Conjecture on limits of boundary lubrication

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The energy needed for passenger cars to overcome friction in the piston assembly only comprises nearly 45% of all engine friction losses and approximately tenth part of it arises in friction nodes operating in the boundary lubrication conditions [1]. Boundary lubrication (BL) can be defined as the regime if the average lubricant film thickness is so small that the surface asperities come into contact with each other under relative motion, the regime in which the load is carried by the surface asperities rather than by the lubricant [2]. If the literature is affluent in information concerning a boundary film formation and the friction reducing in these conditions, it is poor in data regarding the failure of boundary lubrication and start of catastrophic wear. The authors in present study proceeded in critical bibliographic analysis and elucidated basically on experimental approach to contribute in better understanding of possible scenarios focused on limits of (BL) regime. The initiation of more or less dramatic wear is principal manifest of these limits, particularly important for adhesive type. Therefore they are related to molecular state of lubricant and friction pair surfaces as well as to mechanical solicitations.

Authors are presenting dozen different possibilities which may hypothetical influence on initiation of this process. The great quantity of possibilities suggests that this problem has got a complex irreversible and multidisciplinary character. That is probably one of the reasons of lack of unequivocal model of this transitional process from stable adhesive wear to catastrophic one. It stimulates to multidisciplinary, multi-scale and muti-physics analysis of dynamic of interfacial properties.

The development of global interfacial analysis taking into account the topological approach in terms of family of surface characteristics sets as: its morphology, rheology and physical-chemical properties is presented. The cross-correlation with the dynamic of the interface behavior is discussed [3] in context of (BL) various dimensionally extreme systems. Multi-scale view from mono-molecularly smooth cobalt surfaces lubricated with mono-layers of fatty acids to industrially manufactured parts lubricated with additiveted oil is presented to focus on limits of boundary lubricated dynamic interfacial systems. Taking advantage of these points of views the analysis of the current state of knowledge regarding to limits of boundary lubrication is curried out. On this basis, authors were formulated postulates in relation to the initiation of catastrophic wear taking into account multi-physics phenomenology.

The catastrophic wear investigations and scenarios are presented and causes are briefly discussed. Results showing appearing of first symptoms of catastrophic wear, i.e. instability and brutal friction behavior, morphology of rubbing traces and amalgamation of contacted bodies are elucidated [6].

Hypothetical role connected to any group of features in the topological approach is elucidated and experimentally confirmed via the wettability, strongly combined with surface texture and surface free energy.

The value of surface free energy is calculated on the basis of contact angle measurements in relation to recently demonstrated [4] influence of roughness on wettability. Moreover, one can take into consideration that the surface free energy is depended on elementary level of electron structure of solids [5] giving precious information in terms of wear initiation of boundary lubricated surfaces [6]. The relationships experimentally stated between the surface free energy and the catastrophic wear is commented [7].

For scientific reasons some selected results of limits (BL) systems in case of gear oil with AW/EP additives issued from scuffing tests on AISI 4140 ground steel burnished with different forces in order to generate different surface roughness, residual stresses and surface energy are commented.

Results of catastrophic wear tests and contact angle measurements were compared looking on relevant cross-correlations. It was stated and numerically correlated the influence of wettability by lubricating medium on the scuffing resistance of surface lubricated by this medium. Additionally, it was demonstrated the dependence of wettability on selected parameters of roughness and a value of surface free energy.

In order to confirm proposed conjecture on limits of boundary lubrication (catastrophic wear) the results of association AISI 4140 steel with EN-GJL-300 cast iron counter-specimens are analyzed. Advancing the frontiers as C.N.R.S. slogan claims, the authors propose as tribological perspectives for (BL).

References

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