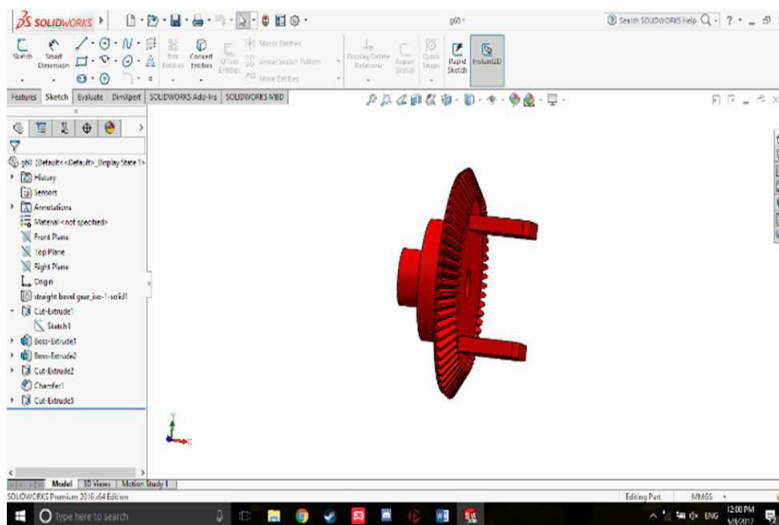


Fig4.4 Bevel gear4

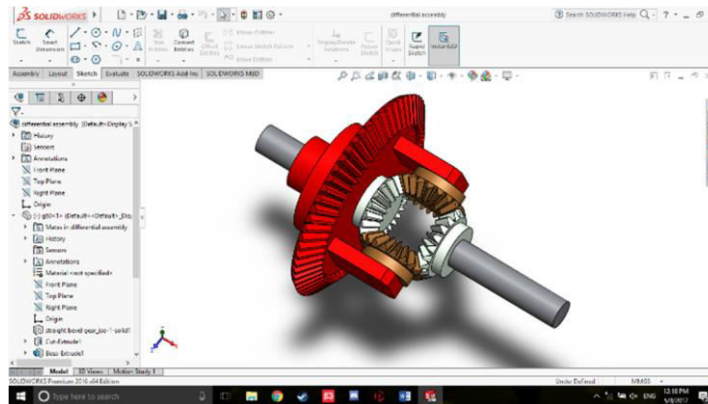


Fig4.5 Final assembly

V.INTRODUCTION TO ANSYS

5.1 Introduction

ANSYS covers all bases in relation to finite detail evaluation (FEA). The finite element technique permits for the theoretical deconstruction of complicated equipment into its constituent elements. All interest-related equations have been solved the usage of the programme, and the ensuing description of its behaviour became exhaustive. These repercussions might then be proven graphically or verified thru tabular facts. This is a better test, and it is made for devices that are too difficult to examine with the aid of hand. Elegant structures may have governing equations, geometries, or scales which can be hard to clear up.

ANSYS is regularly utilised as the foremost FEA coaching tool in mechanical engineering textbooks during the United States. Many professionals outdoor of the conventional nation-states of mechanical and aeronautical engineering now rely upon ANSYS.

5.1.1 ANALYSIS OF DIFFERENTIAL GEAR BOX

1. Engineering Data

We have used two different materials like grey cast iron and aluminum alloy for the analysis of this product.

Density	7200 kg m ⁻³
Coefficient of Thermal Expansion	1.1e-005 C ⁻¹
Specific Heat	447 J kg ⁻¹ C ⁻¹
Thermal Conductivity	52 W m ⁻¹ C ⁻¹
Resistivity	9.6e-008-ohm m
Young's Modulus Pa	1.1e+011
Poisson's Ratio	0.28
Tensile Ultimate Strength	2.4e+008
Compressive Ultimate Strength	8.2e+008

The Material Properties of grey cast iron

Density	2770 kg m ⁻³
Coefficient of Thermal Expansion	2.3e-005 C ⁻¹
Specific Heat	875 J kg ⁻¹ C ⁻¹
Young's Modulus Pa	7.1e+010
Poisson's Ratio	0.33
Resistivity	3.63e-008-ohm m
Thermal Conductivity	114 W m ⁻¹ C ⁻¹
Tensile Yield Strength	2.8e+008
Tensile Ultimate Strength	3.1e+008

The Material Properties of Aluminum alloy

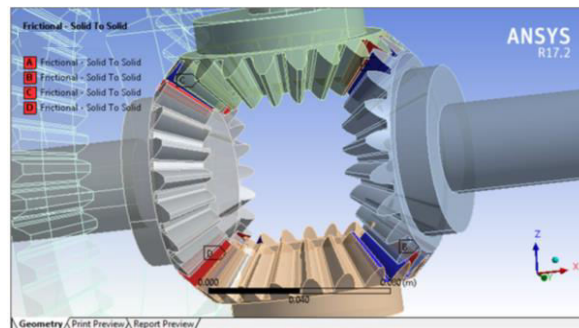


Fig5.1 The temperature situations, the frictional or rubbing contact among the mating gears have to have a coefficient of friction of zero.2.

