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Design and Analysis of Two Stage Reduction Gearbox for All Terrain Vehicles

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Abstract — *The main purpose of this assignment is to provide a gear box with Low reduction ratio, low weight and efficient for engine up to 500cc. It should also be used in "All Terrain" vehicles demonstrated in BAJA FMAE INDIA, BAJA STUDENT INDIA. The assignment starts with study on gearbox, theoretical calculations, model designing on Solid works 2013, analysis, verification, manufacturing, assembly, testing, modification and at last final testing of gearbox.*

Keywords-*Reduction Gearbox, spur gears, Designing, Analysis*

I. INTRODUCTION

It is true that switching over to gear train reduction from a chain improves the gearbox efficiency. It is recognized that a gear reduction will increase the weight of the vehicle but we would like the weight to be minimized so that the drive train weight does not increase the weight of the vehicle by more than 10% of the weight of the previous vehicle. The gearbox manufacturing will result into quick availability to the students participating in various national events for which they require similar type of gearbox as well cost has been reduced drastically so it will be efficient for the students. This gearbox will also help in longer, smoother and efficient working of the machine of all-terrain vehicles that has been connected with the manufactured gearbox unit. This will also help in easier mounting with quick assembly and disassembly of the gearbox to the vehicle.

Available gearbox in the market has higher weight. Also these gearboxes are not compact; they are bulky which is unsuitable for all terrain vehicles. Conventional gearbox also is not suitable with reduction ratio compatibility with engines for ATV. The conventional gearboxes are not equipped with suitable torque. For optimal integration of the reduction box to each system and the vehicle there is a minimum distance of six inches and maximum distance of eight inches between the centerlines of each shaft.

Aditya et al studied the position of the center of gravity in any vehicle affects the dynamic performance like the maximum tilting angle and maximum acceleration. These dynamic parameters are independent of the engine performance and specifications and depend only upon the constructional details of the vehicle. *Chetan et al* experimented and calculated on the power and braking requirements. On the basis of these requirements and results, a detailed market study was carried out and suitable materials, components and parts were selected. All these components were installed, mounted on the roll cage of the ATV thus completing the fabrication process of the vehicle. In this project we are going to manufacture a two stage reduction gearbox.

II. DESIGN OF GEARBOX

2.1. Detailed study of gearbox: By studying the gearbox theoretically the various parameters related to the gearbox such as types in gearbox, single stage, multistage gearboxes etc. can be understood.

2.2. Theoretical calculations: After the detailed study of the gearbox, the calculation of the gearbox will be done by considering various parameters. Reduction ratio is decided according to the comfortable engine provided by considering the FMAEBAJA INDIA event. After the reduction ratio was finalized the diameters of the gears, pinions shaft can be fixed and then the selecting the bearing type as well as sizes for the proper functioning of the gearbox. According to the reduction decided we calculated the teeth for the gears and pinions, also calculated the dimensions for shafts and keys. Finally after all the above calculations it is decided with the calculations for the casing of the gearbox.

2.3. Model designing: Once the calculations of the gearbox finalized, start the designing of the gearbox virtually on the software such as Solid works 2013 by considering the calculated parameters of the gearbox. Designing of Solid works 2013 helped with the proper visualization of the gearbox and its orientation accurately. A 3D model was been formed and it was very easy to detect problems and solve them as compared with the theoretical calculations. With the help of Solid works 2013software we were able to assemble the gearbox virtually and also it helped in deciding the tolerances for the bearings and keys selected. The drafting of the gearbox helps for easy understanding of the gearbox with the dimensions and model. The drafting converts the 3D model to 2d drawings with the dimensions provided.

2.4. Analysis: The 3D model was formed using Solid works 2013 to check whether the calculations design is correct or incorrect, therefore for the analysis of the gearbox model designed. After doing much iteration and up gradation and using various steps such as shape optimization factor in ansys, reduced the ample amount of weight considering gearboxes available in the market. Shape optimization factor helped in removing the material from the designed part without affecting the safety factor in the design.

