Prototype Design for Multi-Face Gearbox with Multiple Forward and Reverse Speed Gears

Akash Agarwal, Sandeep Kumar Sahoo

Abstract: - A gear box has been design with additional reverse speed gears to the existing gear box and corresponding to new gear motion has been developed. The gearbox has been design in such a way that it will result in minimal change in current commercial vehicle for its modification and fixation. The mechanism of right angle spiral bevel gear drive has been used in the gear box by replacing the conventional gearbox mechanism in which only helical gear pairs are used .Complete Gear box has been designed beginning with spiral bevel gears as output gear and input as helical gears. Moreover corresponding shaft and synchronizing mechanism transmitting variable power in both reverse and forward drive. The gearbox design has been done by referring parameters from conventional commercial vehicle's torque and working speed. For initial stage the reverse drive has been added with two speed gears, similarly forward drive has been design. The gear box has been analysed for its overall impact and its capability to sustain the stress, strain and deformation from the load and pressure, when the working parameters are executed and further numerical and simulation analysis has been done to study the stress and deformation. The application of this gearbox comes in the mining areas where different commercial vehicles required variable speed and torque not only in forward but also reverse with keeping in mind of minimal cost and maintenance.

Keywords: - Gearbox mechanics, forward speed gears, Reverse Speed Gears, Design of Gearbox, stress and load analysis

1. INTRODUCTION

TRANSMISSION being an integral part of vehicles dynamics as it transmits power from source that is the engine to the receiver that is the wheels. Forward and reverse are both the directional transmission on which the gearbox of a four wheel or more wheels vehicle acts as it requires power in both the case [1]. In today's engineering arena, reverse speed gear box generally depends on the helical gears arrangement system and consists of only speed gear in the gearbox.

The research work present focuses more on the design and development reverse speed gears arrangement [2]. In this work, the general helical gears arrangement has been replaced by spiral bevel gear arrangement system to accommodate more than one gear speed in the reverse direction as well as forward direction. The development in which feasibility factors considered are mount ability of the gearbox in the existing vehicle, cost of manufacturing and reliability of application[3]. Whereas the design in which technical analysis has been considered on the strength, strain and overall deformation of the gearbox after assembly of the complete gearbox. The following are the gearbox components used and redesign for compatibility and reliability for transmission.

- *Akash Agarwal is an undergraduate in Mechanical Engineering at ITER, Siksha' Anusandhan University, India. E-mail: akash.agr0012@gmail.com*
- *Sandeep Kumar Sahoo is an undergraduate in Mechanical Engineering at ITER , Siksha' Anusandhan University, India. E-mail: sandeep.sahoo95@gmail.com*

1.1 Gear Pairs

For the transmission of power in both the forward and reverse direction for equal number of speed gears, torque and speed, two types of gear has been used for gear pair.

Two spiral bevel gears have been used as face gear. In one face gear which is larger, in both the side two helical gears have been paired so that to accommodate equal speed and torque .One helical gear acts as forward speed gear and other as reverse speed gear.

Similarly, other smaller spiral bevel gear acting as another face gear concurrently attached with the larger face gear through a shaft which will be output shaft for transmission of power to the wheels. Again two helical gears paired similarly with smaller face gear as it is paired with larger face gear for transmission.

1.2 Shafts

Two shafts acting as one input shaft for the transmission of power from the engine is used and other as output shaft which will carry power from the face gear to the wheels are used.

The input shaft will be mounting helical gears to transmit power to the face gears, synchronizer for changing the gears in the shaft for different speed and torque and the spur gear which will act as fixed gear which will transmit power from shaft to the helical gear through the synchronizer by synchromesh process.

The output Shaft will be mounting the two face gears for transmitting power from the face gears to the wheels.

1.3 Synchromesh

The synchronizer used as a main component synchromesh process for varying speed ,torque and direction by changing the helical gear connection to the fixed spur gears through it.

The spur gear is used as fixed gear in the synchromesh for providing continues speed and torque to the shaft and further preventing any bending movement in the shaft.

2. Design and Theoretical Analysis of the components.

Design of the Multi Face Gearbox involves the Reliability based design of gear-pairs, shafts and Synchromesh taking the parameters i.e., face width of gears, diameter of shafts ,Number of teeth in all the gears with respect to the variable factor of Multi Face Gearbox design safety values. The methodology and the necessary procedural frame work to do the safe design of the gearbox is analysed and derived by Author(s) and is verified and implemented .All the equations taken below are according to ASME standard equation referring to Norton Design Data Book and all the values taken are according to AGMA standards[5,6]. The concepts below explain the strategy for safe design of the transmission system considering reliability parameters, in order to improve the reliability of the whole system and as well as at component level [7].

2.1 Numerical Calculation:

2.1.1 Torque calculation from power transmission:

Work Done per min = Force x Displacement = Average Torque x Angular Displacement =T x 2πN/60 (1)

Power Transmitted $=F_t*V$ (2)

$V=\frac{2*\pi*N1}{60}*Dp/2$ (3)

Where,
T:-Torque
F_t:-Force
V:-Velocity
N:-No.of revolutions per minute

Work done is directly proportional to force and displacement. Moreover it is also directly proportional to Average torque and Angular displacement of gear tooth which is used in equation (1) ,(2) and (3) to calculate the require torque.

