BOUNDARY FRICTION ALONG A SINGLE SURFACE ASPERITY CONTACT

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INTRODUCTION

Direct experimental measurements of long range surface interaction forces between contacting surfaces are well described by continuum theories only at large separation gaps, but fail drastically when two contacting surfaces (for example, a single surface asperity contact) are closer than a few molecular diameters of the intervening liquid. This is due to the induced ordering of the molecules into discrete layers brought about by the approach of the second surface, which leads to non-uniform variation of the liquid density and to an oscillatory force law – Solvation forces.

Boundary friction due to the solvation forces are measured and observed to depend on the number of discrete molecule layers between the contact conjunction. To predict the molecular friction, the Eyring model is used to describe the non-Newtonian characteristic of the lubricant.

ELROD'S CAVITATION ALGORITHM

$$\frac{\partial}{\partial x}\left[\frac{\rho_c h^3}{\eta}.g\beta.\frac{d\theta}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{\rho_c h^3}{\eta}.g\beta.\frac{d\theta}{\partial y}\right] = 12\left\{\frac{\partial}{\partial x}[\theta\rho_c h(u_{av})]+\frac{\partial}{\partial y}[\theta\rho_c h(v_{av})]+\frac{d}{dt}(\theta\rho_c h)\right\}$$

$$g=\begin{cases}1 \Rightarrow & \text{Full film region, if } \theta \geq 1\\ 0 \Rightarrow & \text{Cavitation Region, if } 0<\theta<1\end{cases}$$

VAN DER WAALS PRESSURE

$$p_w = -\frac{A_{131}}{6\pi h^3}$$

SOLVATION PRESSURE

$$p_s = -Ce^{-h/a}\cos(2\pi h/a)$$

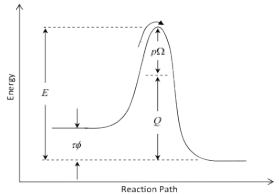
TOTAL PRESSURE :

$$p_{tot} = p_{hyd} + p_w + p_{sol}$$

TOTAL LOAD :

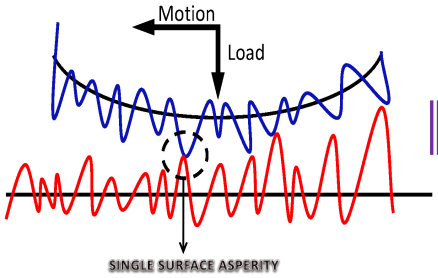
$$W = \int p_{tot}\,dxdy$$

EYRING MODEL

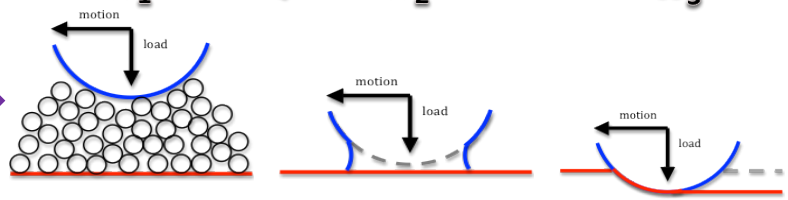


$$\tau = \tau_o + \alpha p$$

$$\tau_o = \theta \ln \nu + \tau_1 - p_v\alpha$$

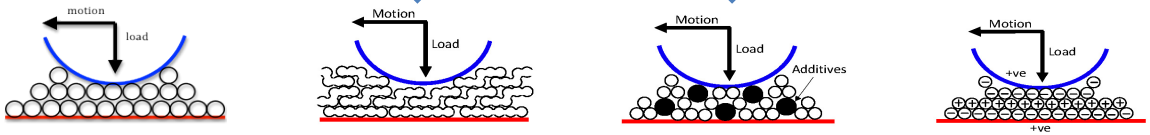


$W_1 < W_2 < W_3$



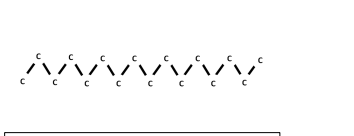
THIN-FILM ADHESION PLOUGHING

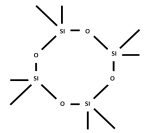
SOLVATION

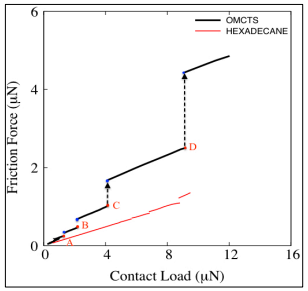


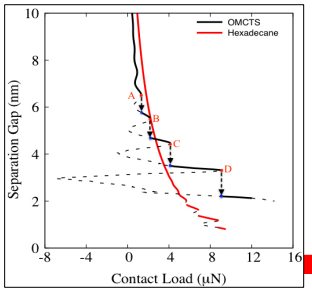
SPHERICAL MOLECULE (OMCTS) | CHAIN MOLECULE (HEXADECANE) | ADDITIVES | POLARITY

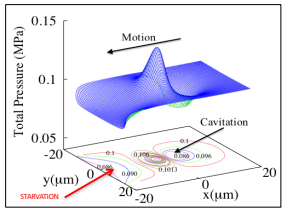
TOTAL PRESSURE AT 8NM GAP



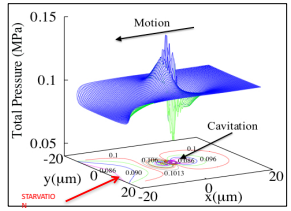






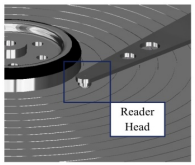


HEXADECANE

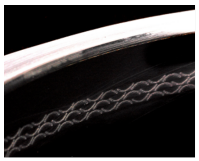


OMCTS

APPLICATIONS



HARD-DISK DRIVE



PISTON RING LUBRICATION

OBSERVATIONS

The boundary friction for a single asperity contact, with spherical or chain lubricant molecules trapped in between, at separation gaps in the range of nanometers can be predicted using the Eyring model. It can be observed that the lubricants with chain molecules are also influenced by the oscillating characteristics of the solvation forces but at a smaller oscillating amplitude and frequency than the lubricant with spherical molecules. The boundary friction for the lubricant with chain molecules show a less significant dependence on the number of discrete molecule layers.

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