Micropitting: An engineering or chemistry problem?

by R. David Whitby

Although micropitting of gears is not a new phenomenon, its significance hasn't been widely recognized until now. It was thought to be a harmless, secondary wear problem, and more attention was paid to macroscopic pitting. Micropitting is now known to affect gear tooth accuracy and, in some cases, can be a primary failure mode of gears, particularly if it leads to macropitting.

Micropitting is surface fatigue caused by cyclic contact stresses and plastic flow on the asperity scale. It results in microcracking, formation of micropits and loss of metal.

All gears are susceptible to micropitting. It can occur with all heat treatments, including through-hardened, carburised, induction-hardened and nitrided. It is also common with carburised and ground gears because these are used for high loads.

The use of extreme-pressure (EP) gear oils has reduced scuffing wear in gears dramatically, but some of the EP additives have been associated with a tendency for micropitting. The micropitting performance of oils has been obtained using accelerated gear-life tests such as the FZG and the BGA micropitting tests. However, the reasons for the very differing micropitting performance of oils and additives are still not fully understood.

The first phase of a collaborative project called "Better Understanding of Micropitting," coordinated by the British Mechanical Power Transmissions Association (the trading name of the British Gear Association) and sponsored by industrial partners throughout Europe, has just been completed. The study found that helical gears produced in case-carburised 16MnCr5 or EN36 steels gave better micropitting performance than spur gears when the "real" Hertzian contact stress at which they operate was taken as the basis for comparison (that is, stress analysis using appropriate FE techniques). The micropitting threshold was found to be primarily a function of lubricant type and temperature with peripheral speed being significant in some cases.

The second phase of the study will commence in early 2004 and will last two years. The research team includes the Design Unit, University of Newcastle-upon-Tyne, QinetiQ and the University of Wales in Cardiff. This phase of the project will investigate gear tooth micro-geometry, surface finish and surface residual stress, as well as the effects of oil additives. The overall practical objective is to understand how to produce "real" spur and helical gears, which don't micropit.

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At Imperial College in London, studies indicate the early stages of micropitting may be due to surface roughness causing subsurface fatigue of the tooth flank. Asperities in the tooth flank surface create stress risers that are spread out over the tooth dynamically during the mesh cycle. This causes a subsurface fatigue of material, resulting in the separation of small elements of the gear tooth from the flank surface. The results suggest that improving surface finish could reduce micropitting significantly because surface roughness produces higher stresses below the surface and can result in micropitting.

While EP gear oils improve resistance to scuffing, the EP additives react with the tooth surface, reducing the fatigue life of the gear teeth surfaces. Lubricants may also react chemically with the surface, causing stress corrosion cracking, etching or the formation of a reaction layer, which modifies surface tractions. Also, oil pressure may induce opening of cracks. Examination of test gears at Lubrizol indicates there are two distinct types of micropitting patterns observed on test gears; one has a sort of glitter whereas the other is dull and grey.

Micropitting in itself is not problematic but may eventually lead to macropitting if the condition does not reverse itself. But is the problem caused by inappropriate gear design, incorrect surface finish or unsuitable EP additives? Many tribology experts, gear manufacturers and lubricant suppliers are busy working to find out. **<<**

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