Resonance Shear Measurements Reveal a New Perspective on Boundary Lubrication

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Resonance shear measurements have provided new insights into the behavior of lubricant oils under boundary lubrication conditions [1-5]. Lubricant oils are widely used in machinery to reduce energy loss and wear, and one major direction in lubricant development has been to lower viscosity in order to reduce friction in the hydrodynamic regime. However, low-viscosity oils often show increased friction and wear in the boundary lubrication regime. This limitation is commonly attributed to direct contact between surfaces once the lubricant is squeezed out of the gap.
Our recent studies show that certain lubricants actually remain confined between surfaces even under conditions corresponding to boundary lubrication, and their effective viscosity can increase by up to three orders of magnitude compared with their bulk values. These findings suggest a new view of boundary lubrication: the high friction observed for low-viscosity oils may arise not from surface contact, but from highly confined lubricant layers whose molecular ordering dramatically increases effective viscosity. We also find that such ordering can be disrupted by introducing branched molecules [3-5].
In this presentation, we will discuss how various lubricant systems behave under confinement, including (1) phenyl ether lubricants and their mixtures [2], (2) isostearic acid[3], and (3) mixtures of isostearic acid with PAO (poly-α-olefin) or hexadecane[4]. Implications of this new perspective for the design of next-generation lubricants will also be addressed [1, 4, 5].

Keywords:
surface forces measurement, resonance shear measurement, lubricant oil, hydrodynamic lubrication, boundary lubrication, confined liquid

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