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Design and Analysis of High Speed Helical Gear by Using Finite Element Method

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ABSTRACT:

In the gear design the bending stress and surface strength of the gear tooth are considered to be one of the main contributors for the failure of the gear in a gear set. Thus, the analysis of stresses has become popular as an area of research on gears to minimize or to reduce the failures and for optimal design of gears In this paper bending and contact stresses are calculated by using analytical method as well as Finite element analysis. To estimate bending stress modified Lewis beam strength method is used. Pro-e solid modeling software is used to generate the 3-D solid model of helical gear. Ansys software package is used to analyze the bending stress. Contact stresses are calculated by using modified AGMA contact stress method. In this also Pro-e solid modeling software is used to generate contact gear tooth model. Ansys software package is used to analyze the contact stress. Finally these two methods bending and contact stress results are compared with each other.

INTRODUCTION:

One of the best methods of transmitting power between the shafts is gears. Gears are mostly used to transmit torque and angular velocity. The rapid development of industries such as vehicle, shipbuilding and aircraft require advanced application of gear technology. Customers prefer cars with highly efficient engine. This needed up a demand for quite power transmission. Automobile sectors are one of the largest manufacturers of gears. Higher reliability and lighter weight gears are necessary to make automobile light in weight as lighter automobiles continue to be in demand. The best way of transmitting power between the shafts is gears. Gears are mostly used to transmit torque and angular velocity. The design of gear is a complex process. Generally it needs large number of iterations and data sets. In many cases gear design is

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traditional and specified by different types of standards. B.Venkatesh etc.(1) presented that the stresses were calculated for helical gear by using different materials. Pushpendra Kumar etc. (2) explained about the bending stress for different face width of helical gear calculated by using MATLAB Simulink. Prashanth patil, etc.(3) investigated the 3D photo elastic and finite element analysis of helical gear. Khalish.C (4) focused on Lewis beam strength equation was used to finding out bending strength of a helical gear. Yi-Cheng Chen et al. [5] in their study stress analysis of a helical gear set with localized bearing contact have investigated the contact and the bending stresses of helical gear set with localized bearing contact by using finite element analysis. S.Vijayaragan and N.Ganesan [6] carried out a static analysis of composite helical gears using three dimensional finite element methods to study the displacements and stresses at various points on a helical gear tooth. For determining the stresses at any stage during the design of gears helix angle and face width are important. Rao and Muthuveerappan [7] have explained the geometry of helical gears by simple mathematical equations. A parametric study was made by varying the face width and the helix angle to study their effect on the root stresses of helical gears. In helical gears there is a problem of failures at the root of the teeth because of the inadequate bending strength and surface pitting. This can be avoided or minimized by proper method and modification of the different gear parameters. In view of this the main purpose of this work is by using analytical approach and numerical approach to develop theoretical model of helical gear in mesh and to determine the effect of gear tooth stresses. The main steps involved in this work are described as follow: Modeling the gear without losing its geometry in Pro/engineer software. Generate the profile of helical gear teeth model to calculate the effect of gear bending, using three-dimensional model and compare the results with modified Lewis theory. Develop and determine models of contact elements, to analysis contact stresses using

2. Literature Survey

2.1: Introduction of Gear

A **gear** or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape.[1] Two or more meshing gears, working in a sequence, are called a gear train or a transmission. A gear can mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation.

