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Analysis of Spur Gear Using Finite Element Analysis

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Abstract: The objective of this thesis is to study the various stress state of spur gear. We calculated the tangential and radial forces which acts on various point upon that basis we can analyze by applying the forces. By using Ansys software bending stress and contact stress on the tooth of spur gear drive is found Gears are machine elements used to transmit power between rotating shaft by means of engagement of projection called teeth. Gears are most common means of transmitting power in the wooden mechanical world. They vary from a tiny size used in watches to larger gears used in massive speed reducers, bridge lifting mechanism and rail road turn table drive. The gears are vital elements of main and auxiliary mechanism in many machines such as automobiles, tractors, metal cutting machine tools rolling mills hosting and transmitting and transporting machinery, massive engines etc.

Key words: Gear design · Spur gears · Mesh generation · Bending and contact stress analysis

INTRODUCTION

Due to globalization industries are facing an increasing competition. Therefore it becomes more and necessary to consider alternative technology of manufacturing materials used for gears.

The high volume production industry such as automobile industry has various manufacturing materials used gears like metal removal method, casting and forming method, but that method which is more suitable containing finishing operations optimal utilization of raw materials, short-cycle times and favorable energy consumptions, compared to convectional manufacturing technology.

Metal removal methods have the manufacturing method profiling and generating methods. In profiling method, the spaces between the teeth are cut by means of a disc cutter and end milling cutter.

In generating method teeth are formed in a series of passes by a generating tool. If it is threaded and gashed, it is called a hob and the process is known as “hobbing”. Most of the structural part application is placed in passenger cars, tractors, metal cutting machine tools, rolling mills and marine engines etc.

Reason for the Gear Tooth Failure: The different modes of failure of gear teeth are bending failure, pitting and scoring, corrosive wear. In bending failure-every gear tooth acts as cantilever. If total repetitive dynamic load acting on the gear tooth is greater than the beam strength of the gear tooth, then the gear tooth will fail in bending.

In pitting failure-it is surface fatigue failure which occurs due to many repetition of Hertz contact stress. The failure occurs when the surface contact stresses are higher than the endurance limit of the material.

Scoring-it is a stick slip phenomenon in which alternate sharing and welding takes place rapidly at highest spots. It is avoided by properly designing the parameters such as speed, pressure and proper flow lubricant.

Corrosive wear-the corrosion of the tooth surfaces is namely caused due to the presence of corrosive elements such as additives present in the lubricating oils. To avoid these proper anticorrosive additives should be used.

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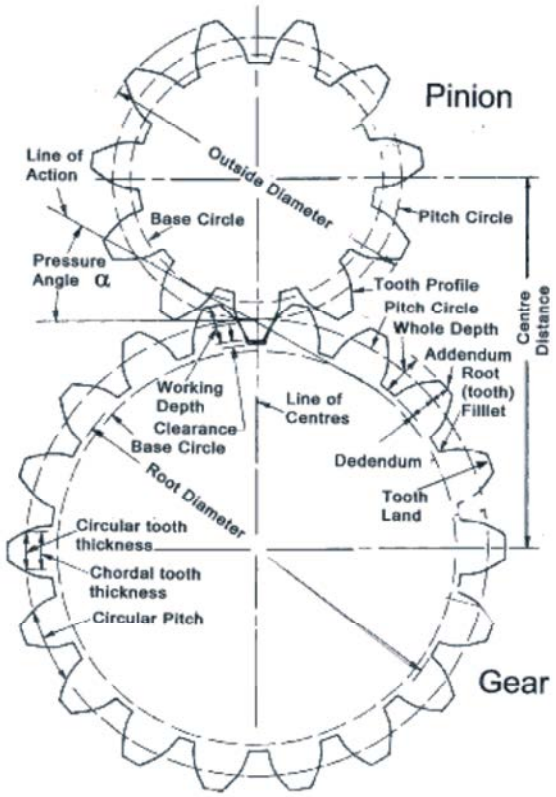

