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Design and Analysis of an ATV 4 Wheel Drive

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Abstract: ***The role of the drive train is huge as in case of an ATV. Drivetrain consists of powertrain i.e the engine and the transmission system which include the CVT, gearbox, shafts and wheels. During the initial stage our main objective was to provide power to the vehicle through a broad range of operating conditions, create a rugged and durable system, maximize transmission efficiency, reliability, and function. And here we have chosen 4wd instead of 2wd to provide better driving conditions. Performance parameters like gradeability, acceleration, top speed, transmission, output ratio etc. have been considered on the basis of their influence over the vehicle under different conditions and calculations and finally suitable conditions are selected for our ATV.***

Keywords: ATV, Differential, Gearbox, Powertrain, Transmission, 4WD

Nomenclature

GVW	Gross vehicle weight=310 N .
Cr	Coefficient of rollingresistance=0.05.
ρ	Air density=1.225 Kg/m^3.
A	Frontal area=1.2 m^2.
Cd	Drag coefficient=0.44.
r	Radius of wheel=21 inch.
α	Incline angle.
V	Vehicle velocity.
ω	Angular velocity.

1. Introduction

A machine consists of a power source and a power transmission system, which provides controlled application of the power. The transmission is an assembly of parts including the speed changing gears and the propeller shaft by which the power is transmitted from an engine to a live axle.

In an ATV there are mainly six department roll cage, powertrain, suspension, steering, brakes. This paper is focused on the study, designing, analysis and fabricating of the powertrain system for an ATV. The primary function for a powertrain system is to transfer the power for the engine to the wheels with minimum amount of loss and maneuver the vehicle within all possible terrain that includes rocky, muddy road with water and with a climb. Powertrain has the most important task of all the other departments, the system must bring proper stability to the ATV along with the performance. The vehicle must be able to accelerate when needed and must be able to produce proper power and required torque with minimum or with no wheel spin. It is required to have minimum wheel spin to keep the losses at minimum level.

One of the deciding factors of any vehicle's performance is the comfort level of the driver, which comes with less driving fatigue. The noise and vibration is another aspect which should be worked on, to reduce the unwanted stresses in the frame. Therefore, NVH consideration is must and should be installed properly. Performance parameters like gradeability, acceleration, top speed, transmission etc will be discussed on the basis of their influence over the vehicle under different conditions and calculations.

1.1 Engine

For the purpose of an ATV our team has chosen the designated Briggs and Stratton engine. It provides 10 HP at 3600 rpm and torque of 19.6 Nm at 2700rpm with a displacement of 305cc and it weighs just 26.4 kilograms.

Engine	: BRIGGS STRATTON 19S232-0036
Displacement	: 305 CC
Max. Power	: 10 HP @ 3600 RPM
Engine Type	: OHV
Max. RPM	3800
Max Torque	: 19 Nm @ 2800 RPM
Lubrication System	: Splash Bore
Diameter	: 3.12 in
Stroke Length	: 2.44 in
Choke Control	: Manual
Ignition System	: Electronic
Carburetor	: Float
Governor System	: Mechanical

1.2 Transmission Type

The transmission that we had chosen is a continuously variable transmission (CVT) system which is directly coupled with the engine and a two-stage reduction gearbox. The use of this CVT implies that manual shifting is not necessary. CVTech was chosen primarily due to packaging constraints given that it mates directly to the Model 19 engine.

Calculation Rolling Resistance RR = GVW * Cr
Aerodynamic Resistance AR= ½* $\rho * V 2 * A * Cd$
GRADE RESISTANCE GR = GVW x sin(α)
TOTAL TRACTIVE FORCE (TTF) = RR+AR+GR

MAXIMUM TRACTIVE TORQUE
MTT=WDW * CSF *R * cos(α) VELOCITY = r*ω TABLE 1 Theoretical values obtained for the drivetrain system

Maximum Velocity	52.2 Km/hr
Acceleration	3.76 m/s^2
Gradability	42.2

1.3 Powertrain

The mechanism by which power is transmitted from the engine to the axle in our vehicle consists of Engine - CVT

Gearbox and Transfer Case - Driveshaft - Differential - CV axle - Wheels. CVT and Gearbox combinedly give the power reduction ratios of the engine to get the required amount of speed and torque. The power train of our ATV vehicle comprises a differential at the front axle that is connected to the central bearing by a shaft of length 33 in. The pinion and crown gear provide a reduction of 1:2 providing the vehicle with an overall gear ratio of 1:24

CAE is a very important step in any design process. The components which were designed for the ATV is then rigorously tested in the CAE software for the real world conditions. By performing CAE we get the data related to the strengths, weakness and other factors like reliability life of the component. This data then can be helpful in optimizing the design to the best possible way.