2.5. Verification: Results and design of our project with various analysis software like solidworks 2013 and ansys 14.2.

III. MATERIAL SELECTION

The first step in the gearbox design process is to select the material. A material is to be selected by doing intensive research on the properties of the various materials. A material is to be selected keeping in mind the various parameters like strength weight durability cost and other parameters for the sake of designing gearbox **18CrNiMo case-carburized steel** is selected as gear material due to its better mechanical properties.

TABLE.1 Gear Material Specifications

MATERIAL SPECIFICATION	VALUE
Surface hardness	HRC 61
Tensile Strength (N/mm^2)	1200
Yield strength (N/mm^2)	850
Poisson's Ratio	0.3
Young's modulus (N/mm^2)	206000

TABLE.2 Shaft Material Specifications

MATERIAL SPECIFICATION	VALUE
Surface hardness	HRC 61
Tensile Strength (N/mm^2)	1200
Yield strength (N/mm^2)	850
Poisson's Ratio	0.3
Young's modulus (N/mm^2)	206000

45C8 carbon steel is selected as shaft material due to its better mechanical properties.

IV. SPUR GEAR DESIGN

Input characteristics:
Power=7.5 KW Rpm=2048
B&G engine- 13.755 ft. lbf@2600 10 hp@3600
Input Torque=25.81 ft. lbf
Gearbox is coupled with CVTech CVT having minimum ratio of 3 and maximum ratio of 0.5.

CVT ratio=3-[2.5(rpm−1800)1800]

Rpm = 2800 rcvt=1.61

Power=Torque*angular velocity
P=T*ω=7.5*1000=35*ω **ω=**214.285**=2*π*N/60**
Hence **N=2047.3 rpm.**

V. RESULT AND ANALYSIS

The volume of the all gears and shafts calculated with the classical method is 99.3788 cu.in, while the optimal design solution offers a smaller volume, equal to 68.069 cu.in. i.e. a 31.503% reduction.

5.1 Gear 1 – Drive Gear

This gear design is done through solid work 2013. And the diameter of the gear is 125.5 inch and it has 57 gear teeth in it. And it act as drive gear

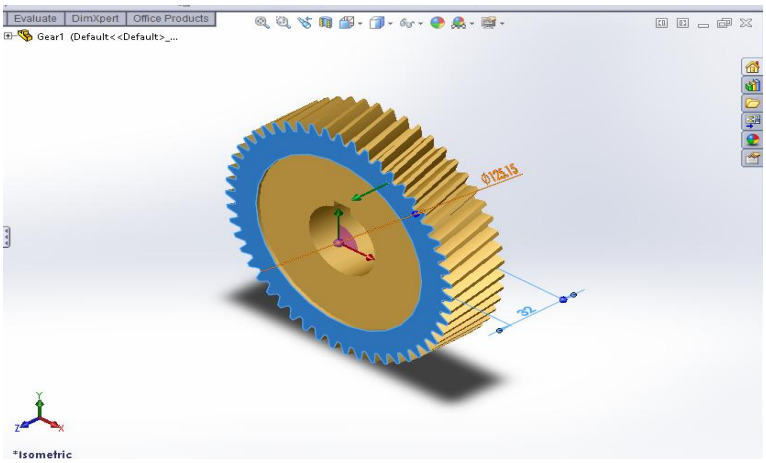

Figure .1 Drive Gear

5.2 Gear 2 – Driven Gear

This gear design is done through solid work 2013. And the diameter of the gear is inch 202.2nd it has 64 gear teeth in it. And it act as driven gear

