International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 12 | Dec 2019 www.irjet.net p-ISSN: 2395-0072

DESIGN AND ANALYSIS OF A TWO STAGE REDUCTION GEARBOX

A.Y.V. Gopi Krishna[1], R.V. Kiran[2]

[1]*M.Tech Student, Dept. of Mechanical Engineering, Chebrolu Engineering College, Andhra Pradesh, India*
[2]*M.Tech Assistant Professor, Dept. of Mechanical Engineering, Chebrolu Engineering College, Andhra Pradesh, India*

Abstract- *An All-Terrain Vehicle is an Off Road vehicle that has the ability to drive on any terrain without any difficulty. These vehicles are designed to sustain any sort of extreme loads that act during off road driving. All-Terrain Vehicles are fitted with large tires with grooves for better traction on slippery terrains, high ground clearance to avoid obstacles, and usually designed with high torque rather than speed. As compared to commercial vehicles, these vehicles are designed to be more strong and durable. These vehicles are vastly used in Deserts.MachineEngineering Design of Gears, Shafts, Gearbox Casing, Bearing selection, Vibrations caused due to the Engine. These analytical designs have been validated through the help of CAD and FEA software like Solid Works and ANSYS. Various Analysis like Structural, Repeated loads and Computational Fluid Dynamics (CFD) have been performed to study the behavior of components and oil flow during operations. The design is also finalized with the fits required for assembly and the final product is expected to be efficient, light weight, compact and long lasting than the other Gearboxes being used today.*

Key Words: **All-Terrain Vehicle, Reduction Gearbox, Computer Aided Engineering (CAD), Computational Fluid Dynamics (CFD), Vibrations, Finite Element Analysis (FEA)**

1. INTRODUCTION ABOUT GEAR BOX

A from the Power source to the output shaft. A gearbox has a set of gears that are enclosed in a casing. The gears are mounted on shafts which rotate freely about their axis. The gears are fixed on the shafts by Fits or by a key. This reduces the capacity of the power source required and hence less fuel consumption. Each Gearbox has its own set of Gear ratiosthat can be selected by the driver or just one set of universal Gear Ratio that will work with the help of a Torque converter or a Continuously Variable Transmission Major components include gears, Casing, Shafts, and Bearing.Gearbox is a device that used for transmitting power.

1.1 REDUCTION GEARBOX

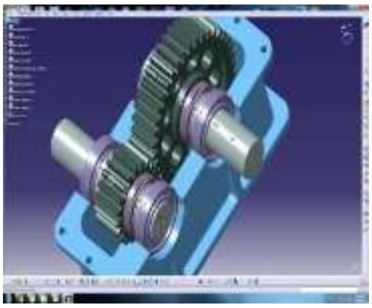
A reduction gearbox is a device by which an input speed can be lowered for a requirement of slower output speed, with same or more output torque. Reduction gear assembly consists of a set of rotating gears connected to an output shaft. The high speed incoming motion from the wheel work is transmitted to the set of rotating gears, wherein the motion or torque is changed. The number of gears used in the

1.2 Types of Reduction Gearbox:

i. Single reduction gear ii.Double reduction

Single Reduction Gear: This arrangement consists of only one pair of gears. The reduction gear box consists of ports through which the propeller shaft and engine shaft enters the assembly. A small gear known as a pinion is driven by the incoming engine shaft.

Double Reduction Gear: Double reduction gears are generally used in applications involving very high speeds. In this arrangement the pinion is connected to the input shaft using a flexible coupling. The pinion is connected to an intermediate gear known as the first reduction



(i)

(ii)

Figure 1: A single Reduction has one set of gears.

2. COMPONENTS OF A GEARBOX: A Gearbox comprises of major components namely:

1. Casing
2. Gears
3. Shafts
4. Bearing

2.1 Casing: Casing is a fixture that fixes all the shafts and assembles all gears into an assembly without any interference. Casing also contains the mounting points to mount it in a powertrain Assembly.

