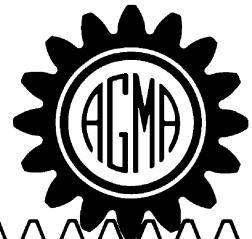


A Short Procedure to Evaluate Micropitting Using the New AGMA Designed Gears

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TECHNICAL PAPER

A Short Procedure to Evaluate Micropitting Using the New AGMA Designed Gears

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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

Encouraging results from a prototype micropitting test using specially designed gears (20:30 tooth ratio, tip relief, and a 560 mm radius pinion crown) on the standard FZG test rig were reported at the 1998 AGMA Fall Technical Meeting. Subsequently, the authors' company purchased several sets of these experimental AGMA test gears and attempted to develop a new test procedure to evaluate micropitting as an alternative to FVA Procedure 54. The new relatively short test procedure involves running the test gears on the standard FZG test rig with oil circulation for 168 hours at load stage 10 and 1500 rpm. The 5-gallon reservoir of test oil is kept at 60 C throughout the test. The oil is cleaned by an in-line filter (200 μ m) before it is injected into the gear mesh at 2 liters/minute. At the end of test, the gears are rated for micropitting, weight loss, pitting, and scuffing. The most common damage mode was micropitting, with only occasional occurrences of pitting and no occurrences of scuffing. Other modes of failure such as gear tooth bending did not occur at these conditions. The involute profile deviation of the gear teeth was not measured.

Five commercially available ISO VG 320 gear oils, with performance in the FVA Procedure 54 micropitting test ranging from FLS 9-low to FLS >10-High, were evaluated using this procedure. The degree of micropitting coverage ranged from 34% to 7% in the new test procedure. Micropitting generally originated in the middle of the gear tooth, instead of the root or tip. Overall, there was excellent correlation of the degree of micropitting damage between the new test procedure and FVA Procedure 54.

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A SHORT PROCEDURE TO EVALUATE MICROPITTING USING THE NEW AGMA DESIGNED GEARS

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Introduction

The American Gear Manufacturers Association (AGMA) has developed a new gear design for the study of surface fatigue life using the FZG gear test rig. The objective of the AGMA project is to develop a gear surface fatigue life mathematical model that will include lubricant and additive effects. Typical inspection properties of lubricating oils such as viscosity index, acid number, and elemental analysis are not a sufficient basis for estimating the ability of the lubricant to provide protection from surface distress such as scuffing, pitting and micropitting.

Pitting and micropitting are forms of rolling contact fatigue, which are strongly influenced by lubricant base stock type and additive chemistry. Although many studies have been reported over the years^{1, 2, 3}, the relationship still must be determined through testing of each oil formulation. Few established methods are available to evaluate pitting and micropitting. One method that is used to evaluate pitting is described in FVA Information Sheet No. 2/IV.¹¹ The most commonly used test to evaluate micropitting is described in FVA Information Sheet No. 54⁴ (commonly called FVA Procedure 54). This micropitting test can take several months to complete, and therefore is not convenient for the purpose of screening new technology. A screening test was developed using a roller disc machine⁵. Although successfully used to produce useful data, the equipment is not readily available and requires skilled technical support to prepare test specimens, run the test, and interpret results. Another test method was recently reported which uses modified gear geometry and different metallurgy, but is run on the standard FZG test rig^{6,7}. This test is run at only one load stage with rating after 100 hours and again after an additional 300 hours. Although results reported are promising, this test has not been widely used perhaps due to limited availability of test gears. A need still exists in the industry for a reliable,

simple, and widely available screening test for micropitting performance of lubricants.

Two types of test gears are available commercially to evaluate pitting and micropitting. FZG Type C-PT test gears (16:24 tooth ratio, surface finish $Ra=0.3\pm0.1$ micrometers) are used to test for pitting performance according to FVA Information Sheet No. 2/IV. FZG type C-GF gears (16:24 tooth ratio, surface finish $Ra=0.5\pm0.1$ micrometers) are used to test for micropitting according to FVA Information Sheet No. 54. Höhn et. al.¹² provide a detailed summary of the various test gears used in pitting, micropitting, and scuffing tests. The AGMA prototype test gears are somewhat different, with a 20:30 tooth ratio, and surface finish $Ra=0.5-0.8$ micrometers. The AGMA gears are designed with tip relief, which the FZG Type C-PT and C-GF gears do not have. The tip relief is meant to avoid hard contact at the tips of the gear and pinion teeth. The AGMA gears are also CBM form finished, which produces a different surface texture compared to the other types of gears. Additional design details of the AGMA test gears are provided elsewhere⁸. The AGMA test gears represent modern gearing design more closely than FZG Type C-PT or C-GF gears⁸. Results of prototype testing of the new AGMA test gears were reported at the 1998 AGMA Fall Technical Meeting⁹. Additional information about the test design and initial test results can be obtained from AGMA^{8,9,10}.

A subsequent batch of AGMA test gears was produced and limited quantities were made available to interested organizations with the understanding that test results would be reported to AGMA in generic form. M. Hoeprich¹³ conducted a study using the AGMA test gears in a short duration, high load test (load stage 12). Even though the test ended early due to tooth breakage, important information regarding the detailed failure mechanism was derived from study of the other teeth. Significant micropitting and pitting were observed on the pinion and gear teeth¹³.