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Contact analysis of involute profile teeth

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ABSTRACT

In this project, the purpose is to provide an in-depth understanding of tooth engagement in splined couplings based on variations in the clearance between mating teeth. It is standard practice to assume that 25-50% of the total spline teeth in a coupling are engaged due to variations from the manufacturer. Based on the assumed number of teeth engaged, the load capability of a splined coupling is determined.variations from tooth geometry from manufactured, the number of teeth actually engaged is dependent on the applied load and tooth errors. Advances in engineering technology in recent years have brought demands for gear teeth which can operate at ever increasing load capabilities and speeds when a failure occurs they are expensive. reliability a critical economic factor and for designers to produce gears with a high reliability they need to be able to accurately predict the stresses experienced by the loaded gear teeth. Variations in tooth geometry from manufactured, the number of teeth actually engaged is dependent on the applied load and the tooth errors. The variations result in sequential tooth engagement with increasing load. The purpose of the project is to incorporate the fundamental theory of stress and deflection in a model which stimulates tooth engagement based on tooth variations. This will allow the designer to estimate for a given torque load and to determine the probable loads on each individual tooth. Modelling is done in pro-e or solid works software and the finite element analysis using Ansys software and parametric studies are performed to determine the effect and sensitivities of variations in tooth parameters and tooth errors.

Keywords— *Contact stress, Involute profile tooth*

1. INTRODUCTION

1.1 Introduction to involute tooth spline

Gearing is one of the most critical components in a mechanical power possible that gears will predominate as the most effective means of transmitting power in future machines due to their degree of reliability and compactness. In addition, the rapid shift in the industry from heavy industries such as shipbuilding to industries such as automobile manufacture and office automation tools will necessitate a refined application of gear technology.

Involutes spines are frequently used as shaft couplings when large amounts of torque must be transmitted. The involutes geometry is better suited for carrying tooth loads than conventional rectangular keys, due to its curved profile and generous fillets.

The purpose of this project is to incorporate the fundamental theory of stress and deflection in a model, which simulates tooth engagement based on tooth variations. This will allow designers to estimate, by statistical modeling, how many teeth will be an engagement for a given torque load and to determine the probable loads and stresses on each individual tooth.

An in-depth understanding of the subjects presented is necessary to develop an analytical model, which includes tooth geometry, modifications, errors, deflections, stresses and engagement.

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1.2 Introduction to contact analysis

Contact problems are highly nonlinear and require significant computer resources to solve. It is important that you understand the physics of the problem and take the time to set up your model to run as efficiently as possible.

Contact problems present two significant difficulties. First, you generally do not know the regions of contact until you've run the problem. Depending on the loads, material, boundary conditions, and other factors, surfaces can come into and go out of contact with each other in a largely unpredictable and abrupt manner. Second, most contact problems need to account for friction.

Contact problems fall into two general classes: rigid-to-flexible and flexible-to-flexible.in rigid-to-flexible contact problems, one or more of the contacting surfaces are treated as rigid. In general, any time a soft material comes in contact with a hard material, the problem may be assumed to be rigid to flexible.

You must identify where contact might occur during the deformation of your model. Once you've identified potential contact surfaces, you define them via target and contact elements, which will then track the kinematics of the deformation process. Target and contact elements that makeup contact elements that make up a contact pair are associated with each other.

2. OBJECTIVE

The purpose of this project is to define how the interaction of the teeth in a splined coupling can be reduced to a practical simulation of spline tooth behaviour. Such a model integrated with user-friendly computer software, which assists mechanical designer's to more effectively manage spline design parameters and couplings that are more reliable.

The new model has been developed which can predict the number of teeth engaged and the load distributed across engaged spline teeth. It is believed that it can improve the reliability of splines through an increased understanding of the effect of manufacturing variation on individual tooth stress.

An additional objective of this project is to provide a tool for performing to learn which tooth geometry parameters and errors have the most significant influence on engagement and stress.

This project is focused on the failure of internal and external spline teeth employed to transmit loads to friction and separator plates in heavy duty brakes.

The tooth deflections analyzed are due to bending, shearing and contact. This work is focused on tooth failure as a result of static loading.

