

Design And Analysis of Portal Axle For SUV

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Abstract: Portal axle is gearbox designed to increase the ground clearance of the vehicle for off-road driving conditions. The higher ground clearance depends on the arrangement of gear train of the portal axle. The gear train and shafts are the most critical part in the portal axle as they transmit and withstand very high loads. They should be designed to withstand overloading and lightweight for greater durability and performance of the portal axle. The modeling and simulation of helical gears in portal axle is important to predict the actual motion behavior. However, gear train design in portal axle is difficult to study comprehensively due to their relatively low cost and short product life cycle. In this study, modal analysis of portal axle is simulated using finite element method (FEM). The axle tube is above the center of wheel hub and where there is a reduction gearbox in the hub. System is analyzed by Finite element analysis.

Keywords: Portal axle, Gear train, Helical gear, FEM.

I. Introduction

Portal axles (or portal gear) are an off-road technology where the axle tube is above the center of the wheel hub and where there is a reduction gearbox in the hub. This gives two advantages: ground clearance is increased, particularly beneath the low-slung differential housing of the main axles; and secondly hub gearing allows axle half shafts to drive same power but reduced torque. This reduces load on axle crown wheel and differential. The Portal Axle is a gearbox unit at least two gears (input and output gear) combined to give greater off-set between the input gear and output gear. Portal axles are commonly installed on four wheel-drive (4WD) vehicles for driving on off-road conditions and to gain additional ground clearance to protect underneath components from damage. Fig.1 shows the comparison between a normal vehicle and vehicle with portal axle.

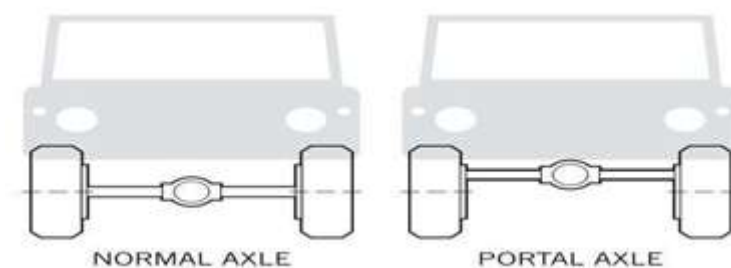


Fig. 1 Difference between normal axle and portal axle

Compared to normal layout, portal axles enable the vehicle to gain a higher ground clearance, as both axle tube and differential casing are tucked up higher under vehicle. Size of the differential casing can be reduced to gain even more ground clearance. Additionally, all drive-train elements, in particular transfer gearbox drive-shafts, can be built lighter. This can be of use in lowering center of gravity for given ground clearance. To be able to drive off the pavement, off-road vehicles need several characteristics. The portal axle designed to give desired ground clearance to the vehicle system. In the project the design of this portal axle is to be carried out for different gear train as spur & helical and hence to do comparative study for both the gear trains. The input shaft, gear train and output shaft is mainly design for portal shaft. The analysis will perform by FEM approach using CAD (creo/CATIA) model & ansys software

II. Problem Statement

Normal cars other than off-road vehicles its suspension gets damage due to low ground clearance which decreases the life of vehicle. Portal axle unit is a special gearbox unit designed to increase the vehicle's ground clearance. This gearbox can also be regarded as off-road technology where the axle tube is above the centre of the wheel hub. It allows driving on off-road so that the vehicle can go over high terrains and obstacles. Portal axle is normally designed for spur gear train system.

III. Objectives

1. To design portal axle with two idler gear for helical gear.
2. Get numerical results by using FEA approach.

IV. Design And Analysis

Specification of mahindra scorpio S2:

<ul style="list-style-type: none"> • Body type = SUV(Sport utility vehicle) • Number of gears = 5 • Length = 4456 mm • Height = 1930 mm • Ground Clearance = 180 mm • Width = 1820 mm • Drive train = rear wheel drive • Mileage = 16.7 kmpl • Max Power = 75 bhp @ 3200 RPM • Max Torque = 200 Nm @ 1400 RPM 	
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Given:

Power = 55 Kw, $N_2 = 2800$ rpm , Gear Ratio = 1.5
 (Standard value of Speed ratio for High speed Helical gear is 1:1 to 10:1)
 So, $N_1 = 1.5 * 2800 = 4200$ rpm
 Since, both gears are of same material (cast steel), Pinion is weaker.

