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Design and Analysis of All Wheel Drive Gearbox

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Abstract - *The main purpose of this paper is to provide a gearbox with low reduction ratio, low weight and efficient for engine up to 500cc. It should also be used in All- Terrain Vehicles demonstrated in international SAE BAJA. Engine power is transmitted via a hollow shaft in the gearbox to the intermediate differential, which has the task of distributing driving force equally to the front and rear wheels and of compensating for the difference in speed when cornering. The power is transmitted on the one hand from the intermediate differential to the rear axle differential via the propeller shaft and on the other hand, via a drive shaft to the front axle differential. The Assignment starts with the study of gearbox, theoretical calculations, and model designing on CATIA V5R20, analysis on ANSYS Workbench 14.5, verification, assembly, modification and at last final testing of gearbox.*

***Key Words*: SAE BAJA, Reduction Gearbox, spur gears, Designing, Analysis.**

1. INTRODUCTION

Compared with original 2WD vehicle that drives front wheels or rear wheels solely AWD system contains a roll to distribute engine drive to torsion to each front shaft and rear shaft. Sometimes AWD system was equipped with cross-country vehicle that runs on rough road. Hardware configuration that is handled during this paper differs from center differential 4WD and selective 4WD as a result of it distributes same power to any or all four wheels equally ranging from CVT the facility is transferred to primary shaft of 2 stage gear box then to the intermediate shaft wherever a cogwheel try transfers it to front differential and for rear wheels the facility is transferred by output shaft.

AWD system is often used for each of longitudinal and lateral driving safety. During this regard it's vital to search out the current vehicle state also as road state. as an example, vehicle climbs high slope hill, escapes from low letter of the alphabet surface and has lateral movement like double lane modification or circular motion with high rate. And analysis concerning model prognosticative management ought to be done together with these numerous driving things. Then it's expected that vehicle performances like driver's riding quality and steady state cornering are improved.

2. OBJECTIVE

AWD is optimized for on-road and off- road use. It's the aptitude to send the engine's power to any or all four tires all of the time. It'll facilitate keep your vehicle moving forward higher than front-wheel drive or rear-wheel drive on snow-clad or rain-slicked roads. All vehicles use differentials. These area unit units with gears, connected to the output shafts that flip the wheels, that let the wheels flip at completely different speeds.

3. DESIGN METHODOLOGY

1. Searching for all necessary parameters needed for engine & gear case picks.
2. Calculation of needed power output from given data.
3. Comparison & choice of correct gear case

In previous cars, the motive force facet kill switch was placed to the proper facet on the SIM. Completely different methodology for determination condition is often supported the quality of downside. We tend to first of all study the most torsion provided by the engine, losses at the CVT, reduction revolutions per minute in gearcaseand most torsion accessible at the tip of the gear caseassembly and output shaft. Conjointly calculate the friction effort, drag force needed to drive the vehicle at varied speed. Choice of fabric is administrated by finding out varied material property and composition. The Geometrical model is formed by exploitation the CATIA. Conjointly Static and Thermal analysis is administrated by exploitation the ANSYS Workbench 14.5.

4. ENGINE SPECIFICATIONS

The cool engine used on the vehicle is also a 4stroke, (305cc) displacement Briggs & Stratton engine of "Over Head Valve" kind (OHV). It equipped to teams by Briggs and Stratton at sponsored value and is to remain stock as per the Rulebook. It has a .75" key-way device shaft as output and a compression relation of 8.0 to 1. The engine weighs roughly sixty four lbs. Engine idle revolutions per minute is on the point of 1750 revolutions per minute. At competition, the governor typically set at soap 3800 revolutions per minute below its revolutions per minute capabilities.

5. CONTINOUS VARIABLE TRANSMISSION

The CVT plays a most important part in the performance of the vehicle as there will be no clutch to press, no lever to changing the gear ratio. Thus it not only saves the weight and driver fatigue but also provide smooth ride and saving time in acceleration. This is due to the capability of CVT by change the diameter by rotational force. CVT is the pulley system where the pulley can change size to achieve the output power. This is all reason to use a CVT for fast acceleration and easy optimization of engine power.