2.2 Gears: A gear is a rotating machine part having cut teeth, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce

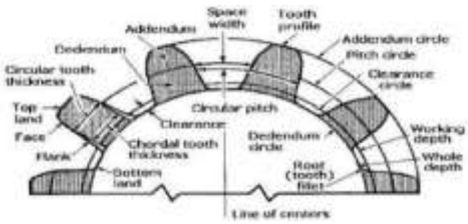


Fig 2 Terms used in Gears

a change in torque, advantage, through their ratio.

2.3 TRESSES IN SHAFTS

The following stresses are induced in the shafts:

Shear stresses due to the transmission of torque (i.e. due to torsional load).

Bending stresses (tensile or compressive) during the forces acting upon machine elements like gears, pulleys etc. as well as due to the weight of the shaft itself. Stresses due to combined torsional and bending loads.

3. METHDOLOGY FOR MATERIAL SELECTION

3.1 **Design Considerations**: The gears and shafts present in the reduction gearbox undergo various forces acting over them. The two stage reduction gearbox consists of three shafts and four gears (two driver gears, two driven gears). When certain RPM is given as an input to the driver gear of the first stage of reduction, it starts rotating in a particular direction by causing a rotational moment on the driven gear of the first stage of reduction.

3.2 REQUIRED SPECIFICATIONS

Many parameters have been gathered from the present ATVs. Table 3.1 mentions the requirements that should be fulfilled by a Gearbox the final product should comply with all these parameters. The components must structurally comply without any failure.

3.3 MATERIAL SELECTION

Material selection plays an important role. Material takes up most of the cost required to make a gear box. So many alloys are available in the market at low prices. But keeping the weight in mind as well as performance an optimal material that can sustain the above requirements are selected for each component of the Gearbox. In order to reduce the variety of materials that are being used, it was decided that only one material should be used for all the shafts, another for Gear and another for the casing.

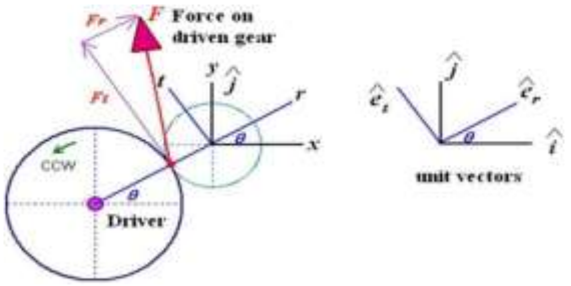


Fig 3 Forces acting on gear

SPECIFICATION	VALUE
Input Power	Briggs & Stratton 300cc Engine
Horse Power	8 HP(7.365 KW)
Maximum Torque	19.659 N.m
Engine Speed(RPM)	Minimum: 1750 Maximum: 3800
Engine Vibration	50 Hz
Wheel Speed(RPM)	Minimum 47.3 RPM Maximum 669 RPM
Maximum Acceleration	7.8 □/□
Maximum Speed	60 □ □/□
Maximum Output Torque	520 N.m
Maximum Dimensions	500*80*130 mm
Maximum Weight	8 Kg
Operating Temperatures	60°□ to 180°□
Vehicle weight	290 Kg

Table 1: Minimum requirements a Gearbox should meet.

MATERIAL	YIELD STRENGTH (MPa)	DENSITY ($Kg/m3$)	COST (Kg)
EN31 STEEL	550	7500	71
EN8 STEEL	415	7500	55
AISI STEEL	690	7500	120
CAST IRON	350	7850	80
CAST STEEL	550	7500	100

Table 2 Materials suitable for gears

4.0 DESIGN OF TWO STAGE REDUCTION GEARBOX

4.1 DESIGNING OF GEARS

The first criteria in designing the gears is to keep them simple, less weight and at the same time to keep the cost as low as possible. So, the weight and cost have their respective weightage during the design such that both the parameters could be worth enough. The machinability is another important consideration.