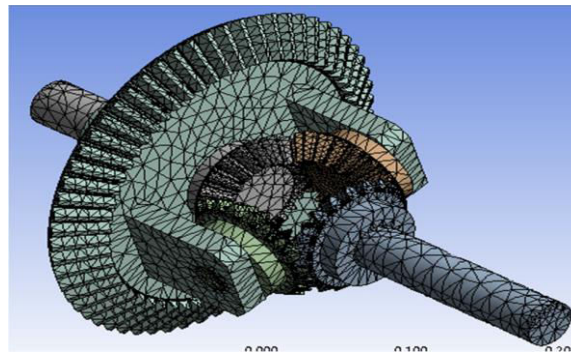


Fig5.2 meshing Part

In this example, I'm displaying fine meshing on an aluminium alloy with 0.6-inch factors and first-rate meshing within the centre of the span angle. We can do the analysis as it should be and completely via meshing with a purpose to determine the load values on the differential equipment container.

5.1.2 Torque acting on the Differential Gear Box

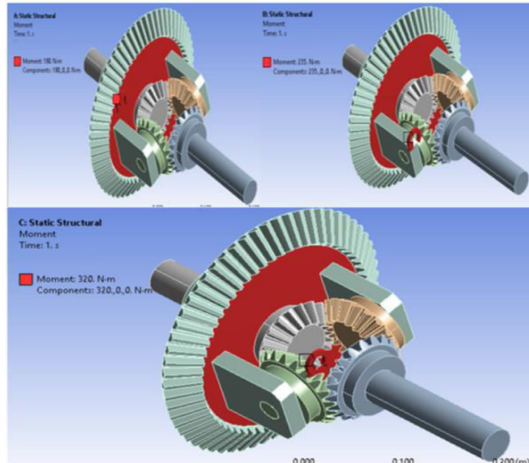


Fig: 5.3 This figure shows the combined image of all torques applied on the differential gear box the torques applied are **190, 235, 320 (N-m)**.

5.1.3 Fixed Support for Differential Gear Box

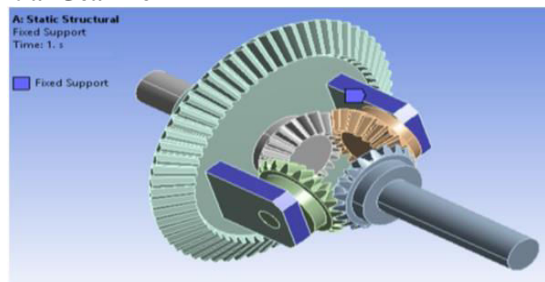


Fig: 5.4 We have the constant helps for the solar gear hands on this photograph on the grounds that we can't do the structural analysis with out supplying the permanent helps and because doing so does not imply any forces on the evaluation of the paper..

IV. EXPERIMENTAL RESULTS

Total Deformation of Grey Cast Iron

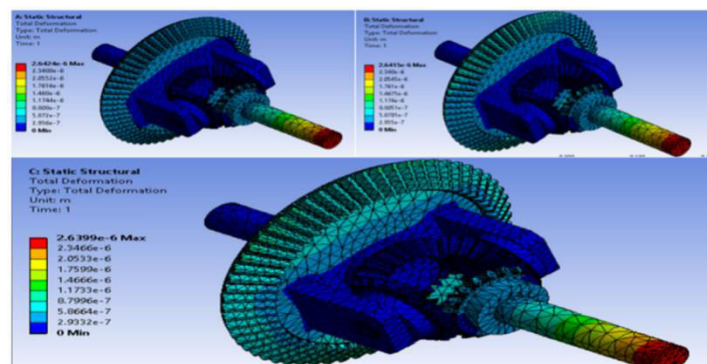
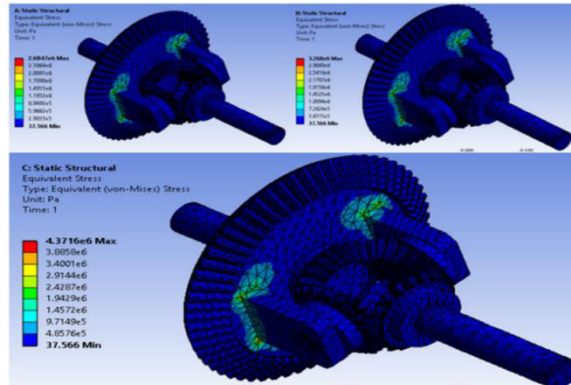


Fig: 5.5 It shows the Total Deformation stress values of the differential gear box at different torques at 190, 235, 320 (N-m) on Grey Cast Iron

Von-Mises Stress of Differential Gear Box



Fig’ 5.6 It shows the Von-Mises stress values of the differential gear box at different torques at 190, 235, 320 (N-m) on Grey Cast Iron.

