Design and Fabrication of Single Speed Double Reduction Gearbox of Baja vehicle

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Abstract : This report is about design, fabrication of Baja SAE ATV(All Terrain Vehicle) drive train.Baja SAE is an intercollegiate engineering design competition for undergraduate and graduate engineering students. As we know the participation of students in SAE Baja competition is increasing year by year.The object of the competition is to simulate real-world engineering design projects and their related challenges. Each team is competing to have its design accepted for manufacture by a fictitious firm. The students must function as a team to design, engineer, build, test, promote and compete with a vehicle within the limits of the rules. Calculations are done with respect to required maximum torque and maximum speed. Our transmission system is assembly of CVT (continuous variable transmission) and single speed gear box.

Keywords — ATV, All Terrain Vehicle, Briggs and Stratton Engine, CVT, Gear Box, SAE BAJA INDIA, Transmission.

I. INTRODUCTION

This report will give brief idea of SAE BAJA ATV Transmission System and their actual engineering design and formulation. The content describes the formal equation and describes generation of concepts and explanations of the final systems. The report and calculation that we have done is fully based on finding a gear reduction ratio with respect to the design and manufacturing.

Our transmission system is combination of CVT (Continuous Variable Transmission System) and Gear Box. We have to consider different parameters of CVT for calculation. As per the All Terrain Vehicle we have to look out for maximum torque and speed basis on this the calculations have to be done. In SAE BAHA competition there is event of hill climb, we have to ensure that the BAHA vehicle climbs the hill as per these we have to lookout for the maximum torque at which vehicle must climb the hill.

We have to also look for the vehicle maximum acceleration as per the acceleration event in SAE BAJA. We have to consider both for maximum torque and the maximum Acceleration. The engine Briggs and Stratton which we have to use which is specifically assigned by the event organizer of SAE BAJA. Initially the engine have low torque, to increase torque we need to place CVT followed by Gear Box. It is the best combination to increase the performance of the car.

II. DESIGN AND CONSIDERATIONS

2.2 Considerations

For design we have to look for different parameters to achieve the maximum torque and acceleration. This consideration helps to find the total required gear reduction. First is gross weight which include overall vehicle weight including driver weight then tyre friction coefficient and radius etc that we have mention below.

- Gross weight of the vehicle
- Tyre radius
- Frontal area
- Air density
- Aerodynamic drag
- Maximum speed
- Coefficient of rolling resistance
- Gradeability
- CVT max and min reduction
- Engine performance parameters

This parameters helps us to find the total required gear reduction.

2.1 design and working

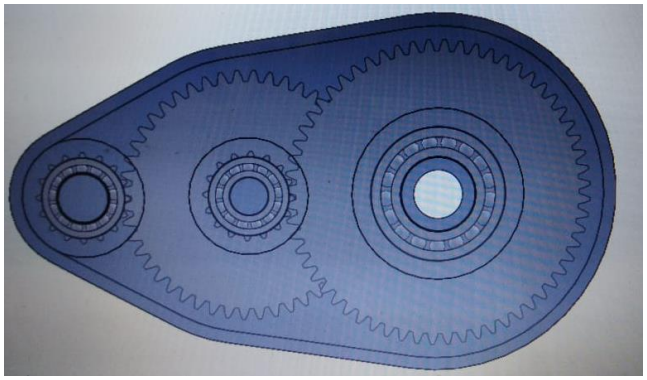


Fig.1: Gear box 2D view

The Fig.1 shows the actual design and arrangement of gears and Gear Box. The arrangement shows the meshing of the gears. The power transmission of power is from one end to the last end. As par shown in CAD model from left to right

the first gear is input gear on which CVT output is mounted and input is connected to engine. Then the power is transmitted from first gear to second gear which is compound gear that is on single shaft two gear are mounted. From second gear to third gear power is transmitted from the shaft. Third gear and forth are mesh each other and power is transmitted from third gear to forth gear. Gear reduction done by considering calculated ratio.

The ratio are calculated by considering different parameters with respect to required maximum torque and acceleration. It is fully depend on CVT reduction. . CVT have a number of gear ratio which have to increase power. It helps to adjust vehicle's engine torque in different number of ways. CVT output shaft is then connected to single speed gearbox. This gearbox helps to give required output torque and speed. By properly turning of CVT we improve power of vehicle.

2.2 Calculation

Gross weight of the vehicle(W)	2403.45 N
Tyre radius(R)	0.2921 m
Frontal area(A)	0.923 m^2
Air density	1.122 kg/m^3
Aerodynamic drag coefficient(Cd)	0.44
Maximum speed	16.66 m/sec
Coefficient of rolling(μ) Resistance (loose sand)	0.2
Coefficient of rolling Resistance (Solid sand)	0.8
Gradeability 60%	30.96^0
tan Θ	0.514439

Rolling Resistance (Loose Sand) RRL:-
(W x μ) = 2403.45 x 0.2
= 480.69 N
Rolling Resistance (Solid Sand)RRS :-
(W x μ) = 2403.45 x 0.8
= 1922.76 N
Air Resistance AR:-
= ½ x ∫ v^2 Cd
= ½ x 0.923 x 1.122 x 16.66 x 0.44
= 63.2364 N
Gradeability 60% :-
tan Θ = 60/ 100
= 30.96