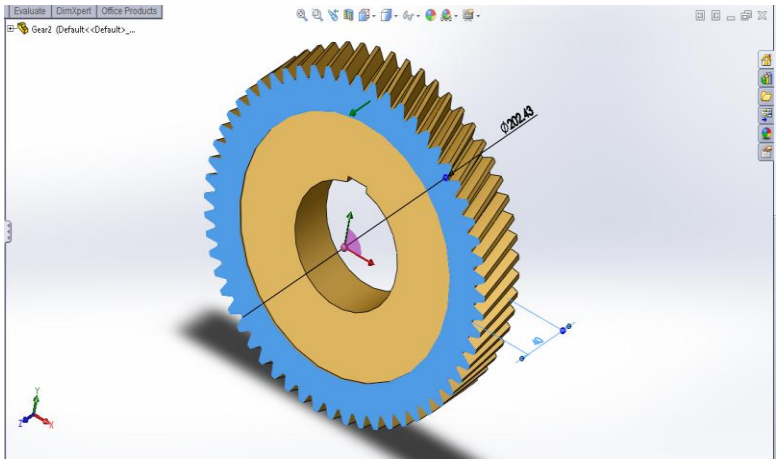

Figure .2 Driven Gear

5.3 Driver Shaft

This drive shaft is designed in solid works 2013. And the total length of the shaft is 1.2 inch and the spur gear diameter is 0.2 inch and angle inclination of the gear 22.92 degree.

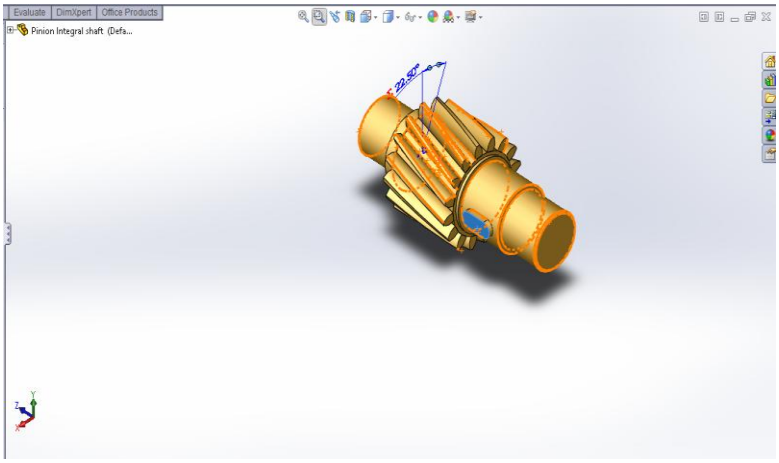

Figure .3 Drive Shaft Gear

5.4 Lower Casing

This casing is designed in solid work 2013 and it come in both upper and lower casing of the gear box it has oil sump.

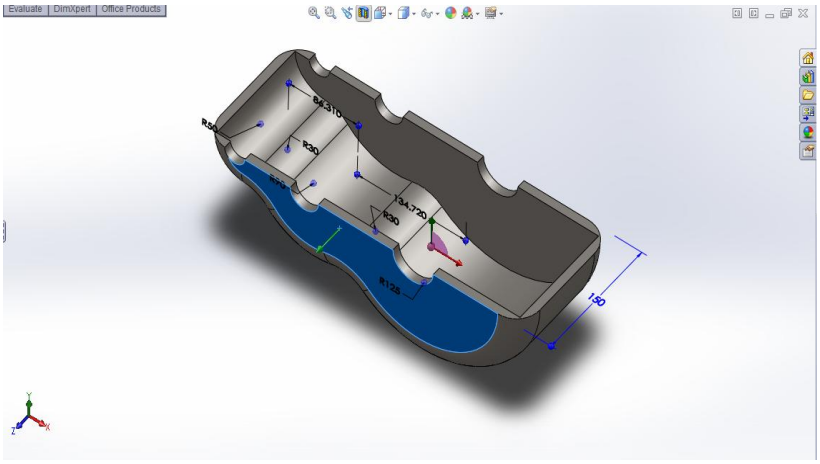

Figure .4 Gearbox Casing

5.5 Gearbox Full Assembly

The gearbox is assembled in solid work 2013 and it has 2 reduction gear coupled together to increase the torque of the vehicle.

