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High-pressure rheology and its influence on asperity lubrication.

For Newtonian lubricants, the linear proportionality between shear stress and shear strain rate always will maintain an oil film between the lubricated surfaces. Calculations show that oil film pressure variation built up by the roughness geometry will smoothen the surfaces and make them almost conforming. This is clearly seen also in real rolling contacts, where a mean oil film thickness much less than the peak-to-valley roughness of the co-operating surfaces still gives a total separation and no metallic contact. For very smooth ball bearing surfaces, an oil film thickness less than 10% of the peak-to-valley roughness still separates the surfaces with a continuous oil film.

That is only possible when the local shear strength of the lubricant is at least as high as the local shear stress. An added sliding motion for the lubricated rolling surfaces will thus strongly change the local shear stresses and displace the lubricant from the high-pressure regions under the elastically compressed roughness peaks. The smaller the roughness mean slope is, the smaller the local pressure gradients at the asperities will be, and thus also the lower will the tendency be to scrape off the oil from the high peaks.

To predict the surface roughness height and form allowed for different mean oil film thickness, different lubricant types, different oil film pressures and temperatures, and for different rolling and sliding speeds, it will be necessary to measure the high pressure rheology of the lubricant in detail. Experiments have shown that such a small sliding motion of the lubricated rolling surfaces as one wavelength of the surface roughness (25 microns) strongly changes the asperity lubrication behaviour. The allowable amount of sliding is thus a function of the contact pressure distribution, the lubricant type, the temperature, the surface energies and the contact time, as all those parameters influence the lubricant motion around the asperities.

Much more experimentally measured lubricant rheology data are thus needed, and some of them will be measured in the new 4.5 GPa high-pressure chamber in Lund.