Advances in manufacturing and lubricating gears

By R. David Whitby

Last January, at the 15th International Tribology Colloquium in Esslingen, Germany, a number of very interesting papers were presented on the methods of manufacturing gears and the impact on their lubrication.

Engineers at one of the world's leading manufacturers of gears, ZF Friedrichshafen, explained that different methods are used to produce gears for vehicle transmissions, depending on the specifications and volumes involved. While mainly shaved gears were made previously, today's low-noise requirements mean that gears are increasingly finish-machined, using shot peening or honing after hardening. Different production methods give differing gear quality, surface condition and internal stresses.

ZF conducted basic tests to compare the influence of surface condition and lubricant viscosity and additive type on the service life of rollers and tooth flanks, using appropriate transmission tests, notably manufacturing-oriented pitting tests. They found that gear tooth flank service life is influenced decisively by the quality of the marginal zone (surface structure and material), the lubricant (viscosity and additives) and the operating conditions (temperature and speed). In the mixed-friction range, tribological boundary-layer formation plays an important role.

The engineers also found that the DIN factors pertaining to roughness influence, ZR, and lubricant influence, ZL, are not sufficient for applications in vehicle transmissions. With new, lower-viscosity transmission oils, gear tooth flanks need to be made with increasingly low levels of roughness and irregularity. Relative lubricating-film thickness can be a useful parameter, especially if lubricating-film thickness is calculated with the help of measured pressure viscosities.

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Researchers at NMI in Germany and Afton Chemical Corp. in the United States and Japan are looking at the effects of oil viscosity and surface roughness on tribological layers in gear contacts. They reported that lower oil viscosity and high gear tooth surface roughness reduce tribological layer thickness, while high oil viscosity and lower gear tooth surface roughness increase it. Previous work, using secondary neutral mass spectrometry and a nano-indenter to analyze tribological contact layers, had found that the alkyl structure of ZDDP and the type of cation have a profound effect on the thickness and nano-hardness of the tribological layer.

The latest study extended that work by varying oil viscosity and surface roughness, while keeping the additive chemistry constant, to determine their impact on the tribological layer. The new study also used Scanning Electron Microscopy together with focused ion beam imaging of the rectangular, well-shape cross-section to look at the surface layer.

The researchers observed that thinner tribological layer thickness is the result of greater micropitting, which removes surface material. Greater micropitting implies that the surface experiences shorter tribological load history because more fresh material is exposed to the tribological load of the surface. In addition, greater micropitting also brings the maximum nano-hardness closer to the surface.

Researchers at the Technical University of Munich in Germany used an FZG twin disk test rig to better understand the effect of surface roughness and texture on the formation of a lubricating oil mean film thickness and pressure distribution over the Hertzian contact zone. They investigated the influence of roughness and surface texture as a function of load and sum velocity. The results showed that surfaces with circumferential grinding have a decreasing film thickness with increasing surface roughness, while surfaces with transverse grinding show almost no influence of roughness on film thickness.

With increasing roughness, the bandwidth of measured pressure maxima is increased, and peaks and troughs of roughness result in peaks and troughs of pressure. An influence of film thickness on the pressure bandwidth was not observed for thick film conditions, and researchers also found a good correlation of pressure measurements with initial calculations.

Together, the studies indicate that, for the lubrication of gears, the physics and the chemistry of surfaces and lubricants appear to be intimately connected. **<<**

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