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Transmission System In An All Terrain Vehicle

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ABSTRACT : *The purpose of this paper focuses on the Transmission System of an All-Terrain Vehicle(ATV) and the methodology for designing a Transmission System of an All-Terrain vehicle System. This study will help acknowledge various components used in the transmission systems and better understand these components and its integration with each other. The transmission opted for this vehicle is a rear Wheel Drive System. The transmission system consists of a CVT coupled to a Reduction Gear Box. All relevant calculations have been included in the paper*

KEYWORDS–*All-Terrain Vehicle, Rear Wheel Drive System, Reduction Gear Box, Transmission System*

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I. Introduction

All-terrain vehicle (ATV) have been widely used either by civilian or military. In some cases, there are ATV that has been used in agriculture field. This type of vehicle is designed to operate in difficult and complex terrains. During recent years the use of ATV is also seen in the racing competitions like SAE BAJA, MAC, etc. Generally, ATV consists of three main parts. These parts are structure or better known as chassis, transmission and suspension. We can see various ATV transmission systems throughout the course of years.

Transmission system for any vehicle is basically meant to transmit the power supplied by the engines to the wheels, to thereby propel the vehicle. Using the transmission system we can vary the torque and speed as per the vehicle requirements. Automobile transmission systems have seen a numerous changes over the years.

Types of Transmission systems

1.1 Manual Transmission

In a manual transmission system the gear ratios shifting is done manually with the help of lever. Use of a clutch assembly is mandatory in such case to cut down the power from the engine during shifting.

1.2 Automatic Transmission

It is a type of transmission system in which the shifting of gear ratios is achieved automatically freeing the driver from shifting the gears manually. It provides with a wide range of ratios. Based on the layout, the transmission system may be classified as

1.2.1 Front Wheel Drive

If the drive from the engine is given to the front wheels of the vehicle then the system is said to be front wheel drive.

1.2.2 Rear Wheel Drive

If the drive from the engine is given to the rear wheels of the vehicle then the system is said to be rear wheel drive.

1.2.3 All-Wheel Drive

If the drive from the engine is given to all the four wheels of the vehicle then the system is said to be all-wheel drive.

For an all-terrain vehicle as the vehicle is said to run on different terrains, either all-wheel drive or rear wheel drives are suitable. For the purpose of reducing complexity and weight rear wheel has been chosen.

II. Components

2.1 Briggs and Stratton Engine

Briggs & Stratton is an American Fortune 1000 manufacturer of gasoline engines. These engines often have simple designs, for example an air-cooled single-cylinder petrol engine with a pull-cord starter, capacitor discharge ignition and a gravity-fed carburettor.

Engines of similar design and displacement are also used in smaller vehicles such as motorcycles, motor scooters, and go-karts.

Fig 1. briggs and stratton engine

2.1.2 Specifications

- Model - 19L2320054G1
- Horsepower - 10hp
- Displacement - 305cc
- Torque - 14.50 ft-lbs
- No. of Cylinders - Single
- Configuration - Horizontal
- Technology - OHV
- Engine Fuel - Gasoline
- Factory Set RPM - 3800 RPM
- Oil Capacity - 24 ounces
- Length - 12.3 in
- Width - 15.4 in
- Height - 16.4 in
- Weight - 50.4 lbs

2.2 Continuously Variable Transmission

A continuously variable transmission (CVT) is an automatic transmission system which offers a wide range of ratios.

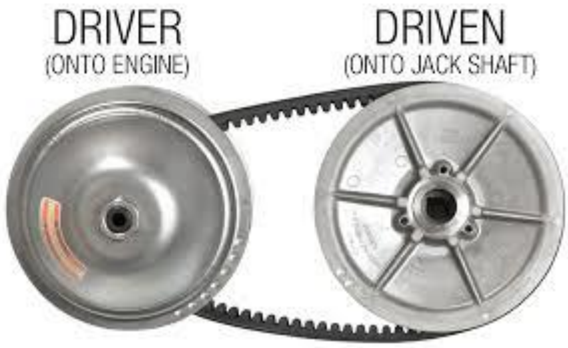

Fig 2. cvt

A CVT consists of driver pulley, driven pulley and a belt to transmit the power from driver to driven. The Belt slides over the conical surface of the pulley to produce a continuous range of ratios.

A mechanical CVT works on the principle of centrifugal force. The driver pulley is coupled to the crank shaft of the engine. Masses present in the driver pulley rotate and tend to produce a centrifugal force which is responsible for the belt to slide over the pulley surface.

A CVTech CVT which has a lower ratio of 3 and an upper ratio of 0.43 is selected for the current project.

This CVT has an engaging rpm of about 1900 and the engine delivers its maximum torque at 2300 rpm.

So, at 2300 rpm the ratio in the CVT will be around 2.5 which will serve our requirement to achieve the required torque of 538 N-m.

2.3 Gearbox

Gearbox is used to transmit the power to drive shaft. With the help of gearbox the speed and torque of an All Terrain Vehicle can be controlled.