2.2:Types of Gears:

External vs internal gears

Figure: Internal Vs External gear

An ***external gear*** is one with the teeth formed on the outer surface of a cylinder or cone. Conversely, an ***internal gear*** is one with the teeth formed on the inner surface of a cylinder or cone. For bevel gears, an internal gear is one with the pitch angle exceeding 90 degrees. Internal gears do not cause output shaft direction reversal.[5]

2.3:Spur gear:

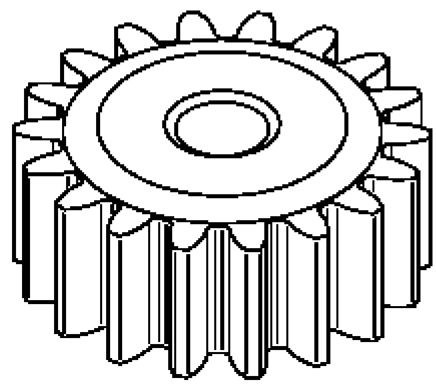

Figure: Spur Gear

Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form (they are usually of special form to achieve constant drive ratio mainly involute), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together

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correctly only if they are fitted to parallel shafts.

2.4: Helical gear:

Figure: Helical gears

Top: parallel configuration

Bottom: crossed configuration

Helical or "dry fixed" gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. Helical gears can be meshed in *parallel* or *crossed* orientations. The former refers to when the shafts are parallel to each other; this is the most common orientation. In the latter, the shafts are non-parallel, and in this configuration the gears are sometimes known as "skew gears".

The angled teeth engage more gradually than do spur gear teeth, causing them to run more smoothly and quietly. With parallel helical gears, each pair of teeth first make contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face to a maximum then recedes until the teeth break contact at a single point on the opposite side. In spur gears, teeth suddenly meet at a line contact across their entire width causing stress and noise. Spur gears make a characteristic whine at high speeds. Whereas spur gears are used for low speed applications and those situations where noise control is not a problem, the use of helical gears is indicated when the application involves high speeds, large power transmission, or where noise abatement is important. The speed is considered to be high when the pitch line velocity exceeds 25 m/s.

A disadvantage of helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with additives in the lubricant.

2.5: Skew gears:

For a 'crossed' or 'skew' configuration, the gears must have the same pressure angle and normal pitch; however, the helix angle and handedness can be different. The relationship between the two shafts is actually defined by the helix angle(s) of the two shafts and the handedness, as defined: [9]

$E = \beta_1 + \beta_2$ For gears of the same handedness

$E = \beta_1 - \beta_2$ For gears of opposite handedness

Where β is the helix angle for the gear. The crossed configuration is less mechanically sound because there is only a point contact between the gears, whereas in the parallel configuration there is a line contact.

Quite commonly, helical gears are used with the helix angle of one having the negative of the helix angle of the other; such a pair might also be referred to as having a right-handed helix and a left-handed helix of equal angles. The two equal but opposite angles add to zero: the angle between shafts is zero – that is, the shafts are *parallel*. Where the sum or the difference (as described in the equations above) is not zero the shafts are *crossed*. For shafts *crossed* at right angles, the helix angles are of the same hand because they must add to 90 degrees.

- 3D Animation of helical gears (parallel axis)
- 3D Animation of helical gears (crossed axis)

CONCLUSION

In this project we designed one helical gear with calculations in Creo-2 with helical angle 20 degrees and face width 32mm and pressure angle 20, by using ANSYS WORKBENCH we analyzing this model at high rotational speed and high pressure and high torque values in static structural then we finding deformation of the object and maximum stress values and safety factor values

The aim of this project is reducing the stress values on the object, to minimizing the stress.In this process we changed helical angle from 20 degrees to 15 and 45 degrees and remain all dimensions are constant. The present used material for helical gears is Steel and to get better results we also chosen another two materials (Al-6061 and Al 7475) having high strength values and low weight compare to steel. And then applying same boundary conditions for all models and all material properties. From the above results we observe that while increasing angle the stress values are reduced and while decreasing the angle stress values are increased from the tables.

And then finally we can conclude that from all the results the 3rd method is producing much better results compare to other two methods i.e. the 45 DegreesHelical angle with 32mm face width with **Al -7475** material is producing very less stress **131.31 Mpa** and high safety factor **3.427** values compare to all models.By these changes we reduced nearly **27 Mpa** stress and also reduced weight up to 34% from original modal.

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