Table- 1: CVT Specification

Type of CVT	Gaged CVT
CVT Belt	Cogged Teeth Belt
Maximum CVT Ratio	3:1
Minimum CVT Ratio	0.43:1

Table- 2: Engine Rpm vs. Gear box Rpm

Engine rpm	CVT ratio	Gear box input rpm	Gear box output rpm	Speed	Traction
1900	3	519	43.25	4.76	1939.06
2000	2.5	664	55.33	6.08	1615.89
2200	2.2	830	69.16	7.5	1412.98
2400	2	984	82	9	1292.71
2600	1.8	1184	98.66	10.83	1163.44
2800	1.5	1530	127.5	14.00	969.53
3000	1.4	1757	146.41	16.09	904.89
3200	1.3	2018	168.16	18.50	840.26
3500	1	2827	239.16	26.31	646.3
3700	0.65	4667	398.91	42.80	434.52
3750	0.50	6150	512.5	56.41	387.81

6. TRANSMISSION

Many kind of transmission like manual, sequential, automatic, direct drive, CVT belt, CVT gear, rather than this two kind of transmission that square measure highly regarded among the BAJA groups square measure manual transmission and CVT belt transmission. Manual transmission ordinarily called case is simply put in and paired to engine. However, the disadvantages of manual case square measure the ride comfort. The motive force comfort is compromise and fatigue to extend the comfort ability of the motive force that wills ends up in increase the vehicle performance, it is suggested to use CVT which cannot solely offer the infinite gear quantitative relation however conjointly facilitate in reducing the load and driver fatigue.

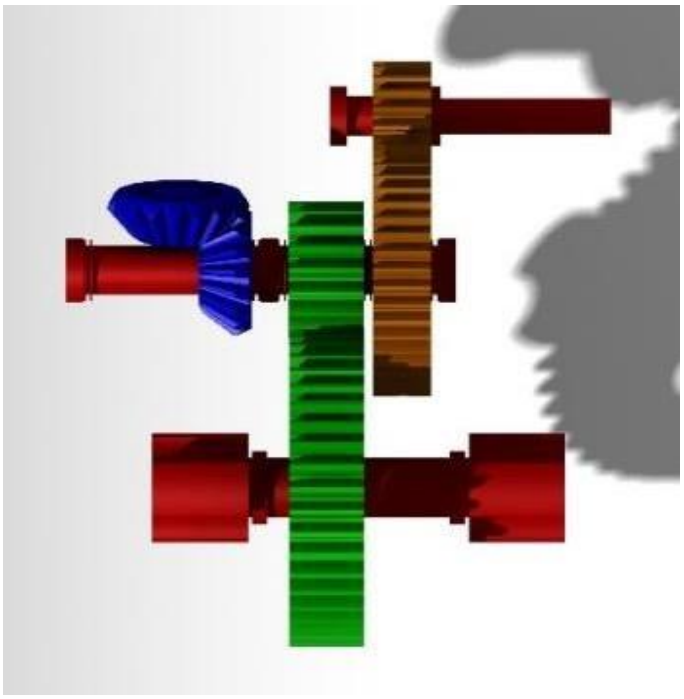

Fig- 1: Top View of Gear Assembly

6.1 Transmission Specifications

- Gaged CVT is coupled with self-designed gearbox.
- Top Speed – 58.4 kmph
- Gear Ratio: 1) Gearbox- 6:1
  2) CVT- 3.9:1 to 0.9:1

- Acceleration – 3.32m/sec^2
- Acceleration Time – 4.88 sec
- Grad ability – 84.9%
- Torque Required to cross Mud Pit -549.98 N-m
- Torque Required to hill climb-520.94 N-m