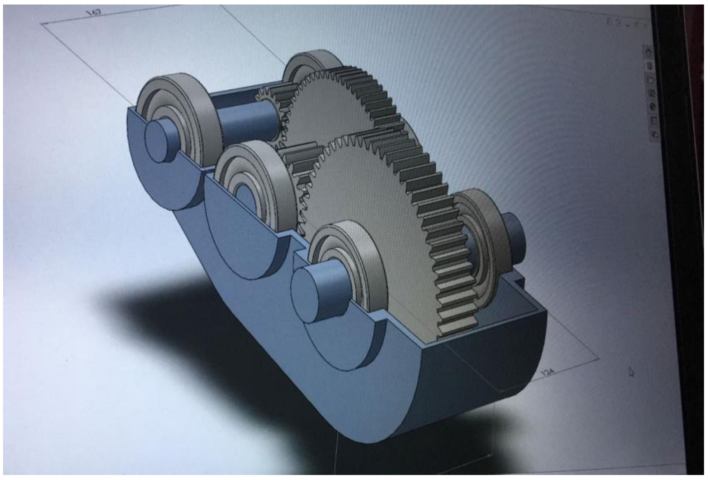

Fig 3. gearbox cad model

3.1 CALCULATIONS

3.1.1 Assumptions

- Mass of the vehicle(m) = 270kg
- Earth Gravitational pull = 9.81m/s^2
- Angle of Inclination = 40^o
- Coefficient of Rolling Resistance = 0.015
- Weight distribution (Front : Rear) = 40:60
- Drag Coefficient (c) = 0.44

3.2 Calculation for Reduction Ratio

3.2.1 Rolling Resistance

Rolling resistance is the amount of force that resists motion of a tire on a surface. Rolling resistance specifically refers to this part of the tire that is making contact with the ground as a vehicle moves, as the rolling resistance is what your vehicle has to overcome in order to move in the first place.

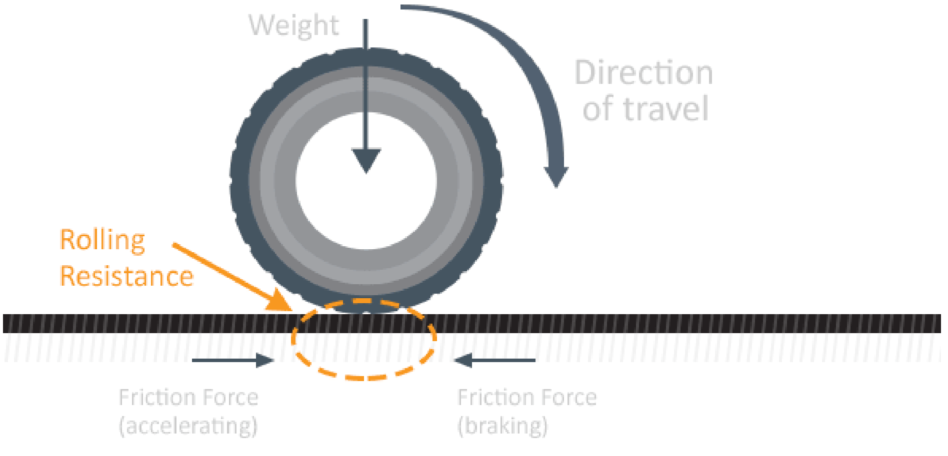

Fig 4. rolling resistance

RR = m × g × Cr

= 300 × 9.81 × 0.3

= 794.61 N

3.2.2 Gradient Resistance

When the vehicle travels uphill, a component of its weight works in a direction opposite to its motion. If some energy is not supplied to overcome this backward force, then the vehicle would slow down, stall and roll backwards.

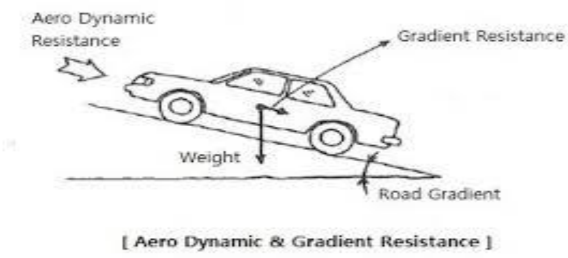

Fig 5. gradient resistance

GR = m × g × sin (θ)
= 300 x 9.81 × sin(40)
= 1702.55 N

Thus, Total Resistance

TR = RR + GR
= 794.61 + 1702.55
= 2497.16 N

Now, Resistance Torque

RT = TR × Tire radius
= 2497.16 × 0.3048
= 761.13 N

Therefore, Reduction Ratio is given by,

Engine Torque × CVT Reduction × Reduction Ratio = Resistance Torque

19.72 x 3 × Reduction Ratio = 761.13

Reduction Ratio = 12.87

3.3 Designing of Gear

Material for both Gear and pinion = 40Ni2Cr1Mo28 (En 24)

Design Contact Stress = 1100 N/mm^2

Design Bending Stress = 400N/mm^2

Assume,

i_1 = 3.7 (Reduction Ratio for 1st Stage)

i_2 = 3.48 (Reduction Ratio for 2nd Stage)

First Stage Calculations-

Taking, z_1 = 18 teeth

Thus, $z_2 = z_1 \times i_1$
= 18 × 3.7
= 67 teeth

i_1 (Corrected) = 67/18
= 3.72

Lewis for Pinion,

Y_1 = 0.3246

Lewis for Gear,

Y_2 = 0.441

Thus, Pinion Weak.

