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Constitutive Models of Friction and Wear Behaviors of Polymeric Solids and Liquids with Complex and Evolving Microstructures

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Abstract: Structural complexity and microstructural changes on boundaries of polymeric solids (composites, self-lubricating polymers) induce variations of dry friction and abrasive wear with respect to sliding directions (anisotropy) and positions on sliding trajectories (heterogeneity). In these cases, additional independent variables are introduced in models of frction force and wear intensity: unit vectors and oriented angles of sliding velocities, radii of curvature and unit vectors normal to sliding trajectories. As an example, heterogeneous friction and wear of polymer pins used in pin-on-disc experiments are analyzed for three sliding trajectories: concentric circles, spiral and lemniscate. Large external loads and high temperatures reorient macromolecules inside of polymeric liquids (polymer melts, liquid crystals), and macromolecules move with a high degree of friction anisotropy. In the frame of Brownian dynamics, the stochastic Langevin equation describes macromolecule motions including anisotropic viscous friction (translational and rotational). In numerical methods (MD, DEM, FEM) the polymeric liquids are modelled as assemblies of moving micro-elements. As an example, anisotropic dry friction is analyzed in contact between models of macromolecules (beat-like, rod-like, disc-like, snake-like) and a hypothetical base plane.