A. Gearbox

The power train system comprises a gearbox of ratio 8, to provide the vehicle with enough torque for the dynamic events. Hence a gearbox has been designed in such a way that the weight of the gearbox should be reduced, and the gear tooth does not undergo failure. A two-stage compound gearbox has been designed and EN353 grade steel is used for the gears while the case is made of Al6061. Gear type is a helical gear, which has an inclined pitch by which chances of the failure of the tooth will be minimum.

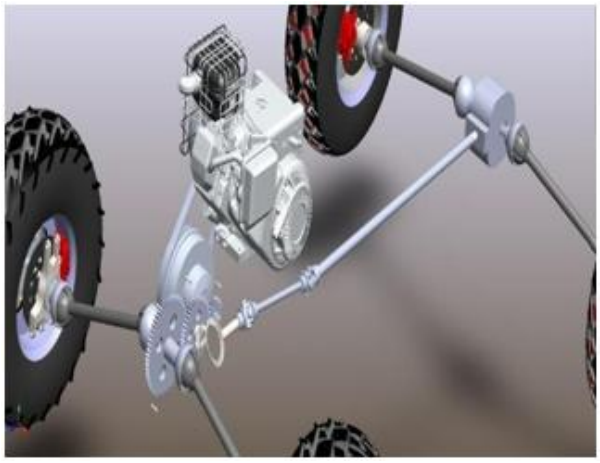

Figure 1: Skeletal View of Gear Box

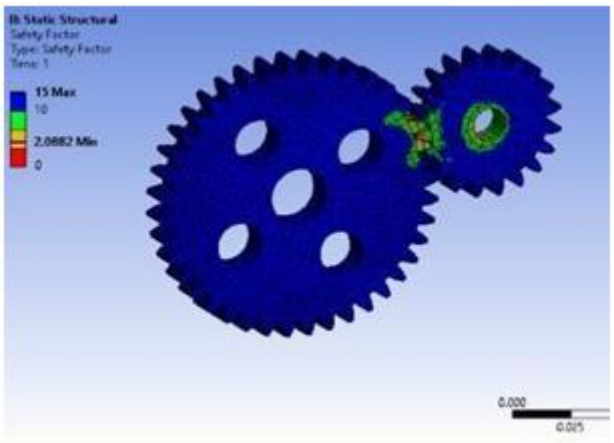

Figure 2: Safety Factor of Gear used in Geartrain

Here we have done the modelling works on solidworks and analysis on ansys software. Analysis has been done for total deformation, equivalent stress and safety factor. From these values we could confirm that our gear design is within the safety limits. The torque that we have applied on gears for analysis purpose is 350Nm which we got from our calculations.

