Investigation and Modelling of Rubber Stationary Friction on Rough Surfaces

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Abstract

This work deals with the investigation and modelling of rubber stationary sliding friction on rough surfaces. Through a novel physically motivated approach of dynamic contact problems, new insights in the understanding of rubber friction are achieved. This is of high interest for materials developers and road constructors regarding the prediction of wet grip performance of tyres on road tracks.

Improvements of contact mechanics are proposed within the frame of a generalized Greenwood-Williamson theory for rigid/soft frictional pairings. The self-affine character of rough surfaces leads to a multi-scale excitation of rubber during sliding process and the resulting hysteresis friction arises from material losses integrated over a range of frequencies. Beside a complete analytical formulation of contact parameters, the morphology of macrotexture is considered via the introduction of a second scaling range at large length scales, leading to a finer description of length scales that mostly contribute to hysteresis friction. On the other side, adhesion friction is related to the real area of contact and the interfacial shear strength which illustrates the kinetics of peeling effects distributed within the contact area at small length scales. This confirms well-known viscoelastic features exhibited by hysteresis and adhesion friction of elastomers on rough surfaces.

The estimation of high frequency dynamic mechanical behaviour of filled elastomers is of major concern for the relevance of hysteresis and adhesion friction simulations. Through the combination of relaxation spectroscopy methods, a generalized master procedure is proposed for filled elastomers and highlights the importance of thermally activated processes related to bound rubber at the vicinity of filler particles above the glass transition temperature.

Friction investigations carried out under confined conditions show the relevance of hysteresis and adhesion concepts on rough surfaces. In particular, the use of a tenside as lubricant allows a quantitative measurement of both components. The model leads to satisfying correlations with friction results within the range of low sliding velocities with a significant improvement through the introduction of a second scaling range. In particular, material related effects are predicted and discussed on the basis of their microstructure. The dynamic indentation behaviour appears to be a promising route for further improvements in the modelling of rubber friction.

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