LUBRICANT VISCOELASTICITY: IS IT OF ANY RELEVANCE TO QUANTITATIVE EHL FRICTION PREDICTIONS?

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KEYWORDS

EHL; Friction; Rheology, Viscoelasticity

ABSTRACT

From the earliest works on EHL friction [1], lubricant viscoelasticity has often been invoked to justify the use of rheological models that are not supported by primary measurements. It is claimed that the transit time of the lubricant through an EHL contact is too short for a purely viscous behavior to be exhibited, according to which shear stress τ would be related to shear rate $\dot{\gamma}$ and the generalized lubricant viscosity η as follows:

$$\dot{\gamma} = \frac{\tau}{\eta}$$

Instead, viscoelastic behavior is claimed, whereby an elastic component is added to the shear stress-shear rate relation, which is written according to the single mode Maxwell model as:

$$\dot{\gamma} = \frac{\tau}{\eta} + \frac{d}{dt}\left(\frac{\tau}{G_\infty}\right)$$

The property G_∞ corresponds to the limiting high rate value of the lubricant shear modulus. However, too low a value has been used for G_∞, compared to the actual known measured value, leading to an overestimation of the elastic effect.

The current work aims at showing that, when measured values of G_∞ are employed in EHL friction calculations, the elastic response of the lubricant may be ignored and a purely viscous behavior can be assumed [2]. For this, a lubricant is selected, for which the rheology is well characterized and for which the real value of G_∞ is known: di(2-ethylhexyl) phthalate (DOP) [3]. Then, friction calculations are carried out for TEHL line contacts operating under steady-state conditions, using the finite element full-system approach [4]. The results reveal that viscous and viscoelastic predicted friction coefficients are virtually the same and that elastic creep of the rollers has a significantly greater effect on friction than the elastic response of the liquid film. This can be clearly seen for instance in Figure 1, which reports friction curves for a steel-steel line contact with an inlet temperature T_0=50°C, a mean entrainment speed u_m=3m/s and a Hertzian contact pressure p_h=1.3 GPa.

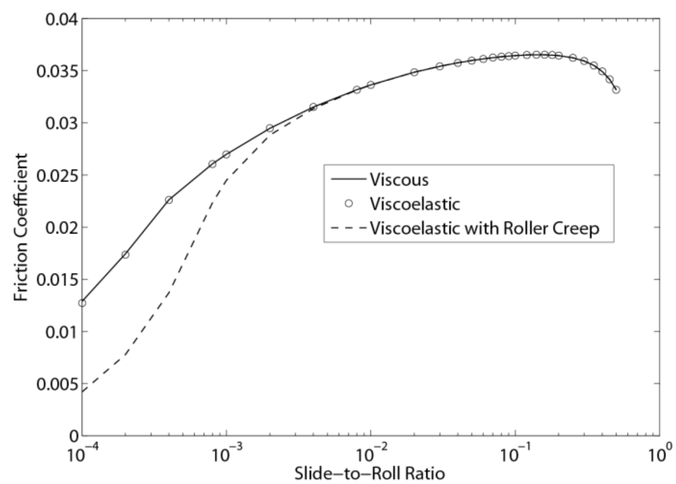

Figure 1: Friction curves for a steel-steel line contact (T_0=50°C, u_m=3m/s p_h=1.3 GPa)

To conclude, the answer to the question raised by the title is a definite no.

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