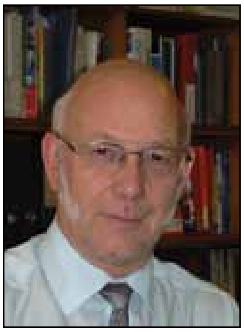

A Proposed Life Calculation for Micropitting

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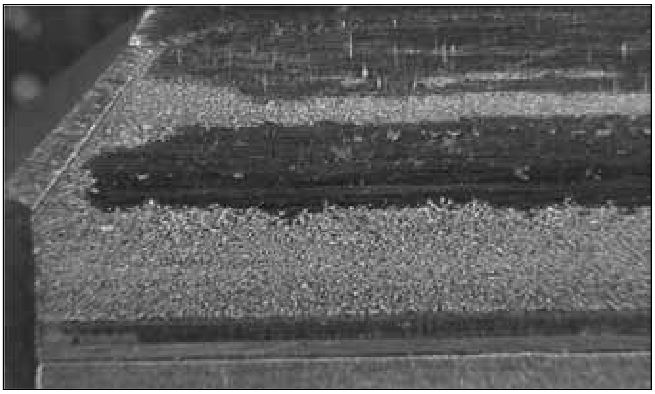
If you make hardened gears and have not seen any micropitting, then you haven't looked closely enough. Micropitting is one of the modes of failure that has more recently become of concern to gear designers and manufacturers. Micropitting in itself is not necessarily a problem, but it can lead to noise and sometimes other more serious forms of failure. Predicting when this will occur is the challenge facing designers.

The new ISO/TR 15144-1 2010 has gone some way to address the problem by proposing a procedure for rating a gear's ability to resist micropitting based on specified oil and operating conditions. However, it is not possible to determine a life for micropitting damage that can be tolerated. One method for determining the "permissible specific lubricant film thickness" is the FVA-FZG-micropitting test, which has the advantage that it is used by the oil industry as a rating procedure for oils with its additives package to resist micropitting. In this test the C type gear, which is a spur gear with a true involute profile, (i.e., no tip or root relief), is run for five different loads until 0.0075 mm flank erosion is reached. This load stage is designated the FZG load stage for the oil. Load stage five is a poor rating and 10 is considered a good oil. The downside of this test is that if the oil has a rating of load stage five, the gears have only been run for 16 hours, and if it is load stage 10, then 75 hours. The fact that the test stops at 0.0075 mm—unless you run the endurance test—does not mean that micropitting stops. It can still continue, and after another 75 hours could have doubled. For example, if you run the standard FZG test gear with an oil that has a designated FZG load stage 10 at a continuous load of 70 Nm—i.e., load stage 5—then after approximately 200 hours of testing there is a high possibility that you could reach the limit of 0.0075 mm, which is designated as a failure. The ideal method would be to use results from an actual test of similar design, but this takes time, and it is not always possible to know the exact duty cycle.



Example of micropitting damage I.

In 2006 a paper "An Analytical Approach to the Prediction of Micropitting on Case Carburized Gears" (D. Barnett, J.P. Elderkin, W. Bennett) presented at the AGMA Fall Technical Meeting, established a procedure to calculate the predicted micropitting erosion based on the macro and micro geometry of a gear set. The calculation procedure was based on testing conducted by the British Gear Association (*www.bga.org.uk*) and the other gears analyzed. At the time no account was made for the additives, but since then the procedure has been improved and an oil retardation factor based on the oils' ability to reduce micropitting was added. Verification is still ongoing, but results to-date show good correlation. Within the procedure, the standard FZG test gear is run with the oil from load stage five until the load stage for the oil is reached with the oil retardation factor set to one. To establish the actual retardation factor for the oil, the limit of 0.0075 mm is divided by the predicted erosion. The ideal procedure would be for the oil retardation factor for the oil to be established by dividing the predicted erosion from the test by the actual erosion, as many oils currently in use are load stage 10 +. This retardation factor will give a better understanding of the oil's potential to retard micropitting. In a newly proposed procedure, the gear set to be analyzed is run through a series of iterations, each one consisting of 1.5 x 10^6 cycles. At the end, the modification to the tooth profile is predicted and then used to establish the load conditions for the next iteration. The number of iterations required for the analysis depends on the running time; a duty cycle consisting of time and load could be constructed for a more realistic result. On completion of the duty cycle, it will be possible to look at the erosion's effect on noise and vibration, contact stress and pitting life and bending stress.

Dontyne Systems software already incorporates the ISO calculation Method A and Method B as part of the *Load Analysis Model* (for LTCA) and *Gear Design Pro* (for gear pair design and rating) modules respectively. The software is being extended to include this procedure as an additional function to enable the user to determine if the micropitting will arrest or continue and whether changing either the micro or macro geometry will reduce micropitting. The software was discussed and demonstrated at Booth 326 of the Gear Expo in Cincinnati. For more information, contact Dontyne Systems directly at *www.dontynesystems.com*.

Additional contributions to this article were provided by David Palmer and Mike Fish at Dontyne Systems Limited.

Example of micropitting damage II.

Example of micropitting damage III.