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Design and Analysis of Differential Gearbox drive for Automobiles

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ABSTRACT: The main aim of this project is to focus on the mechanical design and analysis on differential gear box by varying materials when they transmit power at three different load conditions. The analysis is conducted to verify the best material based on specific strength of the gears in the differential gear box at three different loads by analyzing von mises stress, strain, deformation and also by considering safety of transmission. This development of differential gearbox improves its performance, weight reduction in material and saves engine power

KEYWORDS: Gearbox, Differential, Material, Creo, Structural analysis, ansys

I. INTRODUCTION

Gears are the most important component in a power transmission system. Advances in engineering technology in recent years have brought demands for gear teeth, which can operate at ever increasing load capacities and speeds. The gears generally fail when tooth stress exceeds the safe limit. Therefore it is essential to explore alternate gear material. The important considerations while selecting a gear material is the ability of the gear material to withstand high frictional temperature and less abrasive wear, Weight, manufacturability and cost are also important factors those are need to be considered during the design phase. Moreover, the gear must have enough thermal storage capacity to prevent distortion or cracking from thermal stress until the heat can be dissipated. It must have well anti fade characteristics (i.e) their effectiveness should not decrease with constant prolonged application and should have well anti wear properties. The upcoming requirement of power saving and efficiency of mechanical parts during the past few years increased the use of composite materials. Moreover the use of composite materials have also increased due to their properties such as weight reduction property with enough strength, high specific stiffness, corrosion free, ability to produce complex shapes, high specific strength, high impact energy absorption and many more. Product development has changed from the traditional serial process of design, followed by prototype testing and manufacturing but to more on computer aids. CAE (Computer Aided Engineering) has greatly influenced the chain of processes between the initial design and the final realization of a product. CAE software helps in product designing, 3-D visualization, analysis, simulation and impacted a lot on time and cost saving to the industry. 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.

II. RELATED WORK

SELECTION OF VEHICLE

TATA LPT 1512 CRX TRUCK

SPECIFICATION OF VEHICLE

ENGINE : TATA 497 TCIC BS4 CR

ENGINE DISPLACEMENT : 3783CC

GEARBOX : GB40(8.98) ROD SHIFTING (5F+1R)
POWER : 92KW @2400 R/MIN
TORQUE : 400NM@ 1300-1600R/MIN

III. METHODOLOGY

The first step in the gearbox design process is to select the weight of the product. Stress, displacement is analyzed by considering weight Material. In this paper to replace the materials with Carbonsteel, Manganese Chromium alloy steel, Nickel Chromium alloy steel for reducing reduction in the gear box at higher speed. The analysis is done in ANSYS software. In the present work all the parts of differential are designed under static condition and modelled. Modelling and assembly is done in CREO (3.0). The detailed drawings of all parts are to be furnished. The analysis is conducted to verify the best material for the gears in the gear box at high speeds by analyzing von miss stress, deformation and also by considering safety of transmission. The crown gear and pinion are made in solid modeling software CREO and analyzed in software ANSYS 15.0 for obtaining the Von Miss Stresses in gear and pinion and Total Deformation in the assembly. We are creating the frictional contact between two mating gears and we are doing the structural analysis on gear box by providing the load to the pinion gear in the differential gear box. The comparison has made based on the results of finite element analysis. The study is useful in determining the best material for Crown Gear and Pinion.

IV. EXPERIMENTAL ANALYSIS

Design of differential gearbox

Construct a three-dimensional representation of the bevel gears in CREO. The assembly consist of 2 side gears, 2 ring gears, and on sun gear. After doing the assembly in creo. Save the file in, IGES format Continuing the further work in Ansys mechanical.

