ELASTOHYDRODYNAMIC LUBRICATION AND SURFACE FATIGUE MODELLING OF SPUR GEARS OVER THE MESHING CYCLE

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ABSTRACT
This paper presents the results of a method for evaluating spur gears based on the transient elastohydrodynamic lubrication (EHL) simulation of the full meshing cycle, taking into account the transient variation of contact kinematics and loading during the meshing cycle. The simulation incorporates measured surface roughness, and evaluates elastic stresses in the gear flanks, calculating the transient variation of stress (the stress history) for the tooth material as it passes through the contact, and applying a range of stress and strain-life methods to calculate fatigue parameters and cumulative fatigue damage, using similar fatigue model evaluation techniques to Qiao *et al.*[1]. This allows a prediction of gear surface fatigue life for gears operating under mixed lubrication conditions, whilst taking into account the real, measured surface roughness.

The EHL model is formulated as the coupled system of the hydrodynamic Reynolds equation and the elastic deflection equation, which are solved simultaneously. The EHL model was developed based on the previous work of Davis [2]. The elastic stresses due to the superimposed discrete values of the EHL pressure and shear stress at the EHL mesh nodes are evaluated by carrying out the necessary convolution of the stresses by a Fast Fourier Transform method. The stresses are obtained on the EHL solution mesh and are interpolated to meshes fixed in the pinion and the gear flanks. They are then sorted and stored efficiently to enable fatigue life prediction algorithms to be applied in a straightforward manner.

Results of the fatigue calculations are shown for an analysis which considered test gears used in micro-pitting investigations. Contours of various fatigue parameters are shown in Figure 1, for a layer of gear tooth material extending to 300μm below the tooth surface. These analyses were carried out for the real extreme conditions used in gear testing, with surface roughness profiles measured from the test gears after initial running-in. The simulations therefore are representative of the true mixed lubrication conditions occurring in heavily loaded gears.

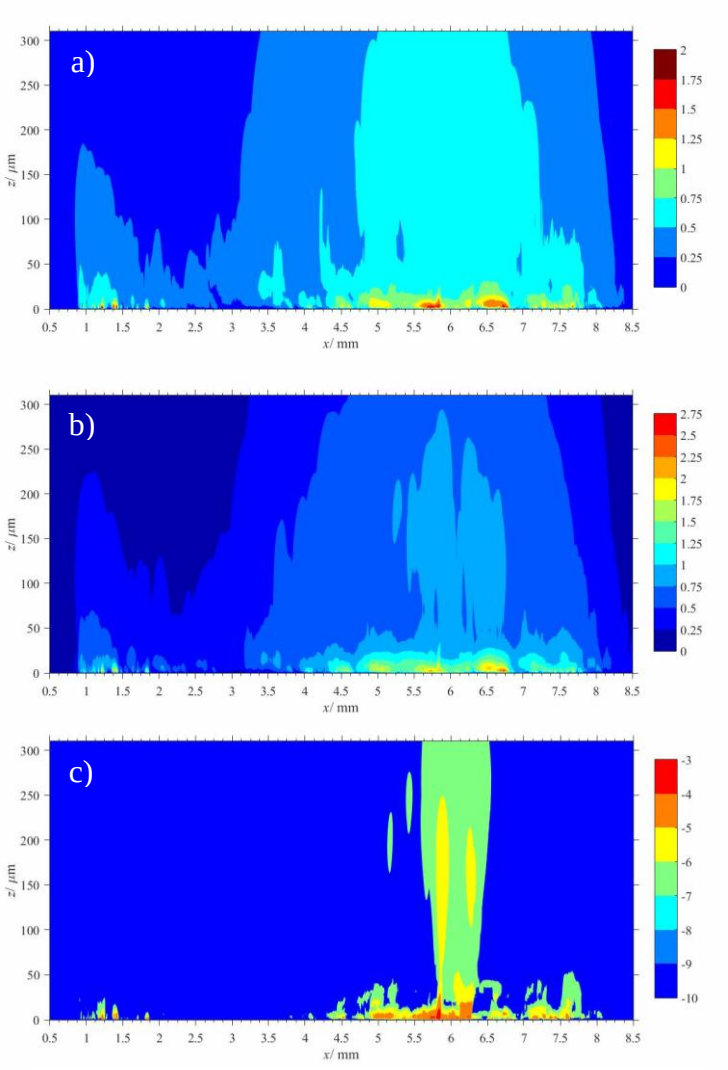

Figure 1. Gear: (a) Dang Van and (b) Findley fatigue parameters for 10^7 loading cycles and (c) Fatemi and Socie accumulated damage, 10^{-n}, indicating fatigue in 10^n cycles

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