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Review Paper on Design and Stress Analysis of Helical Gear and Manufacturing Through Rapid Prototyping Method

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Abstract - *This review paper gives the information about strength of helical gear surface and tooth root strength of helical gear as they are to be major problem for the failure of gear pair. As this gear used in heavy duty or high load transmission system and during this many failure occurs .One of the main gear tooth failure is pitting which is surface fatigue failure due to many repletion of high contact stresses occurring in the gear tooth. Thus, these review papers mainly focus on the theoretical, analytical method, computation of various stresses like bending stress acting on the root of helical gear. Many authors have use different approaches and means to conclude their main intension of finding out the contact stress and gear failure causes in static condition using finite element analysis, AGMA standards. Helical gears have been used for a wide range of engineering applications. The rapid increasing demand for high speed ratio, highly efficient cum light weight engines with quite power transmission has led to the need for optimization of helical gears being used till today. For optimization of any engineering design initially problem function is formulated then variable parameters are decided which would minimize or maximize the objective function so as to give an optimal system performance. In this seminar, an attempt has been done to collect results and observations of previous researchers who have worked on helical gear design. The model of helical gear pairs are generated by using SolidWorks software and ANSYS is used for numerical analysis.*

Key Words: AGMA, ANSYS, bending stress, fatigue failure, helical gear.

1. INTRODUCTION

In engine or machine power transmission has always been of high importance. Gearing is one of the most effective methods transmitting power and rotary motion from the source to its application with or without change of speed or direction. In automobile, highly reliable and light weight gears are essential. Furthermore the best way to diminution of noise in engine requires the fabrication of silence gear system. Noise reduction in gear pairs is especially critical in the rapidly growing today's technology since the working environment is badly influenced by noise. The most successful way of gear noise reduction is attained by decreasing of vibration related with them. Helical gears are currently being used increasingly as a power transmitting gear owing to their relatively smooth and silent operation, large load carrying capacity and higher operating speed. Designing highly loaded helical gears for power transmission systems that are good in strength and low level in noise necessitate suitable analysis methods. The efficiency of any machine depends on the amount of power loss in the process. These gears play a most predominant role in many automobile. Gears with involute teeth have widely been used in industry because of the low cost of manufacturing. Critical evaluation of helical gear design performance therefore plays a crucial role in estimating the degree of success of such gear systems in terms of stresses and deformation developed in helical gears. Helical gears have more advantages than other gears especially spur gears like it has smoother engagement of teeth, silent in operation, can handle heavy loads and power can be transferred between non parallel shafts, high efficient etc. Due to these advantages it has wide range of applications in high speed high power mechanical systems. Helical gears have a smoother operation than the spur gears because of a large helix angle that increases the length of the contact lines. Designing highly loaded helical gears for power transmission systems that are good in strength and low level in noise necessitate suitable analysis methods that can easily be put into practice and also give useful information on contact and bending stresses and one of the main reason of the failure in the helical gear is bending stresses and vibrations. But the stresses are occurred due to the contact between two gears while power transmission process is started. Due to meshing between two gears contact stresses are evolved, which are determined by using analyzing software called ANSYS. Finding stresses has become most popular in research on gears to reduce the vibrations, bending stresses.

