

The Combined Mesh Stiffness Characteristics of Straight and Spiral Bevel Gears

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ABSTRACT:

The combined mesh stiffness of spiral bevel gears is one important factor for dynamic analysis. The total deflection on the contact line of a tooth pair is composed of bending, shear and tooth contact deflections. The bending and shear deflections on the contact line of the gear tooth are evaluated by the finite element method with isoparametric shell elements, and the tooth contact deflections are evaluated using Hertzian contact theory. Based on these deflections, the stiffness is obtained using the so called flexibility method, and then the combined mesh stiffness is obtained by applying the contact and load sharing ratios.

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THE COMBINED MESH STIFFNESS CHARACTERISTICS OF STRAIGHT AND SPIRAL BEVEL GEARS

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INTRODUCTION

As a gear pair operates, the combined stiffness of the meshing teeth changes, and this is known to have strong influence on the dynamic behavior of geared systems. The exact meshing action of a pair of spiral gears is not easily understood because of the complex, three dimensional geometry, but the relationship between a spiral bevel gear and a straight-toothed bevel gear is substantially the same as that between a helical gear and a spur gear[1].

During operation of a gear pair, tooth pairs are in contact and at any contact position of the meshing teeth the equivalent tooth stiffness can be evaluated by considering bending, shearing, and local contact deflections. Spiral bevel gears normally have two or more tooth pairs in contact at all times, and the curved oblique teeth come into contact gradually and smoothly from one end to the other. This gives a smoother engagement and more evenly distributes the tooth loads. The overlapping tooth action transmits motion much more smoothly and quietly than straight bevel gears, which are

the reasons why spiral bevel gears are superseding straight bevel gears in many applications[2,3].

There have been some attempts to evaluate the combined mesh stiffness for spur and helical gears[1,4,5,6,7]. Chakraborty and Hunashikatti[1] evaluated the combined mesh stiffness characteristics for one engagement cycle of a spur gear pair. Umezawa[6] evaluated the mesh compliance of a helical gear pair, Choi[7] evaluated the combined mesh stiffness characteristics for spur and helical gears. In order to evaluate the combined mesh stiffness, the deflections on the contact line which consist of bending, shear and tooth contact deflections must be found. Most attempts for calculating tooth deflections are based on plate theory or beam theory. Krenzer[8] used a cantilever beam formulation as the basis for the calculation of tooth deflection per unit load for spiral bevel and hypoid gears. Holl[5] used the method of finite differences to obtain approximate solutions for the deflections of a thin cantilever plate of finite width. In this study, the finite element method is used to determine the bending and shear deflections, and the deflections due to contact between the mating teeth under load.