Thermodynamical approach of wear contact

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The friction and wear phenomena appear due to contact and to relative motion between two solids. The evolution of contact conditions depends on loading conditions and on mechanical behaviours. The wear phenomena are essentially characterized by a matter loss. Wear and friction are in interaction, due to the fact that particles are detached from the solids. A complex medium appears as an interface having a strong effect on the friction condition.

The conditions of friction are then affected and therefore the conditions of wear evolve simultaneously. The damaged zones belonging to the solids in contact can be also considered as a part of the interface. All these zones constitute a thin layer where the materials loss their own cohesion. The evolution of this layer is complex especially in the transient phase of the interface formation. However, for particular geometries and for steady states, with a constant flux of matter, the wear states can be studied experimentally and conceptually. This framework is a first step of comprehensive study for understand the parameters governing friction and wear. Following the classical terminology the interface is called "third body" and must be considered as an aggregate thin layer of different particles with sometimes a lubricant fluid. This layer develops non linear macroscopic rheology they must be characterized.

The purpose of this presentation is to describe such phenomena taking account of different scales of modelization in order to derive some macroscopic laws. A thermodynamical approach is proposed and models of wear are analysed in this framework where the separation between the dissipation due to friction and that due to wear is made. Applications on different cases are presented.

If macroscopic descriptions of such an interface are known in the literature [4] the connection with local mechanical quantities and discussion based on microscopic scale modelling are not currently developed, unless in some recent studies [7, 6, 2, 5].

Some well known wear criteria, as Archard's law [1], are useful but such models cannot be predictive when the operating conditions are not sufficiently close to the experimental test conditions of their elaboration. Strong interaction exists between debris and the solids in relative motion. The modelization of this interaction can be explored through the evolution of specific internal state variables governing the third-body behaviour.

A general formulation using of thermodynamical considerations on wear phenomena is proposed based on propagation of surfaces or layers inside bodies taking account of damage and loss of sound matter. A thermodynamical description of third body is then obtained and dissipation is analyzed. For a macroscopic view point the behaviour of the interface is modelized by unit of surface of contact. The density of mass by surface unit is related to the volume fractions of detached particles and plays the role of an internal parameter. The driving force associated to wear is then deduced and criteria of wear are proposed.

Finally, particular situations are studied using some constitutive law of the interface. In each case the dissipation is analysed. The matter loss and the geometry change are determined according to specific criteria and associated laws . Analytical and semi-analytical solutions are presented.

References

[1] Archard, J.F. Contact and rubbing of flat surfaces, *J. Appl. Physics*, **1953**, *24*, 981-988.

[2] Dragon-Louiset, M. On a predictive macroscopic contact sliding wear model based on micromechanical considerations, *International Journal of Solids and Structures*, **2001**, *38*, 1625-1639.

[3] Singer, I.L ; Wahl, K.J . Role of the third body in friction and wear, *MRS Workshop series: Tribology on the 300th Anniversary of Amonton's law*, **1999**, *San Jose*, California.

[4] Stolz, C. A thermodynamical approach to contact wear as application of moving discontinuities, *Arch. Appl. Mech*, **2007**, *77*, 165-175.

[5] Stupkiewicz, S. ; Mròz, Z. A model of third body abrasive friction and wear in hot metal forming, *Wear*, **1990**, *231*, 124-138.

[6] Zmitrowicz, A. A thermodynamical model of contact, friction and wear, *Wear*, **1987**, *114*, 135-221.