Effects of profile errors on lubrication performance of helical gears

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1. ABSTRACT

This paper presents the results of a series of transient elastohydrodynamic lubrication (EHL) analyses of the meshing cycle of helical gears. Previous workers have analysed helical gears using a range of techniques, including thin slice models [1] and models which take into account the effects of three-dimensional surface roughness [2]. Previous work by the Cardiff group [3] has investigated the effects of tooth micro-geometry (tip relief) on contact pressures and lubrication performance. The current work investigates the effect of tooth profile errors (deviations from the involute form) on elastohydrodynamic performance.

The profile errors were measured on helical test gears using a Klingelnberg P65 gear measuring machine. The gears are of 6mm normal module, 20º reference pressure angle, 26.3º base helix angle, and 44mm face width, with the wheel having 24 teeth and the pinion 23 teeth.

The gears were analysed over the meshing cycle, and the transmitted load was chosen such that the maximum Hertzian contact pressure would be 1.6 GPa in the example shown here. The tooth load corresponding to the contact pressure of 1.6 GPa is 60 kN with Hertzian semi dimensions a = 0.5 mm and b = 36 mm. Profile error and tip relief geometry was included in the surface geometry based on the digital profile information obtained from the Klingelnberg measurements. It should be emphasised that the profile deviations are at much lower spatial frequencies than surface roughness effects – indeed profile errors would usually be removed by the standard filtering process applied to measurements of gear surface finish.

Figure 1 shows a comparison of film thickness contours for the smooth (upper) case (with tip relief) and the case including profile errors in addition to tip relief (lower). The presence of the profile error features can be seen to have a significant effect on the lubricant film thickness, with the loadbearing area developing a series of grooves. Between the grooves, the loadbearing surface develops ridges which give rise to elevated contact pressures significantly above those found in the smooth result. These are plotted in Figure 2 which is a section. through the contact at x = 0, which is the meshing contact line. The effects of profile errors on lubrication performance of helical gears can be clearly seen in these results, and the paper goes on to discuss the implications of these rarely considered effects for surface longevity.

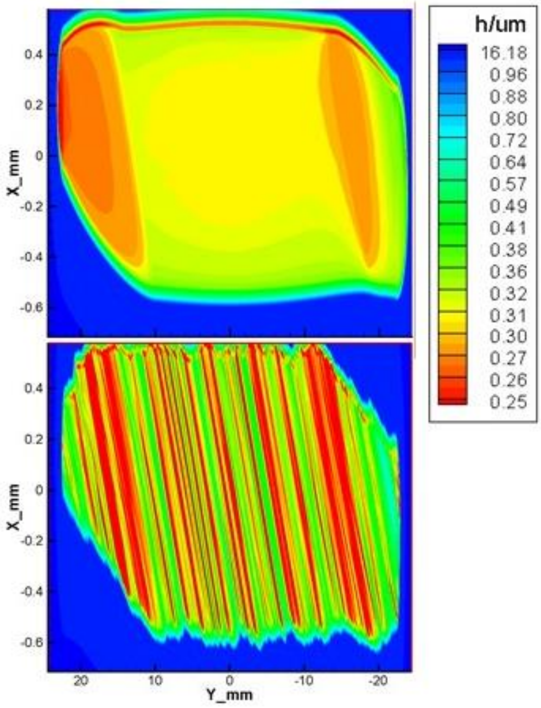

Figure 1: Film thickness contours for smooth case (upper) and case including profile errors (lower)

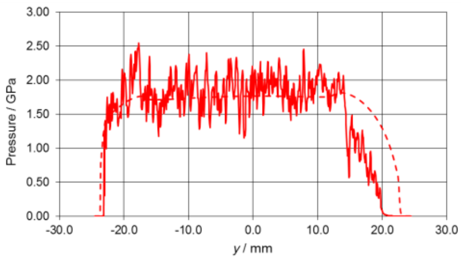

Figure 2: Comparison of pressure section along the contact line, x = 0, near the middle of the meshing cycle with the smooth surface result shown by broken lines.

References

[1] Li, S. *et al.*, Journal of Adv. Mechanical Design, Systems & Manufacturing, 3(2), 146-158, 2009.
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[3] Jamali, H. U. *et al.*, Tribology Transactions, 58:1, 119-130, 2015.