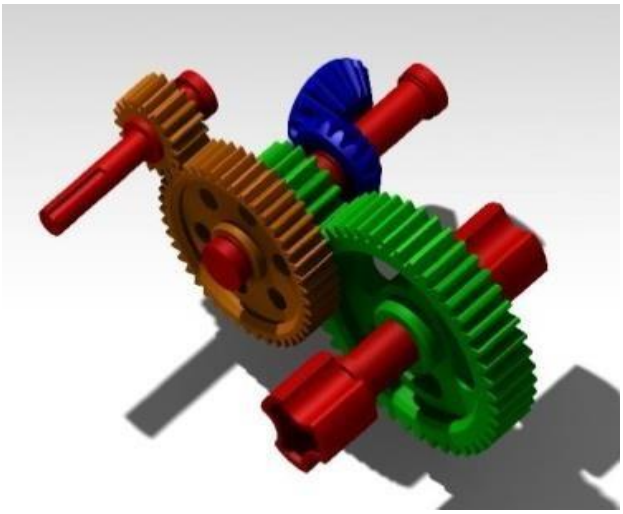

Fig- 2: Isometric View of Gear Assembly

7. FINITE ELEMENT ANALYSIS

Analysis is done to find out different parameters of designed components when actual loading conditions are applied on them, which gives brief idea about stresses, FOS, Deformation, and velocity of the designed components. Following images show different analysis whichincludes first gear pair, bevel gear pair. In addition, there is dynamic fluid flow analysis on the casing and static analysis on intermediate shaft.

7.1 First Gear Pair

Boundary Condition: Rigid wall with a mass equal to vehicle (240 Kg) launched at 60 kmph on the side of the vehicle with termination time of 100 millisecond and meshing size of 5 mm.

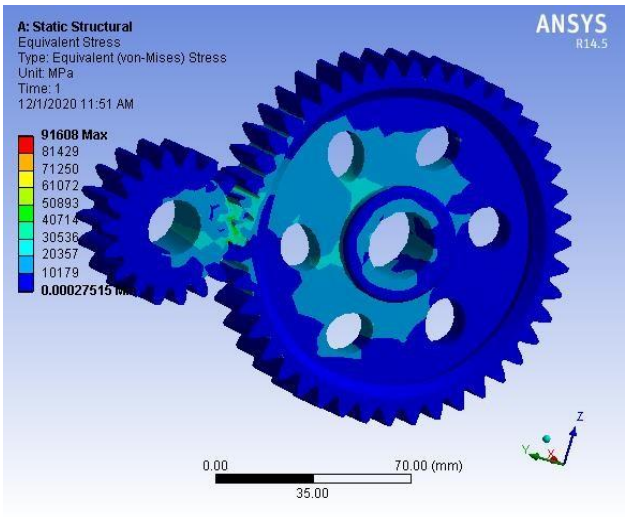

Fig- 3: First Gear Pair

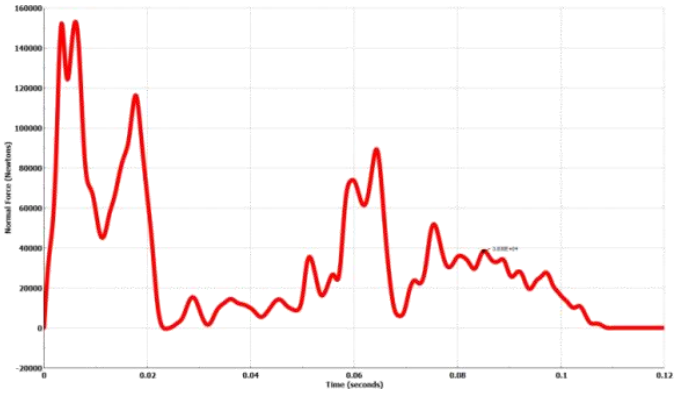

Chart- 1: Normal Force vs. Time for front impact

Table- 3: Analytical Parameters of First gear pair

Parameters	Values
Material	20MnCr5
Mesh Size	5mm
Mesh Type	2D Triangular
Deformation	1.4mm

7.2 Bevel Gear Pair

Boundary Condition: The differential is open type differential with reduction ratio of 2.44:1. The ratio between the bevel gear pair is 1.5:1. All constraints are set before applying load. The center portion where shaft is attached is set as fixed. The force is applied on the point of contact of both gears. The forces in the differential are considered when most of the torque will be transmitted to one wheel at the time of turning when torque transmitted to another wheel is minimum. The forces acting on bevel gear pair are divided into 2 types namely axial and radial.