3. INVOLUTE SPLINE TOOTH

3.1 Nomenclature

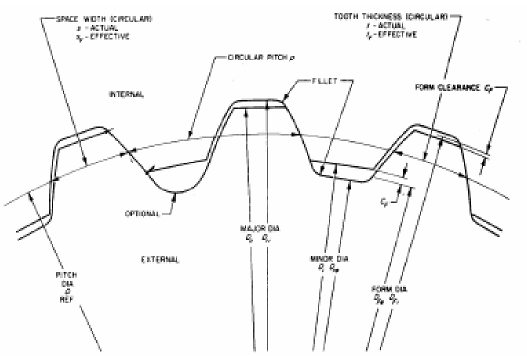


Fig. 1: Nomenclature

The definitions are given by the existing standard on involutes splines and inspection ANSIB92.1-1970.the terminology of teeth is illustrated in fig. The pitch circle is the reference circle from which all circular spline tooth dimensions are constructed. The pitches of a pair of mating splines are equal.

3.2 Tooth errors

Four main errors affect the effective clearance. Because the friction and separator plates are relatively thin, lead variation need not be considered. The remaining three errors are profile, tooth thickness and index variations. The effective clearance in spline teeth is similar to backlash in gear teeth Analyzed backlash in assembled gears and found that the main sources causing backlash are size variations and tooth errors. The size variations are the result of Tooth thickness allowance, which provides clearance for mounting, thermal growth and lubrication.

3.3 Tooth stresses

Because spline teeth are exposed to complex loading, it is important to look at the stress from each component of the reaction force between mating teeth. The reaction force Fn which is resolved in three components.fr is the radii component of the load. It is the tangential component, the reaction moment due to the eccentric loading of the beam. Because the splines in this research have such low-pressure angles (=20*), the tangential component is the dominant force.

3.4 Contact stress

At the point of contact between two mating teeth, there is contact pressure or a contact stress. The radius of curvature at the point of contact and the load determine how large the contact region the internal spline has a negative radius of curvature, while the external spline has a positive radius of curvature.

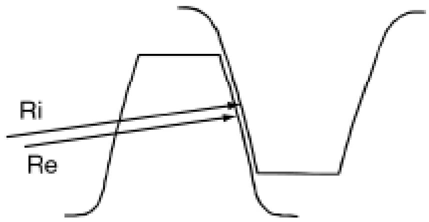


Fig. 2: Contact stress

Substituting equation gives the general equation for the maximum contact stress between two contacting cylinders

4. FINITE ELEMENT ANALYSIS

The finite element method (FEM) or finite element analysis (FEA) is based on the idea of building a complicated object with simple blocks or dividing a complicated object into small and manageable pieces. Application of this simple idea can be found everywhere in everyday life as well as in the gear and the pinion; Analytical methods are used to obtain the solution of a mathematical model consisting of a set of differential equations which represent a physical process within the limit of the assumption made. The analytical method gives results in closed form at all points. Only a handful of analytical solutions is available, heat transfer and fluid mechanics because analytical methods are inadequate in handling complex boundary and nonlinearities in the differential equations and boundary conditions.

4.1 Numerical methods

In numerical methods, the domain is filled by grids and the values of variables are calculated at discrete grid points. The governing differential equations are discredited at the grid points and result in asset simultaneous algebraic equations. These differential equations are then solved using iterative techniques.

The major advantages of numerical solution are its ability to handle complex geometry and nonlinearities in the governing equations. There are six distinct streams of numerical solution techniques finite difference, finite element, boundary element and discrete element method to solve the partial differential equations. The main difference between the six separate streams is associated with the way in which the flow variables the approximated and the kind of discretization process involved.

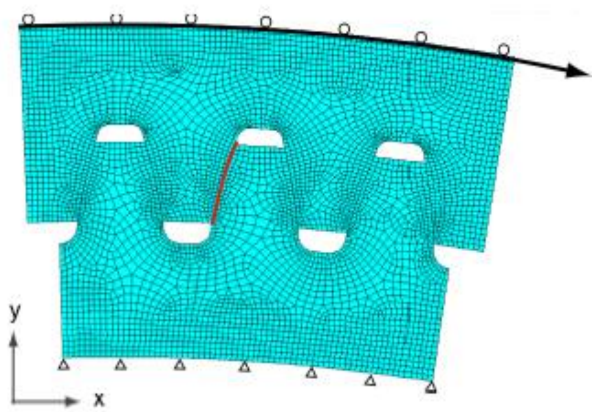
4.2 Contact mechanics

The theory developed by Hertz in 1880 remains the foundation for most contact problems encountered in engineering. It applies to normal contact between two elastic solids that are smooth and can be described locally with orthogonal radii of curvature such as a toroid. Further, the size of the actual contact area must be small compared to the dimensions of each body and to the radii of curvature. Hertz made the assumption based on observations that the contact area is elliptical in shape for such three-dimensional bodies. The equations simplify when the contact area is circular such as with spheres in contact. At extremely elliptical contact, the contact area is assumed to have a constant width over the length of contact such as between parallel cylinders.

