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A POLYNOMIAL EXPANSION BASED MODEL FOR EVALUATING WEAR OF THIN SURFACE COATINGS IN FEA

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In the case of very thin soft surface coatings, the coating layer contribution is often discarded in a large-scale Finite Element Analysis (FEA). This is mainly due to the extensive numerical cost involved. However, to avoid failure of contacting coated parts one has to consider wear of the coatings themselves. This adds additional layer of complexity to the problem. To overcome the excessive computational cost introduced by the full discretization of the layer an alternative approach needs to be considered.

Inspired by the early work of Matthewson [1], using a polynomial expansion based approximation for the surface layer together with FEA can lead to an improved numerical framework. By proposing that the thin layer can be seen as a surface described by a dimensional variable \hat{y} , the displacement field in the coating layer can be approximated by a polynomial expansion as $\mathbf{u} = P_i(\hat{y})\mathbf{u}_i(x, z)$, where \mathbf{u}_i are the unknown displacement modes. By integrating over the layer dimensional variable \hat{y} the initial two phase problem is replaced by an interface problem. As the boundary of the substrate is discretized for FEA, the interface stiffness contribution can be directly added to the global FE-system. Thus, making the method easily suitable for usage with FEA. Furthermore, the only correction to KKT contact conditions is the modification of the gap function to include the displacements on the contacting interface. As there is no volumetric representation of the coating the removal of material due to wear can be described by the change of layer thickness. Making it straightforward to connect the abrasive/adhesive wear rate to a solution dependent field like shear stress or contact pressure as in case of Archard law. In addition, no remeshing routine is required as the thickness of the layer is a mesh independent parameter.

The possibility of including the above mentioned methodology in a FEA based wear simulation is presented. This research work focuses on a specific tribology test (Cross-Cylinder) to investigate the abrasive wear of coated cylinders. The results of the numerical model are directly compared to Greenwood [2] and physical test results. It is shown that there exists a significant cost reduction by considering polynomial based approximation of thin layers without loss of accuracy. Furthermore, the inclusion of wear is straightforward as it scales down to controlling the evolution of just one internal parameter. Finally, the compatibility with FEA is addressed on the example of implementation in commercial FEA software.

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