

# DESIGN AND ANALYSIS OF A TWO-STAGE REDUCTION GEARBOX FOR AN ALL-TERRAIN VEHICLE

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**Abstract :** The atv's are generally small sized, single-seated motor vehicles used for off-road travelling. A two-stage reduction gearbox is a part of a transmission assembly which reduces the rotational speed at the input shaft to a slower rotational speed at output shaft. This reduction in output speed helps to increase the torque of a system. The objective of this paper is to study and analyze the various stresses acting on the gearbox on critical conditions of an atv vehicle. The gearbox failure reasons are predicted and with proper understanding, analysis is carried out. The gearbox design is modelled on CatiaV5 software. We calculated the boundary conditions upon which the analysis was performed using Ansys16.0 software and further verified with theoretical values.

**IndexTerms** - All-Terrain Vehicle, Reduction Gearbox, Catia, Ansys and torque

## I. INTRODUCTION

As atv is a vehicle designed for off-roading it must tackle all the muddy areas, rocks, hills and all the obstacles in its way. Due to off-road terrain the friction is low as compared to normal roads. It requires high torque when climbing hills as well as while starting the vehicle. Also, when running at high speeds at level road, high torque is not required because of momentum. For achieving this a compact and lightweight two stage-reduction gearbox is required which initially provides high torque by reducing the speed of the shaft. Thus, the output shaft has lower rpm than the input shaft. The gearbox also restricts the power flow to the gear train by maintaining a neutral position. The gearbox is designed with spur gears having involute tooth profile as they are having highest efficiency and ease in design considerations and manufacturing cost. During our study, we found that generally failure occurs in the gearbox when the tooth stress exceed the safe limit, thus it became necessary to calculate the maximum stresses acting on the gear under the applied boundary conditions, to prevent these failure analysis is performed on gears.

The gear tooth fails in number of ways such as pitting, stucking, scuffing, corrosion, scoring, etc. but the main causes are due to bending stresses and contact stresses. Thus, based on our survey we performed analysis on two gear materials namely AISI1060 and CI20 in an attempt to suggest a better material according to the situation. After that we calculate theoretically the bending stresses by lewis formulae, the contact stress by hertz equation and finally the deflection by castigliano's theorem. Both the results obtained by analytical and theoretical methods are compared and finally the conclusions are made.

## II. DESIGN CONSIDERATION

In the design procedure we first targeted the transmission line wherein the dimensions of the OEM parts were recorded.

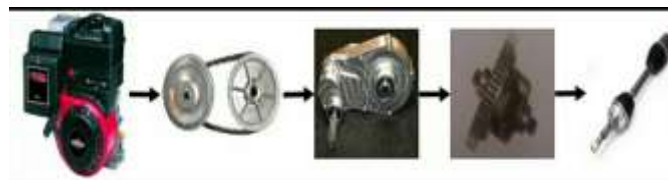


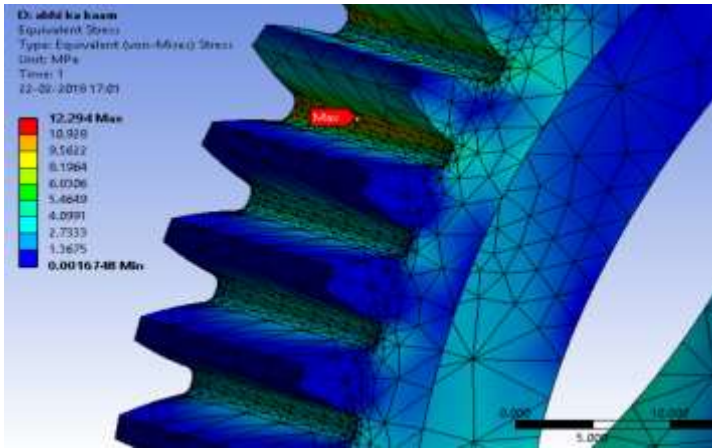
Fig 1: Transmission line of the vehicle

From the above figure we observe that the power coming from the engine is transmitted to the CVT then to the gearbox and from coupling, finally to the shaft. The engine used in the vehicle has a maximum torque of 18.9Nm at 2800rpm and max power of 10hp at 3200rpm. The cvtech cvt used has a low gear ratio of 3:1. The diameter of Tire specifications (22-7-10) with 22" radius and Static friction: 0.75 as well as rolling friction: 0.014 – 0.03. The total mass of the vehicle is taken to be 260kg. However the weight distribution is taken as 65:35.