Let $T_1 = 24$

Using Modified Lewis Equation for Helical gears , $W_t = (\sigma_b \times C_v) b \cdot m \cdot y'$

Tangential Tooth load

$$W_t = P/v$$

Gives,

$$\text{module} = 4$$

$$D_1 = 4 * 24 = 96 \text{ mm}, D_2 = D_1 * 1.5 = 144 \text{ mm}, T_2 = 36$$

Minimum number of teeth on smaller Gear to avoid *Interference* is given by:

$$T_1 \geq \frac{2 a_w \frac{1}{T_2} P_d}{\sqrt{1 + \frac{1}{T_2} \left(\frac{1}{T_2} + 2 \right) \sin^2 \phi} - 1}$$

Let, No. of teeth on Intermediate Gear is $T_3 = 18$. So, $D_3 = 18 * 4 = 72$

It can be seen that, $T_3/T_1 * T_2/T_3 = T_2/T_1$ and $D_1/T_1 = D_2/T_2 = D_3/T_3$

Our assumption is correct. So all gear dimension is correct.

Thickness of tooth, $t = 1.5708m = 6.28 \text{ mm}$

STRENGTH OF DRIVING GEAR:

The maximum value of the bending stress (or the permissible working stress) $S_w = (W_t \cdot h) * 6 / bt^2 = 356.89 \text{ Mpa}$

It is below ultimate stresses s^u , so design is safe

Static tooth load: $S_b = m_n \cdot b \cdot Y = 10264.032 \text{ N}$

Static tooth load is much more than the tangential load on the tooth, therefore the design is satisfactory in static load.

Dynamic Tooth Load:

$$W_D = W_T + \frac{21 v (b \cdot C \cos^2 \alpha + W_T) \cos \alpha}{21 v + \sqrt{b \cdot C \cos^2 \alpha + W_T}}$$

$$W_D = 10702.22 \text{ N}$$

Since, Dynamic tooth load is much more than the tangential load on the tooth, therefore the design is satisfactory in static load.

$$\text{Wear Strength: } S_w = b \cdot Q \cdot D_1 \cdot K / \cos^2 \alpha = 1058.326 \text{ N.}$$

Design is done on CATIA V5 and analysis on ANSYS 16.0.

