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The Effect of Superfinishing on Gear Micropitting, Part II

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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

One of the most common failure mechanism of highly stressed case carburized gears is micropitting (gray staining). [1],[2],[3] The standard FZG gear test (FVA Work Sheet 54) is generally used to determine the micropitting load capacity of gear lubricants. In recent years, FZG gear testing has also demonstrated its usefulness for evaluating the effect of superfinishing on increasing the micropitting load capacity of gears. Such studies, however, can only be afforded by major corporations or research consortiums whereby the data is typically kept confidential. Results from the Technical University of Munich were previously presented in Part 1 of this paper.[4] Part II will present the results of Ruhr University Bochum. Both research groups concluded that superfinishing is one of the most powerful technologies for significantly increasing the load carrying capacity of gear flanks.

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Introduction

It should be noted from the outset that the data presented in Part I and Part II of this paper was generated by independent laboratories. Superfinishing of the gears was the authors' sole contribution to these studies. The authors provided no input on the selection of the testing facilities, procedures or parameters. The conclusions listed at the end of this paper were solely those of the testing laboratory.

Part I of this paper discussed the FZG *Brief Test of Gray Staining* (BTGS), which was designed to quickly induce micropitting. It is an economical test in terms of cost and time to determine how lubricants, lubricant temperature, coatings and surface finishes influence micropitting. The BTGS, showed that superfinishing significantly reduces micropitting in comparison to baseline gears.[4] This finding stresses the importance of surface finish for resisting the formation of micropitting.

Part II of this paper discusses the results of a more intensive micropitting testing performed according to FVA-Information-sheet 54/I-IV. The mineral oil used for lubrication was an ISO viscosity class 200 which contains a special additive (the nature of the additive is unknown to the authors) to reduce the micropitting carrying capacity. Baseline tests with a non-modified standard-FZG-C-gear were carried out to demonstrate the micropitting properties of the oil. The test gears were standard-FZG-C-gears which had the surface modified by superfinishing to a low Roughness Average (R_a). The pitch line velocity during all testing was set to 8.3 m/s and the lubricant was injected at 60°C.

A brief summary of the test procedure taken from FVA-Information-sheet 54/I-IV is given below:

The micropitting test may be used to determine quantitatively the influence of lubricants (especially additives), the lubricant temperature and other influential factors on micropitting. The micropitting test differentiates between oils and thus facilitates the choice of a lubricant with sufficient micropitting load capacity.

The operating conditions (circumferential speed and lubricant temperature) may be suitably adapted for testing lubricants for a large variety of applica-

tions in the micropitting test. To differentiate between the various test options, which are carried out according to the same test sequence, but with different test conditions, they are designated similarly to the FZG-scuffing test by test gear type/circumferential speed/and lubricant (inlet temperature in accordance with the selected test conditions (e.g., standard test: GT-CI8.3190; GT = micropitting test).

The micropitting test consists of two parts. It comprises a load stage test followed by an endurance test. In the load stage test, the ability of the gear-lubricant tribological system to resist micropitting is determined under specified operating conditions (lubricant temperature, circumferential speed) in the form of a failure load stage. The endurance test provides information on the progress of the damage after higher numbers of load cycles.(FVA 54.1-IV *Test procedure for the investigation of the micropitting capacity of gear lubricants*).[5]

Experimental

Gear design

The gears used were the standard FZG-C type gears for micropitting testing. Table 1 gives the general data for these gears.

Baseline Gears

Baseline gears were unmodified from the specifications given in the FVA Information Sheet 54.

Superfinished gears

A set of gears conforming to the specifications given in FVA Information sheet 54 were finished using chemically accelerated vibratory finishing as described in detail elsewhere.[6], [7]. This process utilizes high density non-abrasive media to enhance the performance of components that are subjected to metal-to-metal contact or bending fatigue. The Isotropic Superfinish (ISF®) process generates a unique surface when compared to even the finest honing and lapping in that it has no directionality with a final surface roughness of 0.25 μm R_a or less. This ISF® surface will be referred to as *superfinished* throughout this paper.