4.2 DESIGN OF FIRST STAGE REDUCTION

Desired gear ratio = 2

Maximspeedoftheengine, N = 3800 RPM Reductionratioof CVT at high speed = 0.43, the speed at input shaft of gearbox

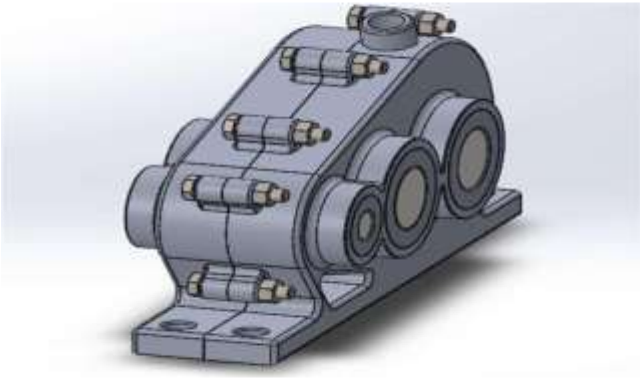
=_= 8837 (say 9000 RPM), *Gear Profile = Involute Pressure.*

5.0 **MODELLING OF TWO SATGE REDUCTION GEARBOX IN SOLIDWORKS**

There are over a dozen modules incorporated in Solid Works. Five of those modules have been used for Product development. Theyare:

1. Part Modelling 2.Assembly Module 3.Drafting 4.SolidWorks Simulation 5.SolidWorks Flow Simulation.

Fig 5 Final Assembly of Gear Box



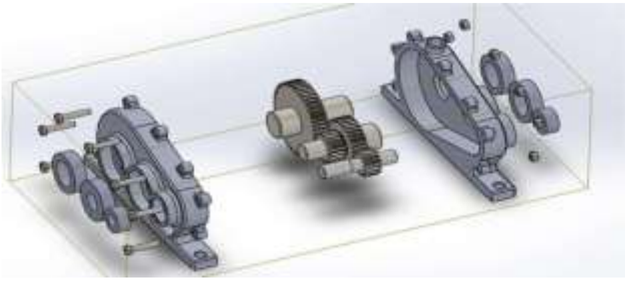


Fig 6 Final Exploded View of the Assembly.

6.0 ANALYSIS &RESULTS:

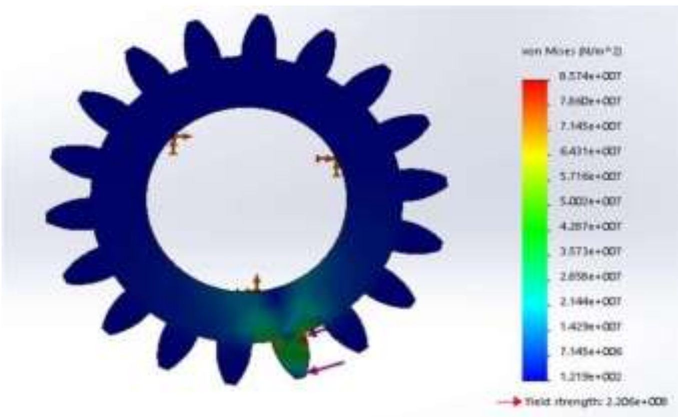


Fig 1Stress for plane carbon steel gear

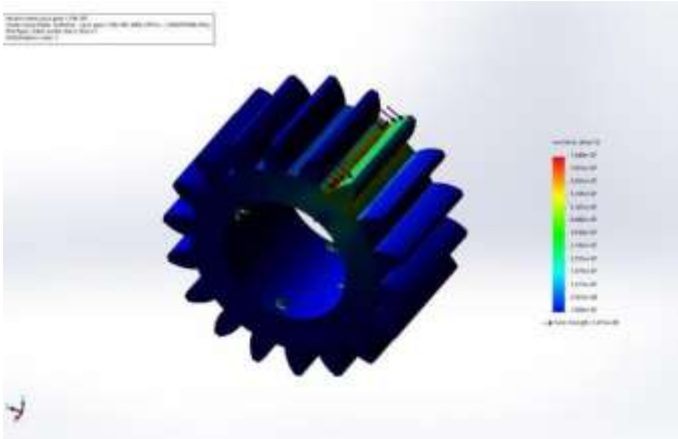


Figure 2: Static Structural Analysis cast alloy steel.