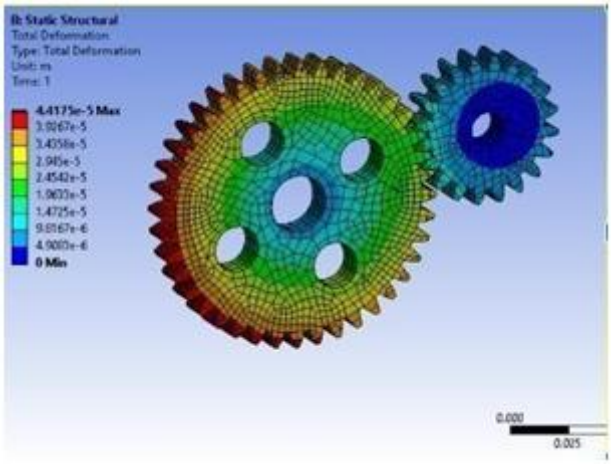

Figure 3: Total Deformation of Gear used in Gearbox

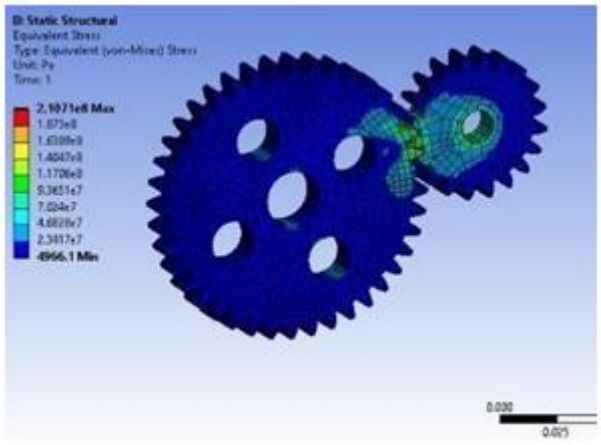

Figure 4: Equivalent Stress of Gear used in Gearbox

B. 4 Wheel Drive

This year we opted to build a 4-WD ATV to improve its rugged terrain performance characteristics. The vehicle drivetrain system consists of a propeller shaft transmitting power from rear to front. At the front the transmitted power

is diverted to wheels by using an open differential with a reduction ratio of 2:1. A central bearing is also used to provide support to the drive shaft at a distance of 20 inch from rear transfer case end.

Driveshaft length: 20 in and 33 in Outer diameter : 1 inch
Inner diameter: 0.775 inch

Figure 5 (a) Overall View of 4 Wheel Drive

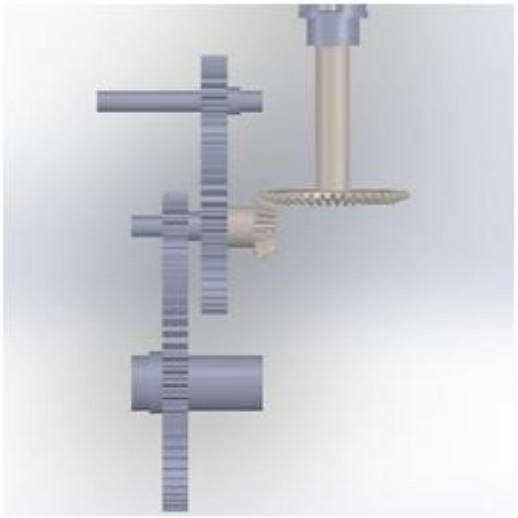

Figure 5 (b) Exploded view of Gearbox

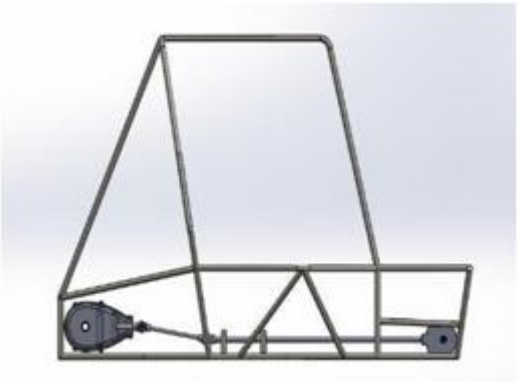

Figure 5 (c): Sideview of chassis with 4WD

C. Wheels

In an All-terrain vehicle, traction is one of the most important aspects of both steering and getting the power to the ground. Tire configuration treads depth, weight, and rotational inertia are critical factors when choosing proper tires. The ideal tire has low weight and low internal forces. In addition, it must have strong traction on various surfaces and be capable of providing power while in puddles.

Dimensions Front : 21 * 7 *10
Rear : 21 * 7 * 10

Figure 6: Wheel in our ATV

1.4 Differential

In automobiles and other wheeled vehicles, while taking a turn the differential allows outer wheel to rotate faster than the inner drive wheel. This is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve rotate farther and faster than the inner wheel. This also works as reduction gearing to give the ratio.