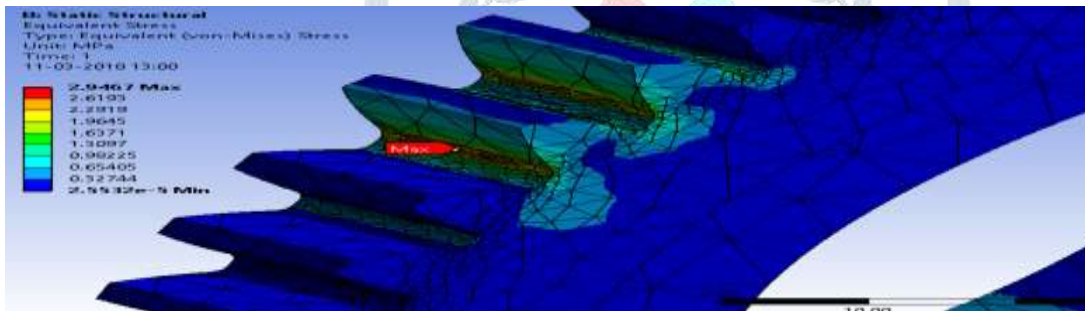
### III. RESULTS AND DISCUSSION

We have performed analysis on every failure mode and data obtained is as follows

#### The bending stress analysis



Bending stress analysis is performed on material AISI1060 with boundary conditions by fixing the bore of the gear and applying the force of 258.36N (2\*T/PCDF). Thus maximum of 12.29Mpa stress is obtained.



Bending stress analysis is performed on material CI20 with boundary conditions by fixing the bore of the gear and applying the force of 161.475N (2\*T/PCDF), Thus maximum of 2.9467Mpa stress is obtained.

| Material  | Theoretical Bending stress value(Mpa) | Analytical value(Mpa) | % Error |
|-----------|---------------------------------------|-----------------------|---------|
| AISI 1060 | 12.30289                              | 12.294                | 0.07 15 |
| CI 20     | 3.00362                               | 2.9461                | 1.915   |

**The contact stress analysis**

In case of contact stresses, the boundary conditions are applied on the area in contact in the direction of motion accordingly

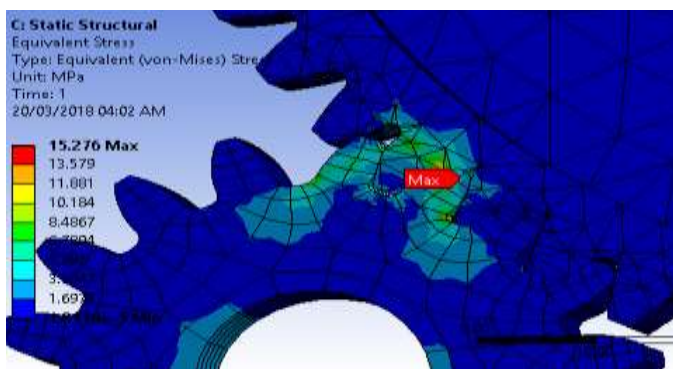
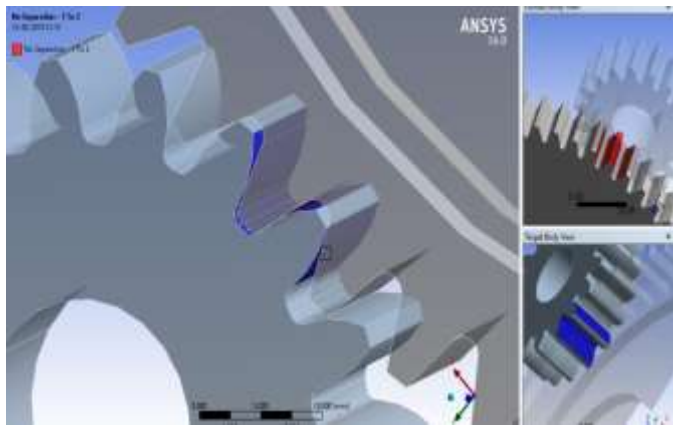


Fig: The contact shear stress is obtained by applying a moment of 30.8Nm, from above it is clearly observed that due to contact between the gears the maximum stress of 15.276Mpa is obtained at the root of the gear