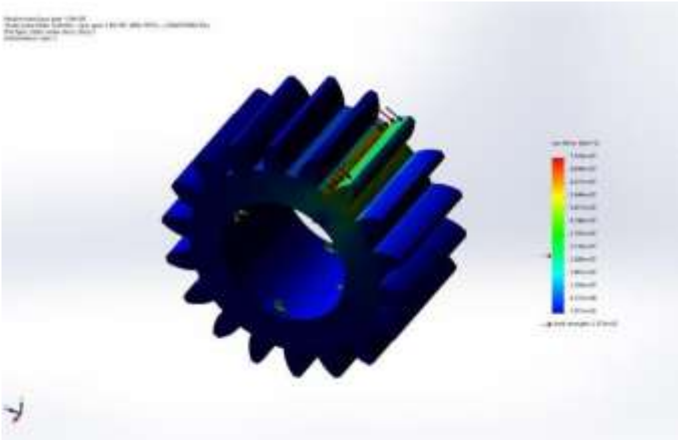


Figure 3 Stress for 1060 alloy.

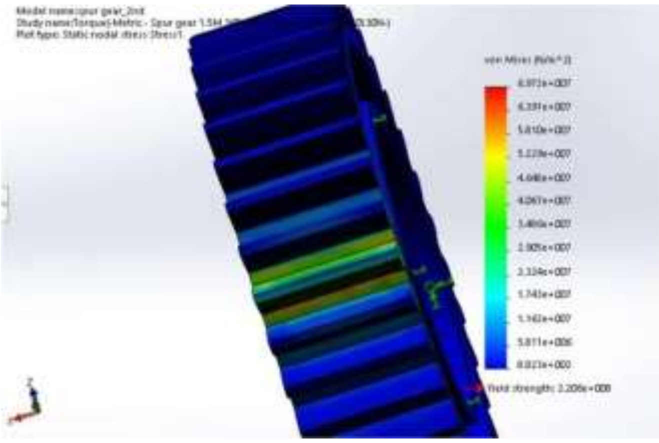


Figure 4: Static Structural Analysis on Gear 2 Plane Carbon Steel.

