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Editorial

FOREWORD TO THE THEMATIC ISSUE: *SCIENCE OF WEAR*

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Along with the closely related phenomenon of fatigue, wear is one of the main causes for component damage and subsequent failure of machines and devices. Its mitigation by appropriate material choice, coatings, surface design, or lubrication is, therefore, of high economic importance. Wear belongs to the most complicated tribological phenomena, but still remains not well understood. Microscopic and mesoscopic mechanisms causing the macroscopically observable phenomenon of wear are extremely varied and can include abrasive or adhesive debris formation, their transport in the frictional zone, reintegration of previously removed material, oxidation, chemical or mechanical intermixing of the involved surfaces, mechanically induced diffusion and so on. Accordingly, the formulation of a general wear law is quite difficult.

The present thematic issue is devoted to the phenomenon of wear considered from different points of view. It is opened with the paper by J. Benad "Numerical methods for simulation of deformations and stresses in turbine blade fir-tree connections". This paper deals with numerical simulations of contact stresses and deformations in technical systems of complicated shape (in this particular case with fir-tree connections in turbines) – as a prerequisite for any wear analysis. The paper is dedicated to the generalization of the Boundary Element Method to contacts of elastic solids of arbitrary three-dimensional shape, while still taking advantage of the Fast Fourier Transformation used in present implementations of BEM. Today, The FFT-based BEM is the most efficient simulation method for contact problems. However, it operates only in the half-space approximation. The three-dimensional version sketched in the paper by J. Benad is a good candidate for a future universal contact mechanical tool which will be as effective as the present FFT-BEM but without its restrictions.

Even under laboratory conditions, it is very difficult to control wear. In practical applications such as wear in contact of tires with the road, the controlling parameters can vary drastically depending on the type of the vehicle, type of tires, type and state of the road, weather and so on. However, technical systems are often operated under such poorly defined conditions and it is important to understand to what extent one can predict the wear under these real conditions. The paper by R. Pohrt, "Tyre wear particle hot spots – review of influencing factors", presents an overview of experimental data describing the influence of various factors in real operation of tires.

Truly vital is the problem of wear in artificial joints (endoprothesis). Wear problems can lead to the necessity of repeated surgical interventions. G. Eremina and A. Smolin analyze exactly this problem in their paper "Multilevel numerical model of hip joint accounting for friction in hip resurfacing endoprothesis". They consider not the complete endoprothesis but "resurfacing endoprothesis" which in itself is a more gentle intervention in the living body. They further analyze the wear process based on the simulation of stress state of the system using the method of Movable Cellular Automata (MCA).

In simulating wear, very often the Archard law is used, stating that the wear intensity is proportional to the normal force and inversely proportional to the hardness of the contacting materials. Experiments show that this law is only a very rough approximation; as a matter of fact, it is never valid. Both experiments and microscopic simulations show that the dependence of wear intensity on normal load is not linear. But exactly this non-linearity could provide a key for the solution of the riddle of the huge variation in the coefficient of adhesive wear! Indeed, is it not paradoxical that Archard's equation, which describes *adhesive* wear, does not contain any parameter characterizing adhesion? From dimensional analysis, it even follows that the coefficient of wear *cannot* depend on the specific surface energy, since no dimensionless combination can be constructed from the specific surface energy and other available parameters. The situation changes completely if the wear intensity is not proportional to the normal load. Then the specific work of separation can be included in the equation of wear. Many empirical studies show that the specific energy of separation definitely belongs to the governing parameters of the wear process, along with the modulus of elasticity, and for plastic bodies, also the yield strength. In the paper "Generalized Archard law of wear based on Rabinowicz criterion of wear particle formation", V. Popov analyzes power-law wear equations under conditions of stationary wear. He finds that under the additional assumption of homogeneity of wear in the contact plane, the work of separation does not enter into the wear equation. Only deviation from this bound (for example due to transport of wear particles) makes the dependency of wear intensity on the specific work of separation possible. In other words, the specific work of separation can only enter the wear equation if the wear process is characterized by some characteristic length. This can be the characteristic Rabinowicz' length or some other structural parameter. In the future, it would be extremely interesting to check the found dependencies both experimentally and using direct numerical simulations.

If the normal contact of two bodies is superimposed by small tangential oscillations, partial slip occurs within the contact interface, which causes wear. This phenomenon is called fretting and arises in numerous engineering applications. M. Heß analyses this problem forthe contact of a rigid (but wearable) indenter and functionally graded materials.

Lubrication is often used to reduce or to control wear. Especially important are additives determining the properties of boundary layers deposited on the surfaces of contact partners. In their paper "Synergistic tribological properties of synthetic magnesium silicate hydroxide combined with amphiphilic molecules" Wang et al. report on the synthesis of magnesium silicate hydroxide (MSH) nanoparticles and their tribological properties combined with amphiphilic molecules (AMs) as additives in base oil. This combination reduces wear losses substantially due to the formation of a double molecular layer on the rubbing surfaces under certain test conditions.

E. Willert considers in his paper "Energy loss and wear in the oblique impact of elastic spheres" the wear processes during impacts of particles between each others or with a solid. Such impacts are a serious source of damage and failure in several technical systems like steam generator tubes, mining machinery and others. According to the Archard law of wear, the wear volume is directly proportional to the energy loss during a tribological contact. E. Willert utilizes this correlation to analyze impact wear.

In the short communication "Numerical implementation of fretting wear in the framework of the MDR", Q. Li et al. describe a numerical implementation of the integral transformations used in the method of dimensionality reduction, which guarantees stability of the numerical process independently of the number of iteration steps. The implementation is illustrated on examples of fretting wear simulation.

The thematic issue is closed with the paper by Tricarico et al. devoted to adhesion in multilayered systems.

The diversity of topics and scales considered in the papers presented in this issue reflects the complexity of the wear process. In developing particular models of wear, it is always prudent to bear in mind this real complexity.