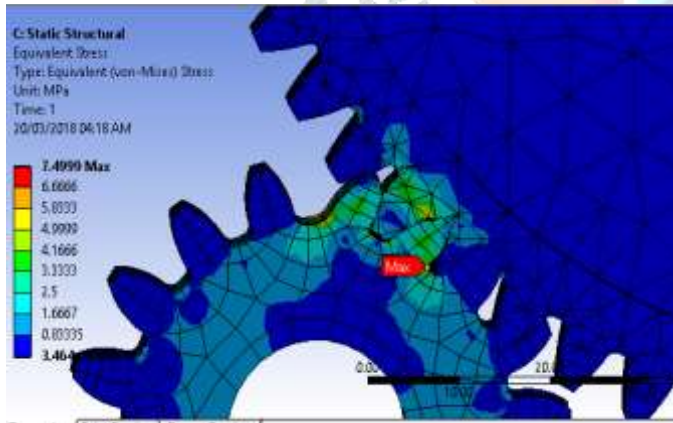
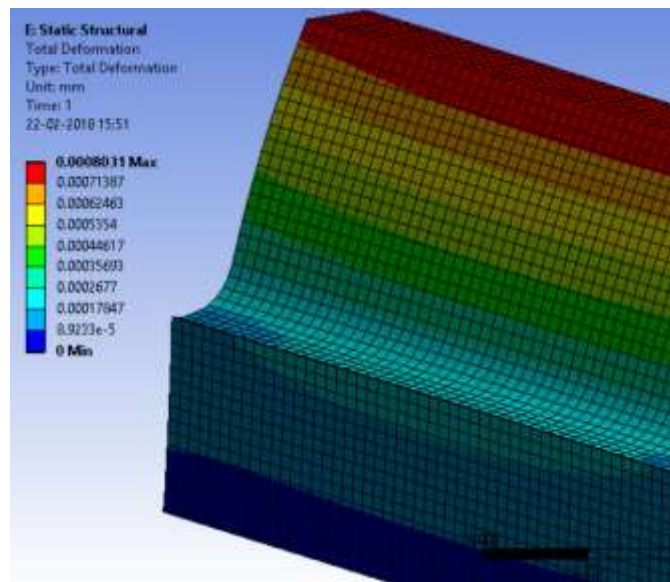


Fig: The contact shear stress is obtained by applying a moment of 17.41Nm, from above it is clearly observed that due to contact between the gears the maximum stress of 7.499Mpa is obtained at the root of the gear.

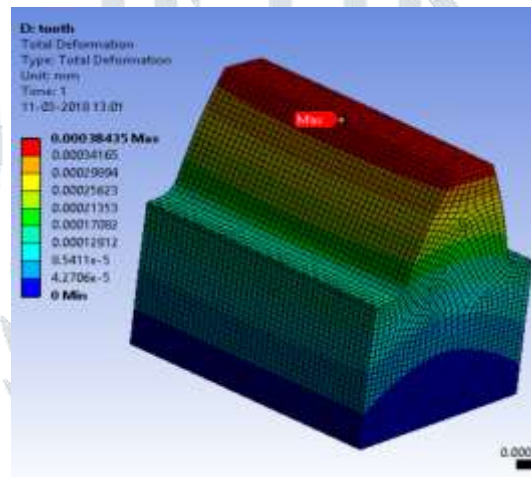
| <b>Material</b> | <b>Theoretical Contact stress value(Mpa)</b> | <b>Analytical value(Mpa)</b> | <b>%Error</b> |
|-----------------|--|------------------------------|---------------|
| AISI 1060       | 15.52  | 15.276                       | 1.427         |
| CI 20           | 7.4419                                       | 7.499                        | 0.6355        |



The deformation analysis



This deflection is obtained by applying the max Force of 258.36N (2\*T/PCD) and fixing the bottom of the tooth, hence maximum deflection in the tooth obtained as 0.0008031mm.



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|           | Theoretical Deflection (mm) | Analytical Deflection (mm) | %Error |
|-----------|-----------------------------|----------------------------|--------|
| AISI 1060 | 0.0008904                   | 0.000803                   | 9.815  |
| CI 20     | 0.000394                    | 0.0003843                  | 2.461  |

The theoretical maximum contact stress calculated by using hertz equation, maximum bending stress is calculated by Lewis equation and the deformation is obtained by castigliano's theorem also the finite element analysis is done on Ansys 16.0. It was found that the stresses and deformation results obtained are in good agreement.

From the above comparison the error for bending stress is in the range of 0 – 2% and contact stress is 0 – 2% and for Deflection 2 – 10%. The value of deflection observed are 0.000803mm and 0.000394mm, which is very negligible to cause the failure. Because usually when the deformations are in range of 2-5mm it would be severe problem. Hence, we can say that the design is safe.

**IV. ACKNOWLEDGMENT**

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