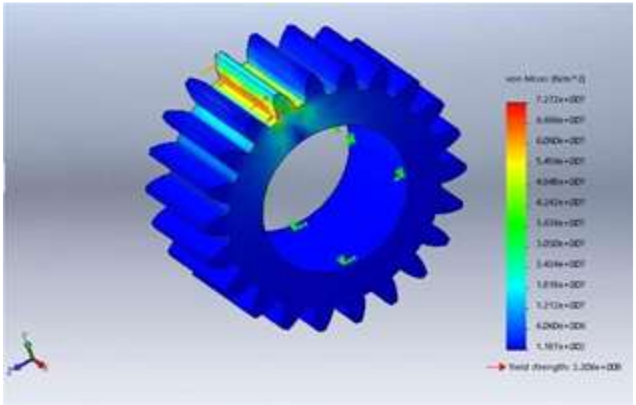


Figure 5: Plane Carbon Steel Static Structural Analysis on Gear 3

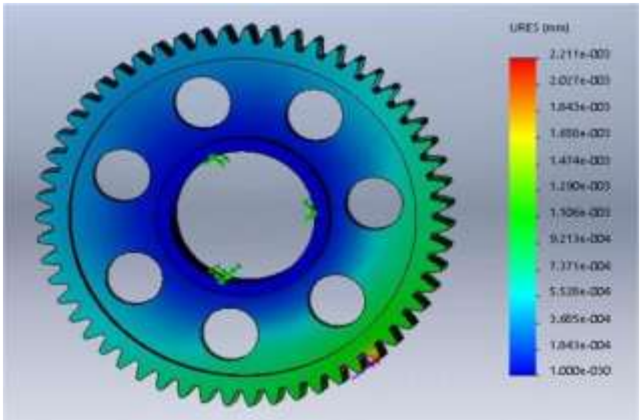


Figure 6 Plane Carbon Steel Displacement Analysis on Gear 4

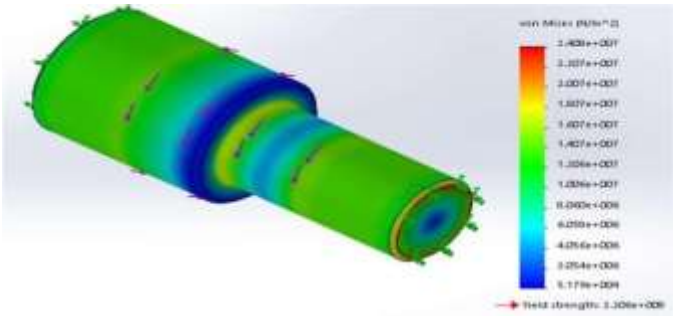


Figure 7 Stress developed in intermediate shaft.

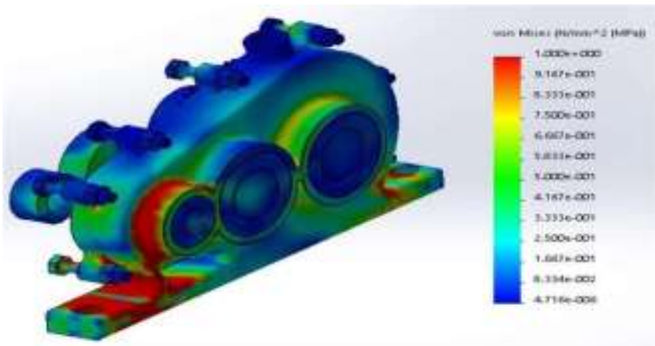


Figure 8 Vibration Analysis on Assembly

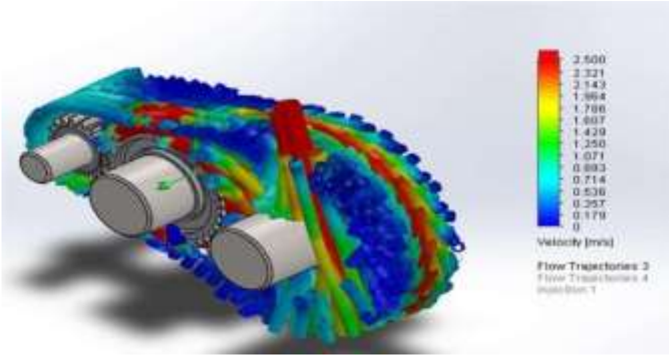


Figure 9 The Oil flow is driven by the movement of gears.