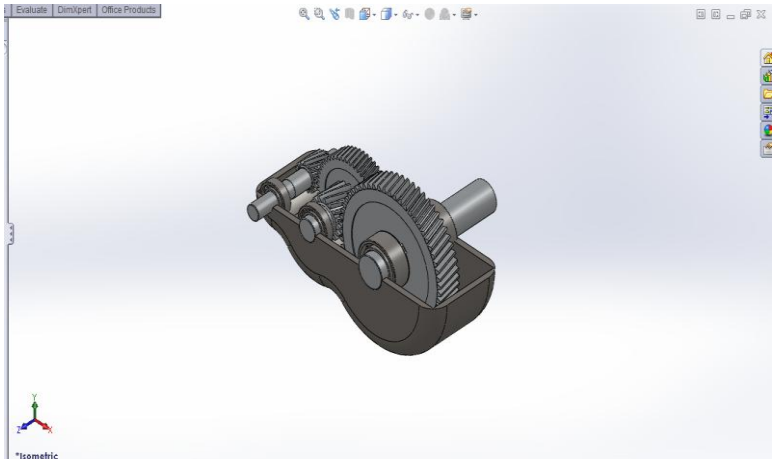

Figure.5 Gearbox Assembly

5.6 Gear Hypermesh in Anysis

The meshing of the primary gear is done in Ansys 14 and it has hyper meshed in it.

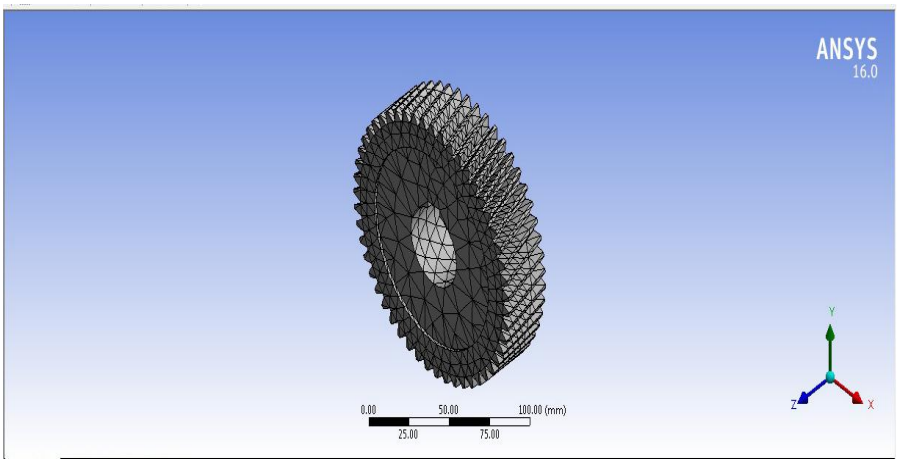

Figure .6 Driven Gear Mesh

5.7 Ansys Result

The analysis is done in Ansys 14 and the maximum and minimum strain applied to the gear is illustrated above in the picture.

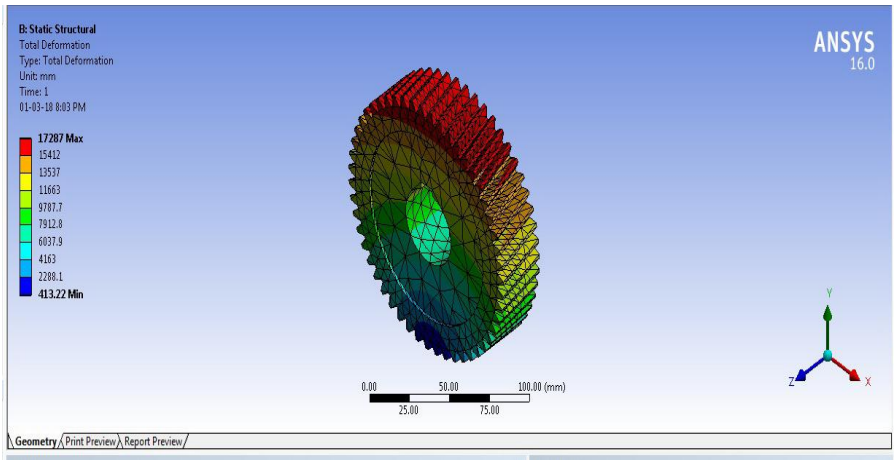

Figure .7 Driven Gear Ansys

VI. CONCLUSION

The product design requires the dimensions and their characteristics of different size. Market requirements stipulated that the product needed to be with different size that can fit the circumstances and conditions where it will be used, therefore required product to be with different size that can meet the market demand. Therefore it is essential to create members of family of same products but with different dimensions and characteristics. Usage of computer in the design of these members as well as, usage of computer in creation of construction of a member of family has considerable effect in shortening the time of product and cost and in increase efficiency and quality of product.

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