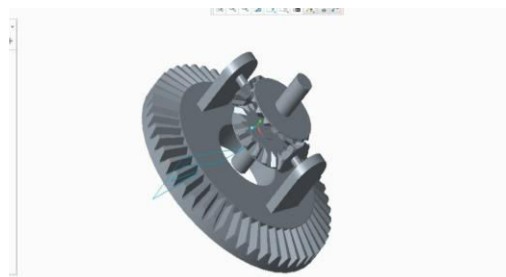


Fig (a)

Figure 1.(a) Assembly of differential gearbox has done in CREO 3.0 Software

Analysis of differential gearbox

Engineering data

We have used three different materials like Carbon steel C45, Direct hardening alloy steel 35 Ni 1 Cr 60 and Case hardening alloy steel 17 M n 1 Cr 60 for the analysis of this product

In this section we are doing structural analysis on gear box by providing the various load and get the von mises stress, strain and total deformation



Meshing of differential gearbox

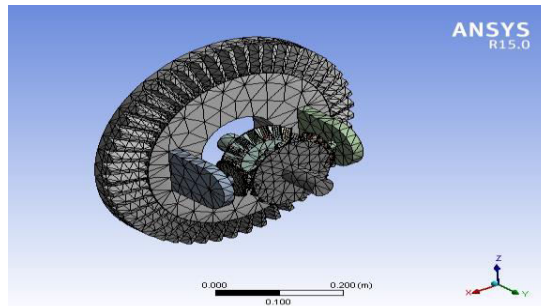


Fig (a)

Figure 2. (a) In this figure, It representing the fine meshing on the three material of element size of 0.6 and fine meshing of span angle center. By meshing we can do the analysis properly and perfectly to know the load values on the differential gearbox

Load acting on the differential gearbox

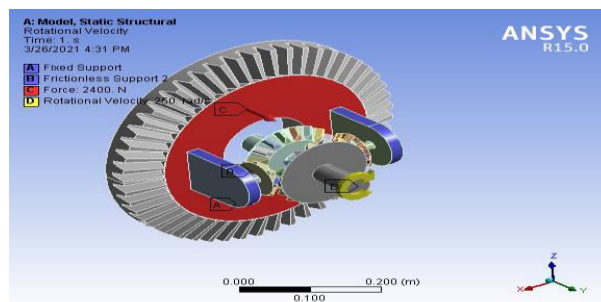


Fig (a)

Figure 3. (a) There are three various load applied on the differential gearbox, The load applied are 2400,1600,1500 (N)

Results

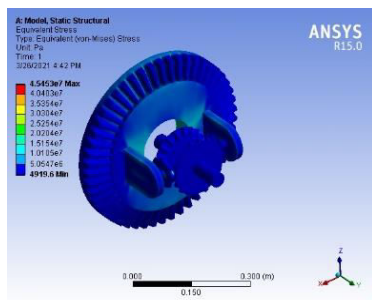
Material Selected	Carbon Steel C45	Nickel Chromium Alloy	Manganese Chromium Alloy
Loads	2400	1600	1000
Parameters	Total Deformation	Stress	Strain

Case 1:

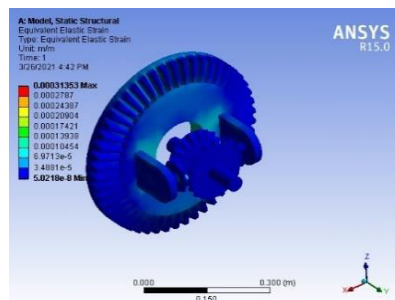
Best Material for 2400N- Manganese Chromium (17 Mn 1 Cr 95)

Best Solutions of Manganese Chromium

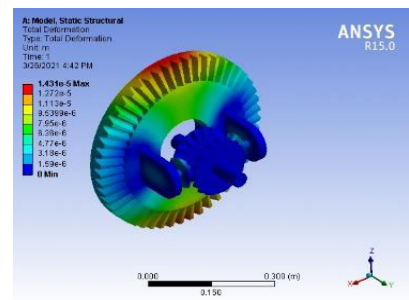
Manganese Chromium Alloy	Minimum	Maximum
Equivalent stress (pa)	4919.6	4.5453e+007
Equivalent strain	5.0218e-008	3.1353e-004
Total Deformation (m)	1.59e-6	1.431e-005



(a)



(b)



(c)

Figure 4. (a) Best stress solution for 2400N (b) Best strain solution for 2400N (c) best total deformation solution for 2400N

Case 2:

Best Material Solution for 1600N-Carbon Steel C45

Best Solutions of Carbon Steel

Carbon steel C45	Minimum	Maximum
Equivalent stress (pa)	2415.9	2.0798e+007
Equivalent strain	2.2937e-008	1.0764e-004
Total Deformation (m)	1.3028e-6	5.8624e-006

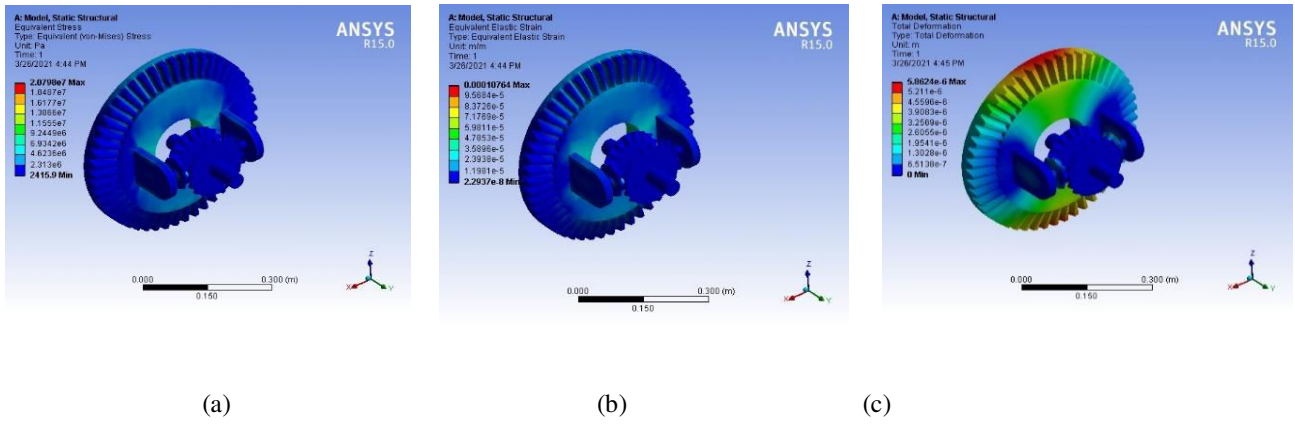


Figure 5.(a) Best stress solution for 1600N, (b) Best Strain Solution for 1600 N, (c) Best total deformation solution for 1600 N

Case 3:

Best Material Solution for 1000N-Carbon Steel C45

Best Solutions of Carbon Steel C45

Carbon steel C45	Minimum	Maximum
Equivalent stress (pa)	1073.7	9.2453e+006
Equivalent strain	1.094e-008	4.785e-005
Total Deformation (m)	2.9867e-7	2.688e-006

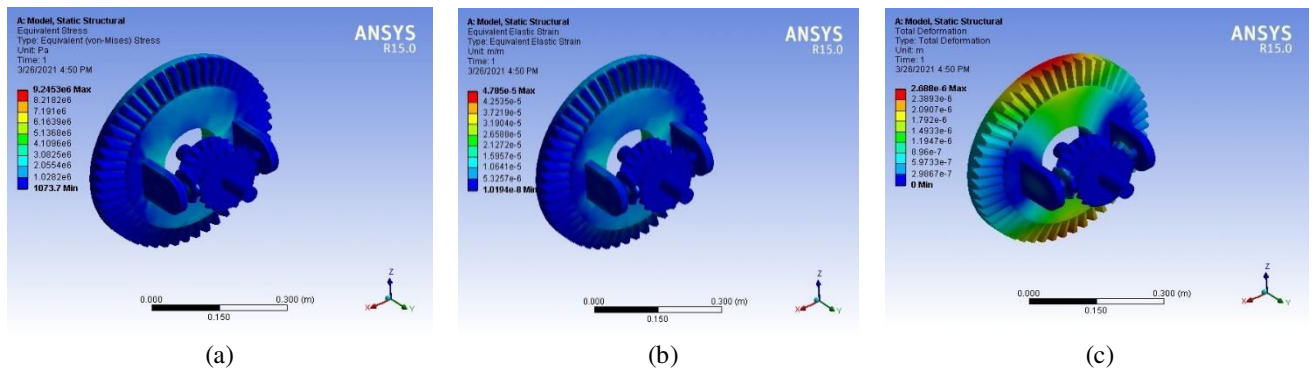


Figure 6. (a) Best stress Solution for 1000N, (b) Best strain Solution for 1000N, (c) Best total deformation Solution for 1000N