The deciding factor in the vehicle's performance is the selection of Differential. In general terms, a differential is a kind of gear box which transfers the different speeds at different wheels so that the vehicle can take turns without slipping. From simplified type i.e. open differential to most complex type i.e. LSD, one can choose a differential based on the track requirement and the costing off course! Here we have chosen an open differential as it is simple in operation and lower cost.

a) NVH

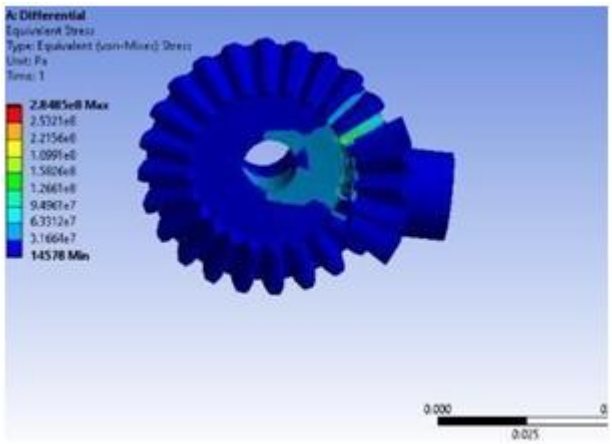

Figure 6: Equivalent Stress of Differential

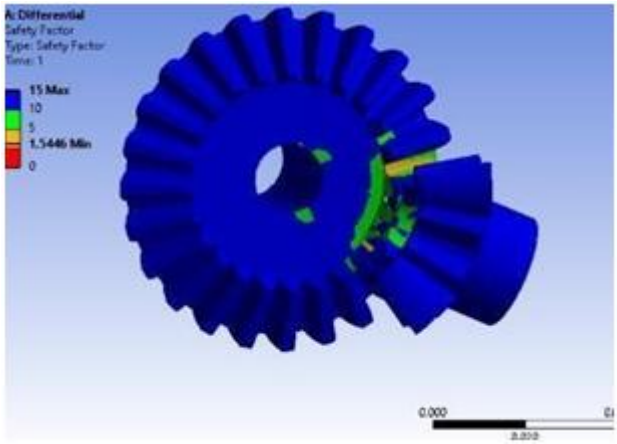

Figure 7: Safety Factor of Differential

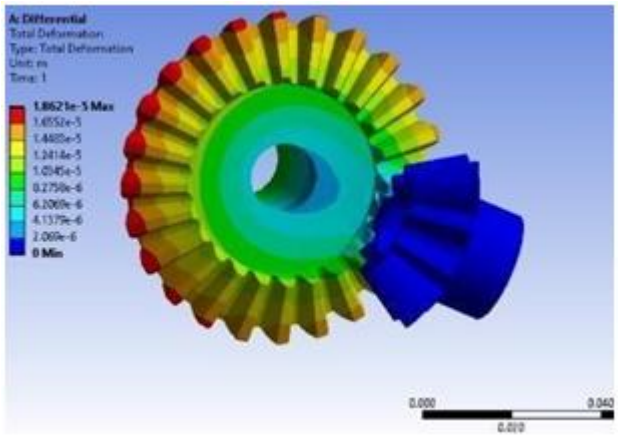

Figure 8: Total Deformation of Differential

Basically, it deals with the noise and vibration problem which is going to rise due to the running engine. As vibration is considered to be very fatal for any structure and in this case of the roll cage, some of the vibration problems are fatigue stress induced in the roll cage, loosing of nuts from bolts, noise is also very fatal but not from structure but for environment. So there are many solutions like padding the engine or harnessing the engine on spring or usage of rubber bushing and using lock nuts for all bolts used in the vehicle. Therefore, if the resonance condition is not reaching in the frame, then the vehicle is safe from the unwanted stresses and the premature failure of the components. Therefore by implementing above measures we can reduce the resonance condition and the vehicle will be in safe condition.

Figure 9: Rubber Bushes for NVH Consideration

2. Conclusion

The project aimed at designing, analyzing, fabrication and testing of transmission systems for an ATV and their integration in the whole vehicle. The first and foremost advantage of this literature is the availability of design detailing along with the specification of each and every components of the Drivetrain in one segment. Here we have given more importance to 4wd mechanism in which power is diverted from rear to front via propeller shaft and differential after first stage of reduction. This project helped us to understand deep into various aspects of powertrain department and its features. The focus was on designing and analysis of gears of gearbox and differential. And hence the gearbox is ready to transmit the required amount of speed and torque for various terrain to tackle all the obstacles in the track.

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