Now, $m = 1.26 \times ([M_t] / \sigma_b \times \psi_m \times Y_1 \times z_1)/3$
= 1.86

Therefore, taking standard value, m = 2.5

Thus, Width of the Gear (b)= m x ψ_m
= 2.5 x 10

= 25 mm
Now,
For checking Dynamic Stress,
$Fs = \sigma_b \times b \times Y_1 \times m$
$Fs = 400 \times 25 \times 0.3246 \times 2.5$
= 8115 N

$Fd = \frac{P}{Vm} \times \frac{(5.5+Vm^{\frac{1}{2}})}{5.5}$

$= \frac{7457}{2.83} \times \frac{(5.5+2.83^{\frac{1}{2}})}{5.5}$

$= 2.637 \times 10^3 \times 1.31$
= 3454.47 N
Thus, Fs >Fd
$Fw = d_1 \times Q \times K \times b$
$= (m \times z_1) \times (\frac{2\,i}{i+1}) \times K \times b$
$= (2.5 \times 18) \times (\frac{2 \times 3.7}{3.7+1}) \times 2.74 \times 25$
= 4858.85 N
Thus, Fw>Fd
Hence, Design is safe in dynamic load.
Thus, For FIRST STAGE ($\psi = 10$)
$i_1 = 3.7$
b = 25 mm
m = 2.5 mm
z_1 = 18 teeth
z_2 = 67 teeth

Similarly Solving For SECOND STAGE, we get ($\psi = 12$)
$i_1 = 3.44$
b = 42 mm
m = 3.5 mm
z_1 = 18 teeth
z_2 = 62 teeth

3.4 Designing of Shaft

For Shaft 1,
Here, N = 3600 rpm
$Mt = 59.34 \times 10^3$ N-mm
T_1 = 1101 N (By Calculation)
T_2 = 502 N

Now, for Pinion 1,
$Ft \times 22.5 = Mt$
Ft = 2637.33 N
$Fr = Ft \times \tan(\alpha)$
Fr = 959.90 N

Now , for CVT,
T1 + T2 – Wc
= 1548.99 N

By Bending Moment Diagram, we get
$Mb = 309.798 \times 10^3$ N-mm

Now, by ASME method,
Shear Stress (τ) = 180
By using Formula, $Mt = (\pi \times D^3 \times \tau)/ 16$
D = 20.61 mm
Thus, taking D = 25 mm
Similarly For Shaft 2 & 3,

Shaft 2 = 30 mm
Shaft 3 = 35 mm

3.5 Designing of Bearing
For Shaft of 25 mm, selecting bearing
For Bearing 1 :
Reaction Force, R= 4189.88 N
$L_{08}= (L_{hr} \times N \times 60) / 10^6$
$= 72$ mr
Now, $L_{10} = 85$ mr
C $= (85)^{1/3} \times 6284.82$
= 2771.324 Kgf
Thus, Selecting Series 64 (6406) bearing as it satisfies the criteria.

Similarly, for other bearings,
Bearing 2 = 6406 (For Shaft 2)
Bearing 3 = 6208 (For Shaft 3)

III. Drive Shafts

The torque output from the gear box is now transferred to the wheels through drive shafts.
This is achieved by using the OEM drive shafts of Maruti Suzuki.

IV. N.V.H Considerations

N.V.H stands for Noise, Vibrations, and Harshness. As the engine used is a generator engine the vibrations from the engine are to be reduced by maximum extent for optimal performance. This can be achieved by using proper damping material for the mounting of engine. We can use materials such as rubber to serve the purpose.

V. Conclusion

After number of research on various papers related to All Terrain Vehicle, successful calculations were made for gearbox and a CAD model of the rear part of the vehicle was made for better understanding.

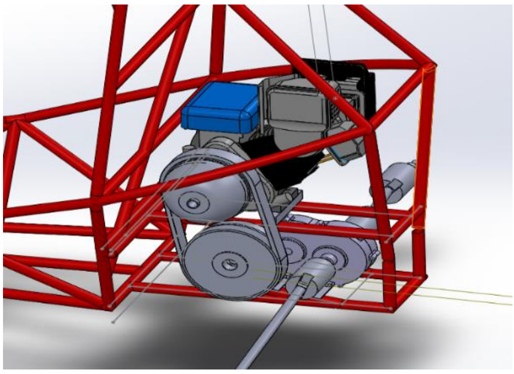

Figure 6. power train layout cad model

Figure 7 & 8. power train layout as fabricated

By using the above calculations and methodology the transmission system for an all-terrain vehicle has been fabricated successfully.

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