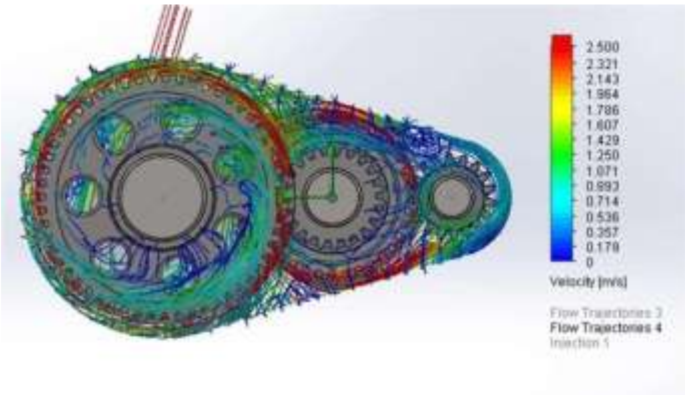


Figure 10 Velocity contours of Oil flow

Result: The study of the oil flow is observed in Figure 9.It has been observed that the oil flow is able to cover all the insides of the casing at medium to high speeds. The figure 10 depicts the velocity contours across the rotating components. It is observed that the velocity of oil is maximum at the periphery of the gear showing that the oils is propagating across the gear tooth effectively. At the base of the casing where the oil is accumulated, there is no stagnancy of oil showing that the oil is being continuously recycled throughout. As per the viscosity point of view, the oil is viscous enough to maintain the surface tension when the oil is accumulated between two teeth. That main force that is driving the major part of the oil flow is the intermediate shaft and the stepped gears mounted on it is observed that the maximum velocity of the oil is occurring around the intermediate gears. Therefore, it is concluded that the Intermediate shaft plays an important role in oil propagation and oil flow is efficient in this setup.

FUTURE SCOPE: The Gearbox designed is lightweight, compact and gives more performance than the present Reduction Gearboxes. However, there still scope for better and more precise design in the following areas. For this Reduction Gearbox, the differential should be connected externally through a chain drive. This will still make the power train assembly little complicated. Assembling the Differential inside the Gearbox itself will make the Power train assembly simpler. The Factor of Safety of the output Gear is too high. This is done because the output shaft is connected to the wheel with the help of a Knuckle Joint. Since the wheel is subjected to various loads from the road condition it is believed that the loads may be transmitted to the out gear also. Considering the loads from the drive shaft will result in better design. The brackets should redesigned in such a way that they do not have to protrude outside completely. This reduces the height and makes the Gearbox look aesthetically pleasing.

CONCLUSION: Today's Gearboxes in All Terrain Vehicles occupy more space, heavy and have limited life based on the operation. Operating these Gearboxes for continuously will produce heat that may affect the structural integrity. The Reduction Gearbox designed.

REFERENCES:

1.Höhn, B-R., and K. Michaelis. "Influence of oil temperature on gear failures." Tribology International 37, no. 2 (2004): 103-109.

2.Golabi, Sa'id, Javad Jafari Fesharaki, and Maryam Yazdipoor. "Gear train optimization based on minimum volume/weight design." Mechanism and machine theory 73 (2014): 197-217.

3.Patnaik, Siddhartha. "DESIGN FAILURE MODES AND EFFECTS ANALYSIS (DFMEA) OF AN ALL-TERRAIN VEHICLE." International Journal of Research in Engineering and Technology 4.

4.Seshadri, Subhash. "Design and CFD analysis of the intake manifold for the Honda CBR250RR engine." (2015).

5.Patel, Mitesh, A. V. Patil, Mitesh Patel, and A. V. Patil. "Stress and Design Analysis of Triple Reduction Gearbox Casing." International Journal 2: 106-111.

6.Lombard, Matt. SolidWorks 2011 Parts Bible. Wiley Pub., 2011.

7.Sellgren, Ulf, and M. Akerblom. "A model-based design study of gearbox induced noise." In DS 32: Proceedings of DESIGN 2004, the 8th International Design Conference, Dubrovnik, Croatia. 2004.

8.Teng, Hongzhi, Jianmin Zhao, Xisheng Jia, Yunxian Jia, Xinghui Zhang, and Liying Cai. "Experimental study on gearbox prognosis using total life vibration analysis." In Prognostics and System Health Management Conference (PHM-Shenzhen), 2011, pp. 1-6. IEEE, 2011.

9.Guan, Yuan H., Teik C. Lim, and W. Steve Shepard. "Experimental study on active vibration control of a gearbox system." Journal of Sound and Vibration 282, no. 3-5 (2005): 713-733.

10. Gorla, Carlo, Franco Concli, Karsten Stahl, Bernd- Robert Höhn, Michaelis Klaus, Hansjörg Schultheiß, and Johann-Paul Stemplinger. "CFD simulations of splash losses of a gearbox." Advances in Tribology 2012 (2012)