A mortar-type computational approach for the simulation of wear in the presence of third bodies and transfer film

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The concept of a *third-body* in tribology refers to particles or layers that form between two contacting surfaces during sliding or rolling motion [1]. Third-bodies and transfer film layers can significantly alter wear behaviour, acting as solid lubricants, carrying load, and protecting the primary surfaces from damage. Despite their near-ubiquity in real-world tribological systems, third-body effects are often neglected in modelling. Accurately capturing third-body effects is crucial for predicting the lifespan and reliability of mechanical components. However, numerical simulation of their behaviour remains challenging due to the complex interactions between contact mechanics, material removal, and debris dynamics, including diffusion and accumulation, and the complex interaction with other tribological properties.

This work presents a numerical approach for simulating wear in the presence of third-bodies using the finite element method. A macroscale modelling strategy is proposed that incorporates the formation, evolution and loss of third-bodies within a tribological system (see Figure 1). The approach leverages a state-of-the-art dual-mortar contact formulation, enabling robust and accurate treatment of non-penetration and frictional constraints. By representing wear and third-body particles via a state variable field [2], the model effectively captures their impacts on contact interactions, wear rates, and frictional responses. A management strategy for the state variables is implemented to account for debris diffusion. The model is validated through numerical examples, demonstrating its ability to capture complex interactions in scenarios such as fretting wear and reciprocating sliding. The proposed approach provides a deeper understanding of a phenomenon often overlooked in wear simulations, and not only unlocks new predictive capabilities but also guides the design of more durable tribological systems.

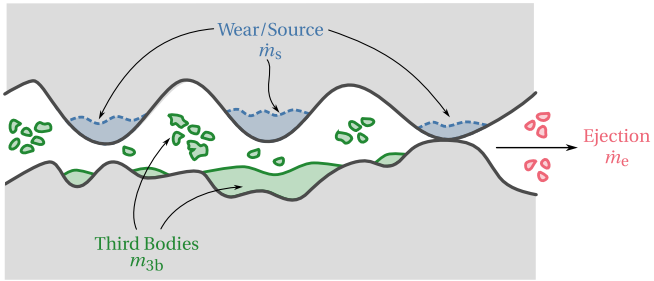

Figure 1: Schematic representation of a tribological system with third-body particles between two bodies in contact.

References

[1] M. Godet, The third-body approach: A mechanical view of wear, *Wear*, 100(1):437–452, 1984, DOI: 10.1016/0043-1648(84)90025-5.

[2] N. Strömberg, An augmented Lagrangian method for fretting problems, *European Journal of Mechanics-A/Solids*, 16(4):573–593, 1997, DOI: 10.1016/S0997-7538(97)80024-1.