4.3 Contact problems

There are many types of contact problems that may be encountered including contact stress, dynamic impacts, metal forming, bolted joints, crash dynamics, assemblies of components with interference fits, etc. all these contact problems, as well as other types of contact analysis, can be split in to two general classes(ANSYS),

(i) Rigid-to-flexible bodies in contact
(ii) Flexible-to-flexible bodies in contact



5. GUIDELINES FOR MANUSCRIPT PREPARATION

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5.1 Concept of contact

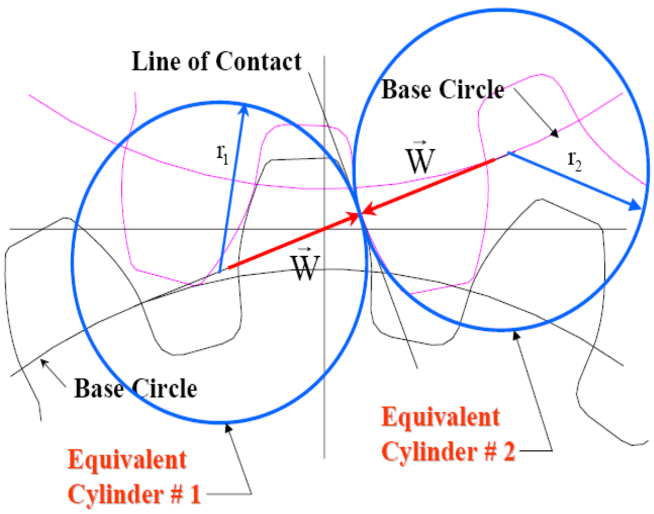
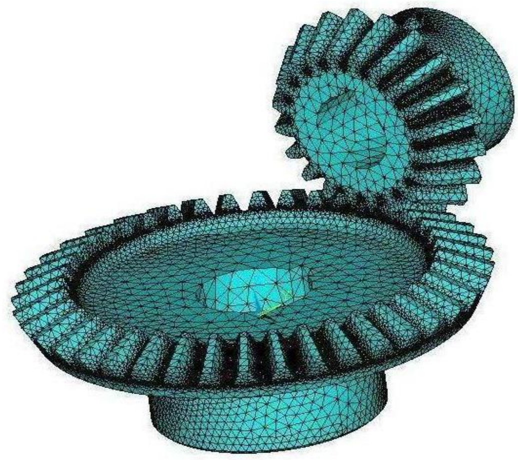
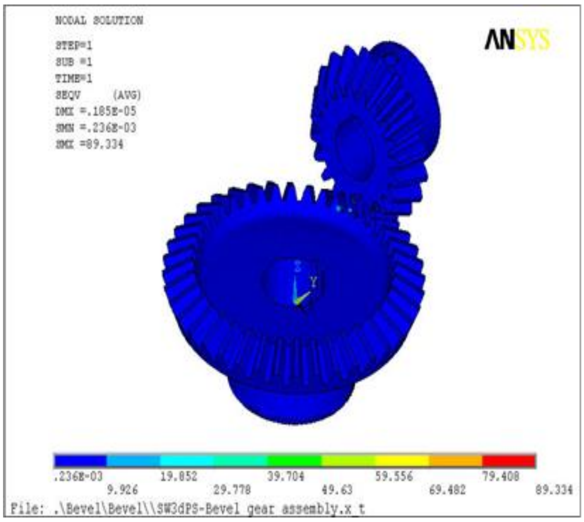


Fig. 4: Contact concept

6. RESULT AND DISCUSSION





In this section, the contact stresses and the tooth deflection of a bevel gear is calculated using an ANSYS model. For contact stress, the numerical values are compared with the values given by the draft proposal of the standards of the AGMA.

In the figure the model is ready for analysis condition. To fill no of nodes and elements using free meshing. It shows the deformation at the point of contact in full view and Fig.2 shows the close look at the stress distribution. It is observed that the maximum stress distribution is found to be 89.334 at the line of contact.

Stress in ANSYS	Stress in AGMA	Difference
89.4 mpa	92.0 mpa	2.6

7. CONCLUSION

The involutes tooth profile has been modeled and analyzed using ansys the various parameters such as contact stress, deflection are completely analyzed and studied. This study shows that depth understanding of involutes profile and to reduce the tooth errors and improves the tooth life profile engagement to reduce the tooth error and perfect engagement of the tooth should be carried out.

In the future, the number of teeth of gear and pinion is to be varied and analyze the same and compare with the AGMA result. The transmission error for all types of gears has to be estimated. A whole gear box with all elements in the system such as bearing and the gear casing has to be analyzed.

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