5.20 Total Deformation of Aluminum Alloy:

Fig: 5.7 It shows the Total Deformation stress values of the differential gear box at different torques at 190, 235, 320 (N-m) on Aluminium Alloy

5.21 Von-Mises Stress of Differential Gear Box

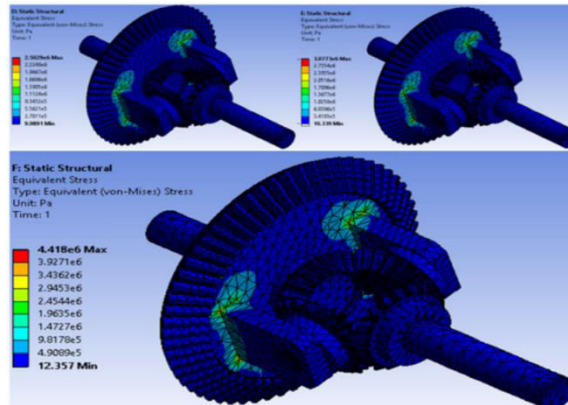


Fig: 5.8 It shows the Von-Mises stress values of the differential gear box at different torques at 190, 235, 320 (N-m) on Aluminium Alloy.

V. CONCLUSION

In order to determine whether or not the frictional touch among the mating gears impacts the load, we've got set the frictional touch at zero.2 in this task. According to the aforementioned findings and graphs, gray cast iron and aluminum alloy are both endorsed to be used as differential gearbox components in cars. However, aluminum alloy is optimum for light application automobiles on the subject of weight.

REFERENCES

[1]. Muhammad Safuan Bin MdSalleh, "Design and Assembly Analysis of Differential Gear Box For Utem Fv Car" <http://library.Utem.Edu.My:8000/elmu/index.Jsp?Mod>
 [2] . T. Loknadh, "Design a crown wheel equipment of differential tools field utilized in heavy vehicles for structural loads" (IJSETR, Volume 4, Issue 7, July 2015).
 [3]. Tejiro Yamanaka, Shoji Haizuka, and Chotaro Naruse, "Study of Influence of Helix Angle on Friction Characteristics of Helical Gears," Tribology Transactions, Vol. 42, No. Three, pp. 570-580, 1999.
 [4] . Wilfried J. Bartz & Dirk Wienecke, "Automobile Gearbox Gears as Tribological Systems," Tribology Transactions, Vol. Forty four, No. 3, pp. 484-488, 2001.



- [5] . Jay Belsky, Ph.D., "Why the "Transmission Gap" in Attachment Research: Differential Susceptibility to Rearing Influence," *Journal of Infant, Child, and Adolescent Psychotherapy*, Rutledge, 2:4, pp. 163–183, 2002.
- [6] . F. K. Choy, H. Chen, and J. Zhou, "Identification of Single and Multiple Teeth Damage in a Gear Transmission System," *Tribology Transactions*, Vol. Forty nine, No. 3, 297–304, 2006.
- [7]. "Detailed and reduced dynamic models of passive and energetic constrained-slip automobile differentials", ISSN Taylor & Francis, Vol. 12, No. Four, August 2006, pp. 347–362.
- [8]. "Development of a new control method for a semi-lively differential for a excessive performance automobile", *International Journal of car Mechanics and Mobility*, Taylor & Francis, forty four:sup1, pages 202-215.
- [9]. Erwin V. Zaretsky, David G. Lewicki, Michael Savage, and Brian L. Vlcek, "Determination of Turboprop Reduction Gearbox System Fatigue Life and Reliability," *Tribology Transactions*, 50:4, 507-516, ISSN Taylor & Francis, 2008.
- [10]. CuneytFetvaci and ErdemImrak, "Mathematical Model of a Spur Gear with Asymmetric Involute Teeth and Its Cutting Simulation," *Mechanics Based Design of Structures and Machines: An International Journal*, Vol. 36, No. 1, p. 34–forty six, 2008.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.423



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

9940 572 462 **6381 907 438** **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details