2.1.2 Formula for Helical Gear calculation:

a = m (4)

d = 1.25*m (5)

H_d = 2.25*m (6)

t = 1.75*m (7)

$D_p = Z_p*m/\cos(\psi)$ (8)
$D_b = D_p*\cos(20^0)$ (9)

$\frac{Z2}{Z1}=\frac{N1}{N2}=Mg$ (gear ratio) (10)

Gear ratio	Calculated value
Mg(1st gear)	3:1
Mg(2nd gear)	1.375:1

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For Gear Tooth (LEWIS BENDING EQUATION)

$$\sigma_b = \frac{Ft}{FJm} * \frac{Ka*Km}{Kv} * K_S * K_B * K_I \quad (21)$$

Using the Lewis bending equation of gear (imperial formula) to calibrate the bending stress of gear tooth.

2.1.6 Gear Tooth Surface stress:

$$\sigma_c = Cp * \sqrt{\frac{Wt}{f*l*d} * \frac{ca*l*m}{Cv} * esg} \quad (22)$$

C_p = elastic co-efficient

L = it is a dimensionless surface geometry factor

$C_a = K_a$

$C_m = K_m$

$C_V = K_V$

$C_S = K_S$

$$\rho_p = \sqrt{\left(r_p + \frac{1}{p_d}\right)^2 - (r_p * cos\phi)^2} - \frac{\pi}{p_d} * \cos\phi \quad (23)$$

$$P_g = Csin\phi - \rho_p \quad (24)$$

$$I = \frac{cos\phi}{\left(\frac{1}{\rho_p} + \frac{1}{\rho_g}\right) * d_p} \quad (25)$$

$$C_P = \sqrt{\frac{1}{\pi * \sqrt{\left(\frac{1-V_P{}^2}{E_P}\right) + \left(\frac{1-V_g{}^2}{E_g}\right)}}} \quad (26)$$

$$\sigma_{C_P} = C_P * \sqrt{\frac{Wt}{F*l_p*d_p} * \frac{C_a*C_m}{C_v}} * C_S * C_f \quad (27)$$

Calibrating the surface stress in formula (22) and (27) of gear equation. Here we are surface wear out of the gear tooth during power transmission.

2.1.7 Formula for shaft calculation:

Reliability Based Design of Shafts. The loading on Transmission Shaft is the Torque (T) and Bending (M). They produce shear stress and bending stress respectively in it. The shear and bending stress are

$S_{shr} = \frac{16T}{\pi d^3}$ (Due to torsion) (28)

$S_b = \frac{32M}{\pi d^3}$ (Due to bending moment) (29)

Where,

S_{shr} =Shear stress (N/mm2)

S_b= bending stress (N/mm2)

d= diameter of shaft (mm)

$$T = Torsion = \frac{60*P*Kl*Kw}{2\pi N} * 10^3 \quad (30)$$

Where, N=Input rpm

Kl =load factor

Kw =wear factor

M= bending moment (in N-mm) P=power (W)

3. Analytical Model Solution

The results obtained from initial Analytical Model solution from gear teeth mesh, gearbox mesh and by then ansys simulation from its boundary condition and then validating its stress, strain and total deformation [8].For Analysis of gear tooth we took the material of alloy steel [9]. This alloy steel AISI 8620 is flexible during hardening treatments, thus enabling improvement of case/core properties. The analysis was done using Ansys software by applying parameters as load, torque and rpm [10, 11].

3.1. For Gear Pairs

In this analysis, the individual teeth mesh for face gear which is spiral bevel gear and helical mesh has been considered. As for the model analysis, the strength and deformation withholding has been analysed.

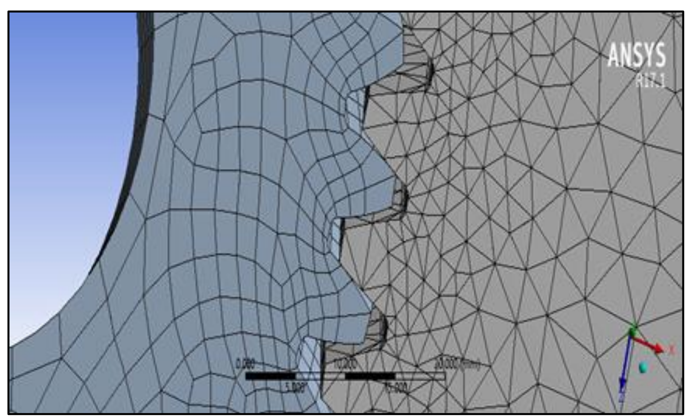

Fig 3.1.1: The Spiral bevel –helical gear pair teeth mesh

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[8] Hui-Long Yu, Jun-Qiang Xi, Feng-qi Zhang, and Yu-hui Hu1," Research on Gear Shifting Process without Disengaging Clutch for a Parallel Hybrid Electric Vehicle Equipped with AMT"

[9] Sunil Kumar Sharma, S. A Rizvi and R. P Kori ," Optimization of Process Parameters in Turning of AISI 8620 Steel Using Taguchi and Grey Taguchi Analysis"

[10] Hepeng Xi, Xiaozhong Deng and Aijun Xu," Meshing Performance Analysis of Spiral Bevel Gears Based on Assembly Misalignment"

[11] Kishore N. Naik and Dhananjay Dolas," Static Analysis Bending Stress on Gear Tooth Profile by variation of gear parameters with the help of FEA."