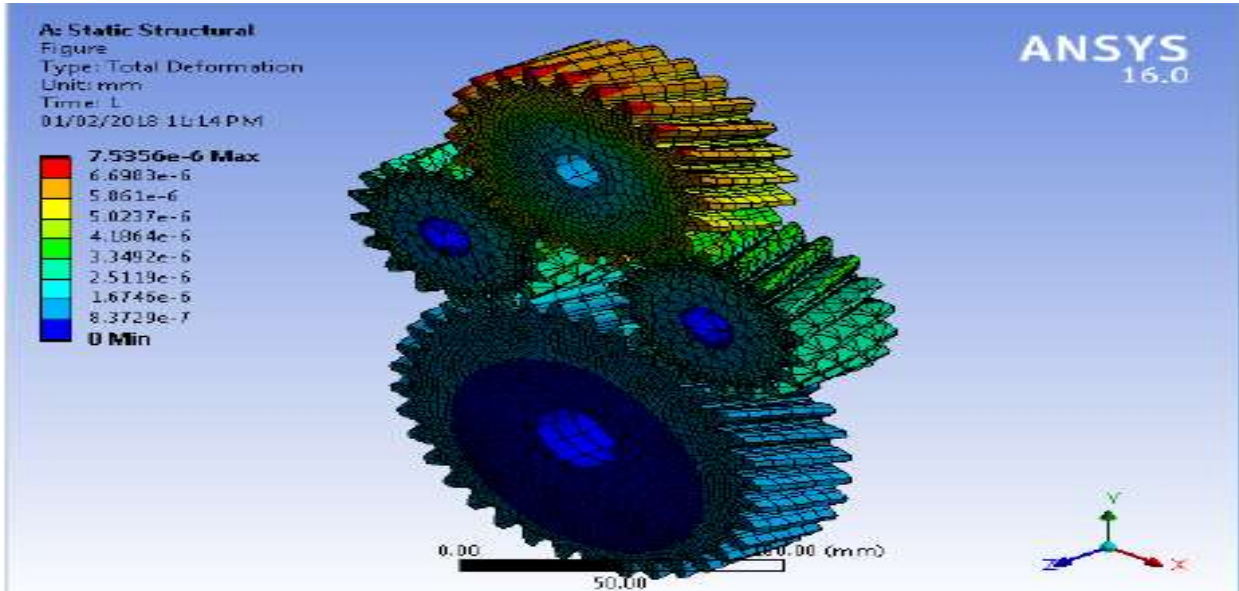


Fig2. Total Deformation in Helical gear train of Portal Axle

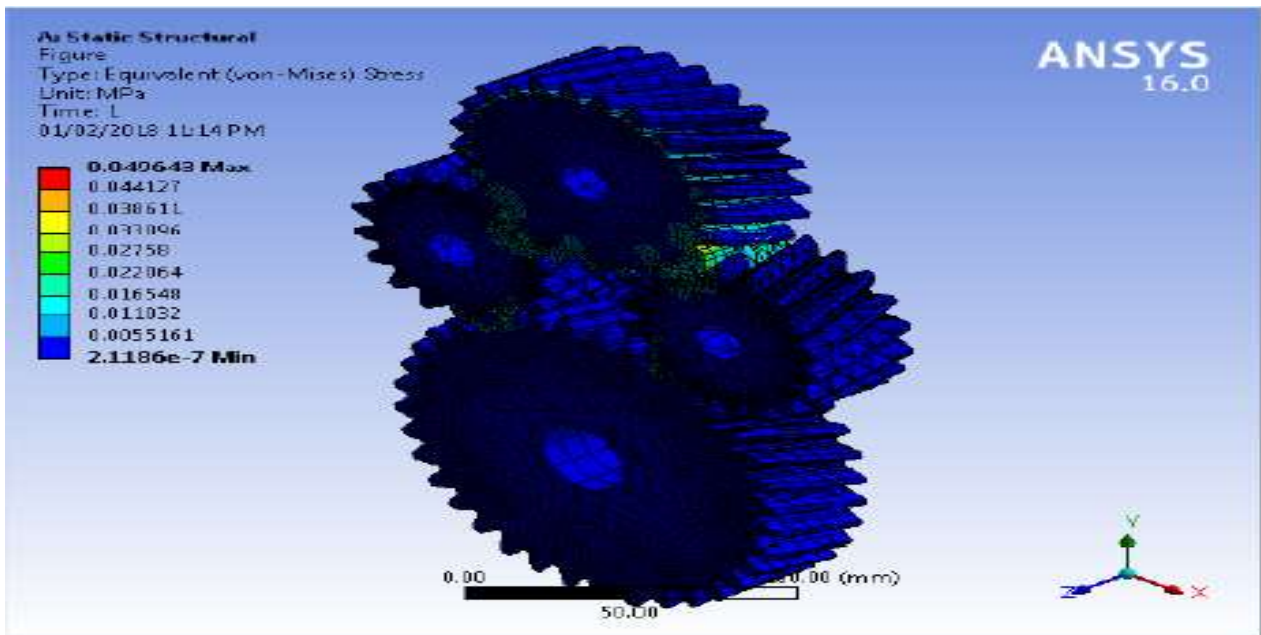


Fig3. Equivalent von-misses stress for helical gear train in portal axle

V. Conclusion

The portal axle is the system which increases the ground clearance of the vehicle. It is mainly beneficial for off-road driving conditions. The Portal Axle is a gearbox unit at least two gears (input and output gear) combined to give greater off-set between the input gear and output gear. Gear train with Helical gear provides more ground clearance than spur gear train for the same number of the teeth, module and pressure angle. In general, helical gears have more load carrying capacity and also produce less noise during power transmission compared with spur gear.

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