Thermodynamic theory of stick-slip mode of ultrathin lubricant film melting

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The theory of ultrathin lubricant film melting is proposed in [1]. Within the framework of this theory the fluctuations are taken into account [2]. It is shown that fluctuations lead to the appearance of stick-slip mode of friction that is observed experimentally [3]. However, this mode has stochastic character and random transitions are realized between liquid-like structure of lubricant that corresponds to the non-zero shear stress, and solid-like structure at zero stress. Besides described above, the mode is observed in experiments in which these transitions have periodic character [3]. The purpose of this work is to describe such mode.

Within the framework of adiabatic approximation according to that the relaxation time of lubricant temperature is much shorter that its value for stress and strain, the two-parameter system is obtained, that is reduced to the unique differential equation of the second order. The system parameters are defined at which the damping oscillations occur during the relaxation process. Thus the special point of focus type is realized at non-zero value of stress. This situation corresponds to the periodic stick-slip mode of friction. However, the described mode is transitional, and liquid friction, corresponding to the sliding with constant velocity, is set in course of time. Taking into account the fluctuations it is shown in indicated case that the periodic stick-slip mode of friction is saved in time, since the action of fluctuations constantly leads the configurative point on phase plane on a nearby phase trajectory. Thus casual addition appears in the periodic mode that changes static and kinetic friction force in time. Since the dependence is not strictly periodic such mode corresponds to the experiments with chain molecules which are complex to form well-organized structures, due to that the fluctuations are laid on oscillations [3].

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