FE-Modeling of Elasto-Hydrodynamic Contact with Free Surface Flow in Partially Flooded Regions

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ABSTRACT

The present work builds upon a recently proposed finite-element formulation for hydrodynamic lubrication with free surface flow in partially flooded regions, [1]. By extending the available model with an elastically deformable substrate, the present work addresses the case of a corresponding elasto-hydrodynamic contact.

A rigid indenter loaded and sliding against an elastic substrate is considered, with a thin lubricant film separating the two solids. In fully flooded regions, where the film is attached to both solids, the standard elasto-hydrodynamic lubrication equations apply. This is not the case in partially flooded regions, where the film is assumed to detach from the indenter and remain only attached to the substrate. In this possible lubrication scenario, free surface flow governs the behavior of the lubricant within partially flooded regions. In order to couple the two governing equations across the a priori unknown boundary between partially and fully flooded regions, a complementarity problem is formulated with both pressure and film thickness as unknown fields.

The specific structure of the posed complementarity problem dictates a C^1 continuous approximation of the film thickness. This has motivated a finite-element formulation based on quadratic B-spline basis functions. Moreover, in order to ensure non-negativity of the film thickness and avoid oscillatory components in the solution, a novel stabilization method has been proposed. The present work comments upon the potential of this new stabilization method beyond this specific application, as a general tool for non-negativity/monotonicity preserving approximations, applied e.g. as a shock-capturing approach.

Specific numerical examples demonstrate the application of the proposed finite-element model to the considered elasto-hydrodynamic contact problem. Novel numerical solutions are presented with relevance for applications at scales where capillary effects are significant, but also at larger scales as a regularization of the lubricant flow outside fully flooded regions.

REFERENCES

[1] Poulios, K., Vølund, A. and Klit, P. Finite element method for starved hydrodynamic lubrication with film separation and free surface effects. *Comput. Methods Appl. Mech. Eng.* (2018) **339**:281–297. DOI: 10.1016/j.cma.2018.04.044