

Local Coefficients of Friction in Worm Gear Contacts

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

The friction conditions in the mesh of worm gear drives have big influence on the efficiency of worm gears. Because the friction conditions of worm gears can't be determined directly, a special test rig (three disk test rig) was built to simulate the contact conditions for discrete points along the contact lines of a worm gear.

The highest values of the local coefficient of friction occur under poor lubricating conditions with the vector of the rolling speed in direction of the contact line, normally in the center of a worm gear flank, the lowest coefficients of friction in the area of the outlet.

Furtheron the local coefficients of friction strongly depend on the type of lubricant and material combination and to a minor extent on load, lubricant viscosity and oil temperature.

The investigations at the three disk test rig offer a cost saving possibility to examine the different influences on the coefficient of friction of worm gears.

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1 Introduction

Important influence on the performance of worm gears is their efficiency. When calculating the efficiency the coefficient of friction must be known. The main influence parameters on the coefficient of friction in the contact of worm gears are the materials of the worm and the wheel, the lubricant, the Hertzian stress, the sliding conditions along the contact lines and the equivalent diameters.

Investigations on worm gears of Neupert /1/, Steingröver /2/ and Rank /3/ show the dependence of the efficiency on sliding velocity, geometry and lubricant although the main interest of these investigations were wear, scuffing and pitting. Fundamental investigations about the determination of the coefficient of friction in general were made by Stöbel /4/ on a twin disk machine. This test rig consists mainly of two disks with parallel axes, with centre distance $a = 80$ mm. For the investigation of sliding conditions as they occur in e.g. traction drives the test rig was modified by Gaggermeier /5/ in that way, that

the axis of one disk could be made skewed for some degrees. Boring motion was simulated by using conical disks instead of cylindrical. Between the disks, which both were made of steel, there was point contact. In a worm gear - worm made of steel, wheel made of bronze - there is line contact. These investigations did also not take into account the sliding velocity of the worm flank relative to the wheel flank along a contact line. So the results of investigations in a twin disk machine cannot easily be transferred to worm gears.

Ueno /6/ and Oetue /7/ described test rigs, which allow to investigate the influence of sliding in direction of the contact line on friction and wear. They determined the coefficient of friction and wear rates for different contact conditions. These investigations were mainly made to optimize the position of the wheel relative to the worm and to determine characteristic material values. Systematic investigations on worm gear friction are not reported.

The above mentioned investigations show, that there are no formulas, based on test results, which allow to calculate coefficients of friction in worm gear drives. Therefore a three disk test rig was designed and built to