

THREE APPROACHES TO UNDERSTANDING SLIDING FRICTION AND WEAR

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The production of nanocrystalline wear debris containing components from the worn specimen, from the counterface and from the environment does not support any of the better known wear models or wear equations based on adhesion, delamination, fatigue or oxidation. This presentation will combine experimental results, molecular dynamics simulations and continuum mechanics to demonstrate important consistencies that are increasingly satisfying. The continuum analysis focuses on two 'fluids' shearing in opposite directions. The picture that emerges is one in which both structural and chemical changes are produced by mechanical mixing related to vorticity, which in turn develops through an instability of plastic flow. These processes can lead to tribomaterial that is nanocrystalline or even amorphous and is certainly far from equilibrium. Predictions of velocity and strain rate profiles are consistent with observations of displacement profiles, structure and composition gradients and the evolution of friction coefficients. The results seem to be applicable over a wide range of size scales, from the nano-scale to macroscopic. They may also provide insight for explaining flow patterns and structures generated during other high-strain rate shear processes, e.g., those observed in localized shear bands and those produced by solid state welding processes and during the formation of mylonite in plate tectonics. Together, the three approaches suggest generic behavior that needs to be included in any realistic sliding wear model. Plastic shear leads to strain rate gradients, causes structure changes, creates heterogeneous material and sets up vorticity that accounts for mechanical mixing. These account for friction and changes in structure and composition. Information on relevant fracture processes leading to debris is still missing, but it needs to be obtained to develop wear models that are realistic