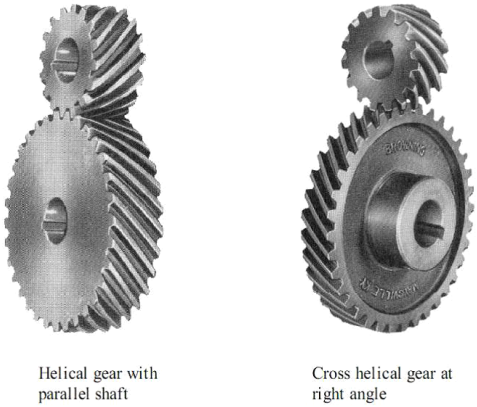

Fig -1: Gear tooth terminology

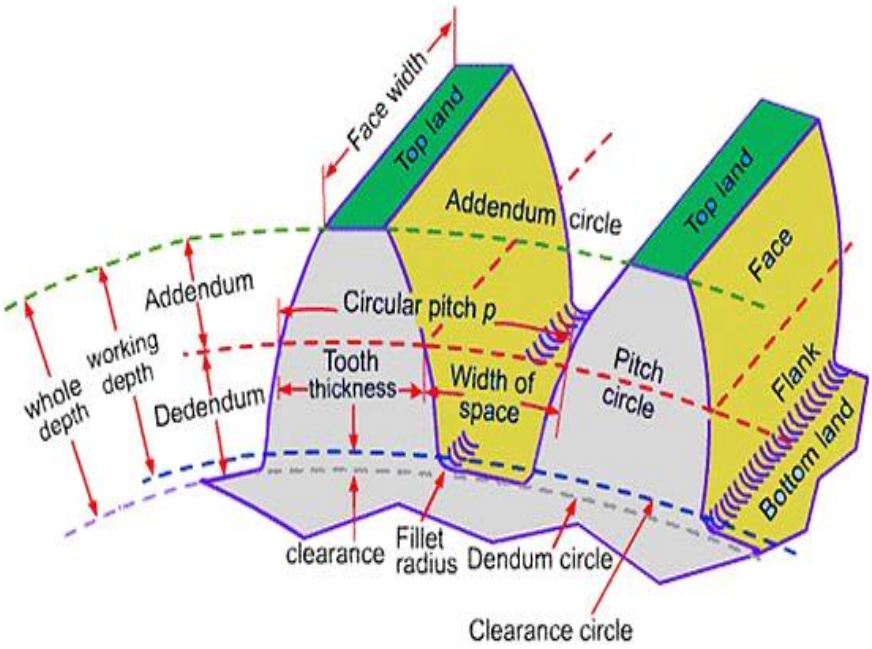

Fig -2: Gear tooth nomenclature

2. LITERATURE REVIEW

[1].S. Sai Anusha, P. Satish Reddy, P. Bhaskar, M. Manoj had done the investigation to make use of helical gear, by analyzing the contact stresses for different Pressure angles (14.5˚,16˚,18˚,20˚)Helix angles(15˚,20˚,25˚,30˚)and(80mm,90 mm,100mm,110mm, 120mm) Face width. A Three-dimensional solid Model was generated by Pro-E. The numerical solution was done by Ansys by using finite element analysis package. The analytical approach was based on contact stress equation, to determine the contact stresses between two mating gears. The results obtained from Ansys; Analytical values were compared with theoretical values. The present analysis is useful in quantifying the above said parameters that helps in safe and efficient design of the helical gear. The effect of helix angle on contact stress was studied by varying the helix angle for four different angles were 15˚, 20˚, 25˚, 30˚. A typical trend has been observed when the 15˚ helix angle stress value was 285.7 high when compared to 20˚ helix angle. The effect of face width is compared with others.

[2].B .Venkatesh et .al. had carried out the structural analysis of a high speed helical gear used for marine engines. These engines are continuously subjected to large stresses and deflections which are needed to be minimized. The dimensions of the

model were obtained by theoretical techniques. These stresses generated and the deflections of the helical gear tooth had been analyzed for different materials and the final results obtained were compared to check the correctness by theoretical analysis and FEM. The project mainly concentrated on reduction of gear-weight and enhancing the accuracy of gears. The same authors, in 2014 came up with another research article "Investigate the Combined Effect of gear ratio, helix angle, face width and module on beam strength and Wear tooth load of Steel alloy Helical Gear" in which the effect of gear ratio, face width, helix angle, module to obtain the optimum beam strength and wear tooth load under variable circumstances was shown. Initially the helix angle, face width, speed and module were kept constant, when the gear ratio was increased; the corresponding beam strength remained constant. Secondly keeping the helix angles, gear ratios, speed, module except face width were kept constant and for variation of face width, the beam strength increased. Similarly for helix angles, gear ratio, face width and speed kept constant, with increase in module the beam strength increased accordingly. All this calculation work was done based on the Lewis equation and Buckingham equation. Similar experiments were done for the wear tooth load of the helical gear tooth and corresponding results were obtained.