V. RESULT AND DISCUSSION

COMPARISON OF THREE CASES

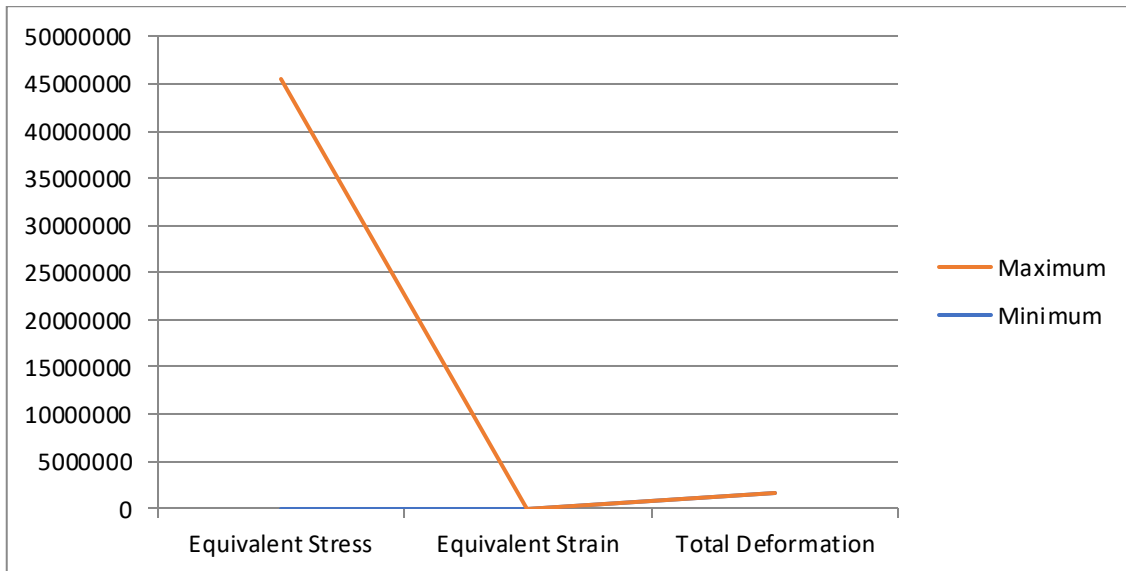
Comparison of Three Cases

By Comparison the solution of the three cases, at 2400N the maximum value of Manganese Chromium (17 Mn 1 Cr 95 Alloy) is less than from the other two cases.

Best Solution

Manganese Chromium Alloy	Minimum	Maximum
Equivalent stress (pa)	4919.6	4.5453e+007
Equivalent strain	5.0218e-008	3.1353e-004
Total Deformation (m)	1.59e-6	1.431e-005

Graph for Manganese Chromium



At 2400N the maximum value of **Manganese Chromium (17 Mn 1 Cr 95 Alloy)** is less than from the other two cases. So Manganese Chromium Alloy is the optimum material for Differential Gear Box.

VI. CONCLUSION

By observing the structural analysis results using Manganese Chromium (17 Mn 1 Cr 95) alloy steel, the stress values are within the permissible stress value. So using Manganese Chromium Alloy is safe for differential gear. When comparing the stress, strain, deformation values of the three materials for all speeds 2400rpm, 1600rpm and 1000 rpm, the values are less for Manganese Chromium alloy than Carbon Steel and Nickel Chromium Alloy. By observing the structural analysis, the maximum obtaining values are less for Manganese Chromium Alloy than other two materials since its stress, strain and deformation values are less. And also weight of the Manganese Chromium alloy



reduces its weight when compared with other two materials. Thereby mechanical efficiency will be increased. By observing analysis results, Manganese Chromium Alloy is one of the optimum material for Differential Gear Box.

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