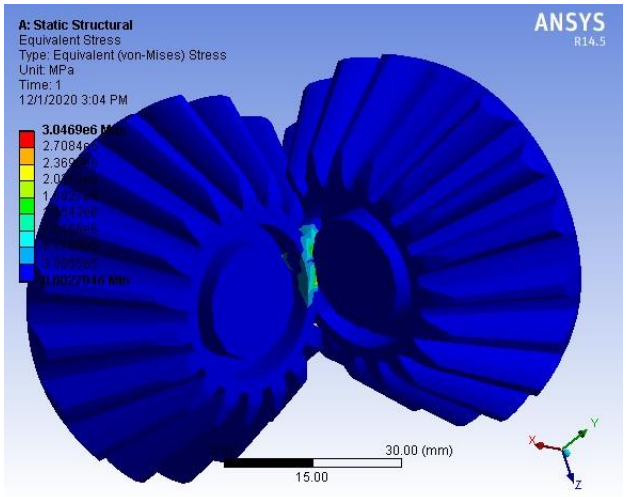

Fig- 4: Bevel Gear Pair

Calculations:

Required Gear Ratio:- $\frac{No.\ rotation\ of\ outer\ wheel}{No.of\ rotation\ of\ inner\ wheel}$

=10.27/6.79
= 1.53

Table- 4: Analytical Parameters of Bevel Gear Pair

Parameters	Values
Material	20MnCr5
Mesh Size	5mm
Mesh Type	2D Triangular
Deformation	1.2mm

7.3 Factor of Safety

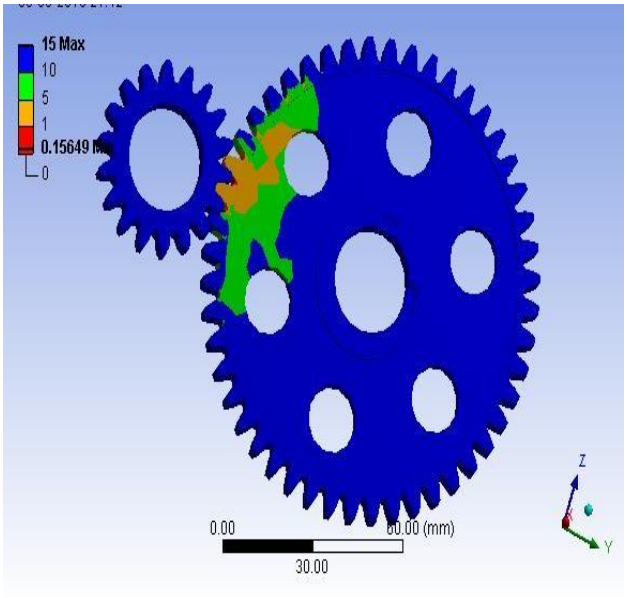

Fig 5: Factor of Safety

7.4 Intermediate Shaft

Boundary Condition: The gear box is designed for the speed of 60 kmph. Before applying the load are set to specify the constraints. The center portion of spur gear where the shaft is attached set as fixed. The force applies on one tooth at the point of contact of two gears. The applied force is for 751 RPM. The forces acting on the gear are divided into 3 types namely tangential, radial and axial.

Calculations:

Force = Output RPM of Primary gear pair × 0.05
(As one RPM is 0.05 N)
= 751×0.05
= 37.55 N

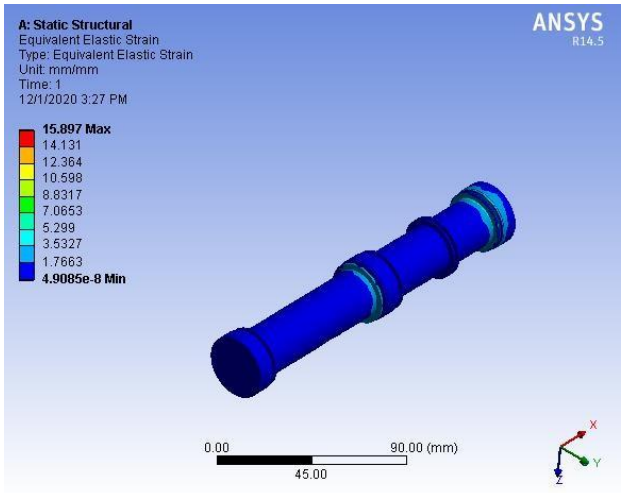

Fig- 6: Intermediate Shaft

7.5 Dynamic fluid flow analysis on casing

Boundary Condition: In the static analysis boundary condition can be applied to geometry, including faces, edges, curves, points, mesh points, verticals, nodes, elements or the entire model. The static load of transmission gear act on shaft. They are divided into two parts namely Tangentialand Radial on each gear have to analysis these load areapplied to find the actual effect of stress and deformation on gear.