[3].Puttapaka Nagaraju presented a paper suggested that the bending stresses of helical gear are analyzed. In this study, bending stress were calculated with different face width by using Lewis equation and these results are compared with the results obtained in static analysis in ANSYS. The author concluded that the maximum bending stress decreases with increasing the face width of the gear.

[4].J.Venkatesh is analyzed the helical gear based on structural analysis of high speed. In this paper, he modified the number of teeth to reduce the bending stress by using AGMA. In contact stress, the different value of helix angle is changed to minimize the contact stress. And then, two methods bending and contact stress results are compared with each other. Finally, the more the number of teeth, the more the bending stress. In contact stress, the more the helix angle lesser will be stress.
[5].Herscovici Saul et.al provided the design formulae and acceptable stress levels so that calculations of the gear tooth geometry, surface compressive and bending stresses at which the gears operate in a known application can be made accurately. Because for designers it is necessary to know the complete gear information for all gears like no. of teeth, diametric pitch, pressure angle, gear width, type of material to be selected and the type of heat treatment as well.

3. DESIGN METHODOLOGY

- Strength of Helical Gears:

  In helical gears, the contact between mating teeth is gradual, starting at one end and moving along the teeth so that at any instant the line of contact runs diagonally across the teeth. Therefore in order to find the strength of helical gears, a modified Lewis equation is used. It is given by

$$W_T = (\sigma_o \times C_v)\, b.\pi\, m.y'$$

Where

W_T = Tangential tooth load,

σ_o= Allowable static stress,

Cv= Velocity factor,

b = Face width,

m = Module, and

y' = Tooth form factor or Lewis factor corresponding to the formative or virtual or equivalent number of teeth.

- The dynamic tooth load on the helical gears is given by

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

Where

C = A deformation or1 dynamic factor in N/mm.

$$C = \frac{K.e}{\frac{1}{E_P} + \frac{1}{E_G}}$$

- The static tooth load or endurance strength of the tooth is given by

$$W_S = \sigma_e.b.\pi\, m.y'$$

- The maximum or limiting wear tooth load for helical gears is given by

$$W_w = \frac{D_P.b.Q.K}{\cos^2 \alpha}$$

$$Q = \frac{2 \times V.R.}{V.R. + 1} \quad V.R. = \frac{D_G}{D_P}$$

Where

Q= Ratio factor

V.R= Velocity ratio

$$K = \frac{(\sigma_{es})^2 \sin \phi_N}{1.4}\left[\frac{1}{E_P} + \frac{1}{E_G}\right]$$

ϕ_N= Normal pressure angle.

- End thrust or axial load on the gear is given by

$$W_A = W_T \tan \alpha$$

- Tangential tooth load is given by

$$W_T = \frac{T}{D_G / 2}$$

- Peripheral velocity

$$v = \frac{\pi D_G . N}{60}$$

4. CONCLUSION

1) If optimization of various influencing factors like contact ratio, gear ratio, helix angle, face width, module, pressure angle is done considering their combined effects then it will certainly enhance the effectiveness and performance of the helical gear and hence power will be more.

2) Helix angle is critical for contact stress as increasing helix angle increases contact stresses because of increase in the area of contact. And also the beam strength of helical gears is an important criterion for its designing as it also decides the force and power to be transmitted.

3) Maximum bending stress decreasing with increasing face width and it will be higher on gear of low face width with higher helix angle.

4) Parametric study is done by varying the geometry of the teeth.

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