Stick-slip motion at friction of two rough surfaces in the boundary lubrication mode

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The thermodynamic model of thin lubricant film melting, confined between hard rough solid surfaces, is built using the Landau phase transition theory. For the description of a melting condition the order parameter φ is introduced which is a periodical part of microscopic medium density function. Parameter φ is equal to zero in liquid-like phase and takes a non-zero value in solid-like structure. The density of free energy for the lubricant in homogeneous case is introduced in the form [1,2]:

$$f = \alpha(T - T_c)\varphi^2 + \frac{a}{2}\varphi^2\varepsilon_{el}^2 - \frac{b}{3}\varphi^3 + \frac{c}{4}\varphi^4, \qquad (1)$$

where T is the temperature, T_c is the critical temperature, ε_{el} is the shear elastic strain, α, a, b, c are the positive constants. The shear modulus of lubricant μ is proportional to the order parameter squared:

$$\sigma_{el} = \mu\varepsilon_{el}, \quad \mu = a\varphi^2, \qquad (2)$$

where σ_{el} is the elastic shear stress. In our consideration the dependencies of friction force on shear velocity and temperature are analyzed. At the high lubricant temperature the shear melting is realized at smaller value of shear velocity. The mechanical analogue of tribological system has been studied, and the time dependencies of friction force are obtained for the increasing shear velocity and temperature. It is shown that the experimentally observable stick-slip motion is realized. This stick-slip friction mode was shown as a result of the first-order phase transitions. We have found that with the temperature increase the lubricant melts at lower shear velocities of the interacting surfaces. In the case of rough surfaces friction regime is not periodic, because the frequency of phase transitions and amplitude of friction force are not constant during time.

[1] I.A. Lyashenko, Tech. Phys. **57(1)**, 17 (2012).

[2] I.A. Lyashenko, A.V. Khomenko, Tribol. Lett., doi: 10.1007/s11249-012-9939-2 (2012).