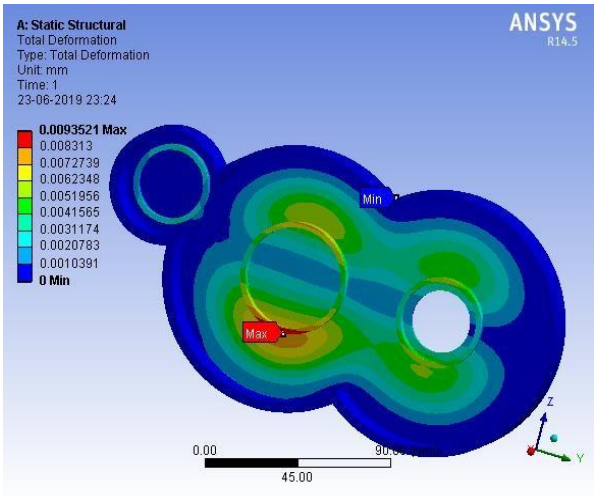

Fig- 7: Fluid Flow

Calculations:

Where $F_t = P/V$

$= 7457/2.8 \times 2.7$

$= 986.375$ N

$F_r = F_t \times \tan Ø$

$= 986.375 \times \tan 20º$

$= 359.011$ N

7.6 Dynamic Analysis of gear velocity

Boundary Condition: The boundary condition is the one of the major important factors to govern the output result of FEA and loading condition or loads are forces, acceleration or deformation applied to a structure or its components. Load cause deformation, displacement and stress in structures. Applying the loads and boundary condition plays a significant role boundary applied whatever needed or required since that closely matched motion as loads acts at the depending on the mannerism of abacus boundary condition are applied condition varies if explicit procedure had been chosen degree of freedom restricts for both pinion and gear except the rotational motion therefore it is free rotate the gear is axially and radially constrained that analytically rigid surface used to simulate shaft method is used and applied at 125 rad per sec of angular velocity.

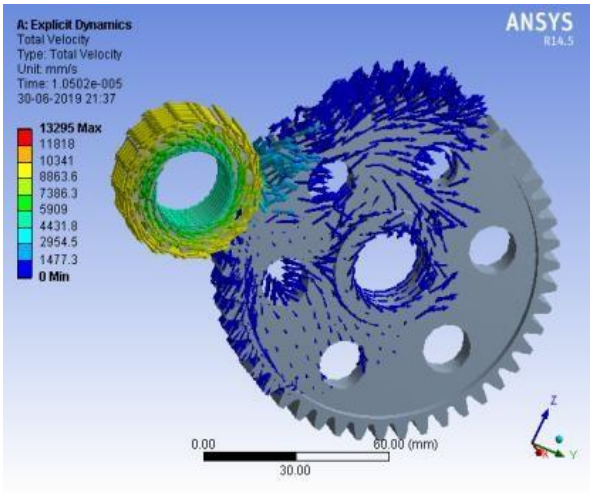

Fig- 8: Gear Velocity

Calculations: Velocity $= \frac{\pi * D * N}{60}$

$= \frac{\pi * 0.584 * 531.01}{60}$

$= 16.24$ m/s

$$\text{Acceleration} = \frac{F-R}{M}$$

$$= \frac{1077.68-279.35}{240}$$

$$= 3.326 \text{ m/s}^2$$

8. CONCLUSION

This paper unveils the additional refined methodology of the AWD shell planning while not victimization transfers case. By shaping the load spectrum within the program additional realistic driving and as a result designer can do additional correct results of strength, equivalent stress, deformation, safety factors and alternative such parameters.

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