

Continuum versus discrete approach in modeling of wear processes

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Wear of materials is a very complex phenomenon due to its tight correlation with all the other phenomena that take place at the interface of two bodies interacting with one another, like friction, contact and lubrication. When two opposing surfaces slide on one another, their asperities come into contact first, adhering and deforming (both elastically and plastically), finally separating again by brittle fracture, ductile fracture, or just by local transfer of atoms from one surface to the other.

It is evident, as the process is highly non linear and multi-scale in nature, that quantifying all these aspects is a challenge, whether the approach is experimental, numerical or analytical. Consequently, hundreds of equations have been developed based on experimental fits [1], but none reaches the simplicity of Archard's wear law to quantify the wear volume [2].

When it comes to numerical simulations in solid mechanics, a body undergoing wear can be represented either as a continuum or as an ensemble of discrete particles. The aim of this pair presentation is to explain the advantages and disadvantages of the two approaches, and how they can be combined for scale-bridging.

From a discrete perspective, atomistic simulations have been used to analyze what happens on the surface of bodies, with a focus at the micro-scale where wear mechanisms have been investigated since a few decades [3]. One of the advantages of this method, that is modeling the material behaviour at the detail of its micro-structure, is also its curse: systems at the engineering scale cannot be modeled yet because of the huge computational cost. Nonetheless, a recent important breakthrough in the field of wear was possible thanks to a particular atomistic approach [4] and showed that this approach can bring significant and fundamental insights in the understanding of the physics of wear.

The continuum scale allows the simulation of several orders of magnitude in surface roughness, bringing simulation tools closer to the engineering scale, especially with boundary element methods [5], which offer unparalleled computational efficiency. However, its bane lies with non-linearities: on top of the complex problem of fractal-surface contact, plasticity, damage and fracture mechanics make it neigh-impossible to simulate a true wear process. Nonetheless, continuum methods can be used to upscale simple laws observed at the micro-scale [6].

In this presentation the two authors will each take the side of one of the two approaches, facing a duel where the merits and limits of each approach will clearly emerge, with the

final intent of delivering awareness in the audience about the combined role of continuum and discrete modeling in the quest of a deeper understanding of wear related phenomena.

...what side will you take?

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