Bendinng Stress: Among the several failure mechanisms for spur gears, failure due to bending stress is very important when the loads are too large, bending failure will occur. Bending failure gears is predicted by comparing the calculated bending stress, determined the reactive forces between the members, pressure angle, helix angle etc. the gear tooth is considered as a cantilever beam under load. The ability of the tooth to resist tooth breakage as the root is often referred to as the beam. The tooth load F_N is supposed to act at the tip corner. Load F_N acts along the line the line of action at pressure angle and when referred to pitch point P. at the intersection of the line of action and centre line of the tooth, this force is resolved as

Radial components = $F_N \sin\propto$
And tangential component = $F_n\cos\propto$
Tangential tooth load
$F_t = mb\sigma_b.y$
Where m = module, b = face width, σ_b = design stress, y = form factor
Forces acting on gears normal load (W_N) can be resolved into two components tangential component (W_T) and radial component (W_R).

Contact Stress: Contact mechanics is the study of the deformation of solids that touch each other at one or more points. The physical and mathematical formulation of the subject is built upon the mechanics of material and continuum mechanics and focuses on computations involving elastic, viscoelastic and plastic bodies in static or dynamic contact. Hertzian contact stress refers to the localized stresses that develop as two curved surfaces come in contact and deform slightly under the imposed loads. This amount of deformation is dependent on the modulus of elasticity of the material in contact. It gives the contact stress as a function of the normal contact force, the radii of curvature of both bodies and the modulus of elasticity of both bodies. In gears and bearings in operation, these contact stresses are cyclic in nature and over time lead to sub-surface fatigue cracks. Hertzian contact stress forms the foundation for the equations for load bearing capabilities in bearings, gears and any other bodies..

Application of CAE: There are many mechanical engineering and design CAD tool capable of creating complex 3D models, assemblies and 2D measured drawings; it does not support architectural or civil engineering practices. It originally caused a major change in the CAD industry when first released by introducing the concept of Parametric Modeling. Rather than models being constructed like a mound of clay with pieces being added or removed to make changes, the user constructs the model as a list of features, which are stored by the program and can be used to change the model by modifying, reordering, or removing them.

Some CAE packages offer outputs consist of solid model data for tooling and rapid prototyping, CNC manufacturing and finite element analysis. A product and its entire Bill of Materials can be modeled accurately with fully associative engineering drawings and revision control information. It is compatible with Unix-variants, Windows and Linux operating systems. All data is interchangeable between these platforms without conversion. PTC have also released a version of the program called Pro/DESKTOP that is marketed towards small businesses and schools who want to incorporate a low-cost CAD package to their curriculum.

Gear Parameter Used
Gear type:-standard involute teeth
Material:-15Ni2CrMo15 alloy steel

Young's Modulus:-2.1$_{\bullet}$10^5 N/mm^2
Module:-8
Pressure angle = 20$_{\circ}$ stub
Gear ratios = 1.5

Advantages of Design of Spur Gear:

- Compact layout
- High efficiency
- Reliability
- Constant velocity ratio.

Ansys: Ansys is a general purpose finite element modeling package for numerically solving a wide verity of mechanical problems. These problems include static/dynamic structural analysis (both linear and non linear), heat transfer and fluid problems, as well as acoustics and electromagnetic problems

Pre-Processor Phase: This section describes the work plane, as well as other tools for both graphical selection and numeric input. Graphical selection on most models requires selecting entities from a 3-dimensoinal model from2-dimensional screen. FEA uses definition of a work plane to locate a 2-dimensional pick in 3-dimensional space. The work plane is a two dimensional plane which you can locate and align anywhere in three-dimensional space. By default, the origin of the workspace is at the global origin and the plane is aligned with the Global XY plane.

Mesh Sizing: Before creating elements, the mesh size was determined using Mesh Control command. A default mesh size or default number of elements can be set, which is used for all geometry where a specific size or number of elements along a line or on a surface. A specific mesh size or number of elements along a line.

Importing Solid Models from Iges Files: As an alternative to creating a model directly in ansys, you can create a solid model in your cad system, save the model as an IGES (INITIAL GRAPHICS EXCHANGE SPECIFICATION) file, then import the model into ansys. Ones successfully imported, you can mesh the model.

CONCLUSION

The theoretical stresses of both bending and contact stress is found manually and then analyzed in ANSYS software.. It is found that comparing with manual results, results are approximate or closer to it. Hence we conclude that ANSYS Software can be used for other analyzing purpose also.

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