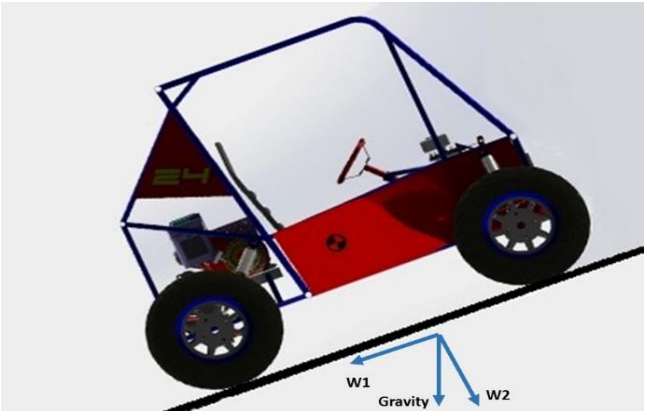


Fig.2: Hill climb

Grad Resistance GR :-
(W x Θ) = 2403.45 x 30.96
= 1236.428415 N

Total Road Load=RRL+AR+GR
= 1780.3548 N

Torque Required at 60% Gradeability :-
= Total road load x Tyre radius
= 1780.3548 x 0.2921
= 520.0416 Nm

CVT Ratio :-

$$\min redu - \frac{(\min redu - \max redu)\,(ideal\ rpm - rpm)}{ideal\ rpm - maximum\ rpm}$$

For different engine RPM we can find different CVT reduction or ratio. It is as shown below

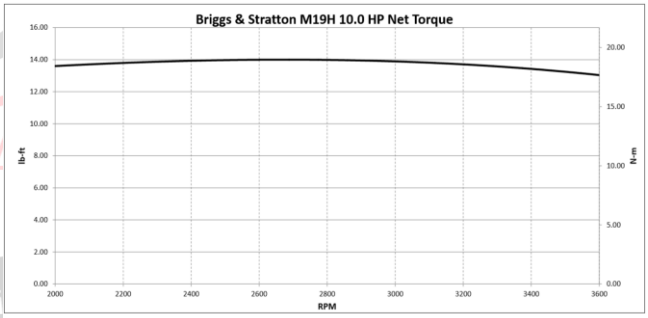
Considering engine rpm as 2000
Then CVT reduction will be

$$\min redu - \frac{(\min redu - \max redu)\,(ideal\ rpm - rpm)}{ideal\ rpm - maximum\ rpm}$$

$$\text{CVT Reduction} = 3 - \frac{(3-0.43)(1750-2000)}{1750-3800}$$

=2.686

Engine speed vs toque chart



Graph.1: Briggs & Stratton M19H 10.0 HP Net Torque
Ref. briggsracing.com/default/files

Total torque at CVT output = engine torque*CVT reduction
=18.62*2.686
= 50.01332 Nm

We need torque to the wheel that is 520.04Nm
So we have to take gear reduction by considering extra allowance that is 11
Maximum torque at wheel=
(total torque at CVT output *gearbox reduction)
=50.01332*11
=550.146 Nm
Maximum torque at wheel= 550.146 Nm

This gear ratio fulfill our requirements

The maximum gear reduction is 11 so we need to divide it in two stage for better performance first stage is 3 and second stage is 3.8

Now for first stage reduction ratio 3 the teeth on gear 1 should be 16 and gear 2 should be 48

And for second stage reduction ratio 3.8 the teeth on gear 3 should be 16 and gear should be 60.

That is

n1=16 n2=48 n3=16 n4=60

As we going to design BAJA Vehicle we have to reduce weight and make it very compact. As the compact design of BAJA Vehicle the gearbox should be very compact.We need to work more on it.

2.3 MATERIAL

2.3.1 Gear Material

The material that we are using is EN8 Medium Carbon Steel which is readily machinable in any condition. It is a medium strength steel and has good tensile strength.

EN8 is suitable for the manufacturing of parts such as gear, shaft, keys etc. it can be further surface hardened by induction processes, producing components with enhance were resistance.

Max Stress is around 700-850 N/mm^2

Yield Stress is 465 N/mm^2

Chemical composition:-

Carbon	0.36-0.44 %
Silicon	0.10-0.40 %
Manganese	0.60-1.00 %
Sulphur	0.050 Max
Phosphorus	0.050 Max

2.3.2. Casing Material

Casing material that we are using is 6061 aluminum. This will help in weight reduction. This alloy is part of the 6000 series of alloy. As such, its major alloying elements are magnesium and silicon .magnesium is added to increase strength, while the silicon is added to reduce the metal melting temperature.

Tensile Strength 241 N/mm^2

Yield Strength 145 N/mm^2

Chemical composition:-

Magnesium	1.2 %
Silicon	0.8 %
Copper	0.4 %
Chromium	0.35 %

III. CONCLUSION

We choose above custom gear drive transmission system.

To do our analysis, we generally have analyzed the overall system to find what desired torque and speed. CVT transmissions were analyzed to find the resulted torque and speed to the wheels. for max torque we decided to use the single speed double reduction gear box. By considering different parameters like weight and compact size custom gear box is perfect option for BAJA Vehicle. CVT with single speed gearbox is combination for max power transmission.

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