WET AND DRY FRICTION OF ELASTOMERS IN ADVANCED SIMULATION COMPARED TO EXPERIMENT

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Understanding friction means understanding the interaction of material properties, surface properties and lubricant. Surfaces can be regarded as fractal structures in many cases, which allows a mathematical description of friction phenomena.
Profile analysis for granite and asphalt revealed their self-affine surface, so their surface descriptors could be found using height distributions and the height-difference correlation function.
Based on this fractal analysis, Klüppel & Heinrich had developed a friction model for rubber on rough surfaces. This is usable for wet friction and can be transferred to dry friction with a limited number of fit parameters, mostly gained from material constants.
The total friction consists of the adhesion friction and hysteresis friction. The latter appears when local asperities deform the rubber sample and cause energy dissipations. On dry systems, adhesion has to be considered additionally to hysteresis friction, because of molecular interactions.
To find the viscoelastic behaviour of the samples, dynamic-mechanical analysis was performed and resulted in master curves for the shear moduli G' and G", according to the time-temperature-superposition principle, applying horizontal and, for filled samples, vertical shifting. Relaxation time spectra gained from the shear moduli were used for simulation.
Friction was investigated in S-SBR samples with a thickness of 2 mm elastomers with different silica amounts, from unfilled up to 80 phr. The change of the wet and dry friction on both substrates was measured with 50mm*50mm samples sliding stationary between 0,01 mm/s and 30 mm/s on dry and wet surfaces with a pressure of 12.3 kPa at room temperature.
Further, NBR samples filled with up to 20phr PAOS and with or without carbon black were prepared and measured on granite, steel and glass with the same parameter set. These samples were expected to show reduced friction due to hard silica structures on their surfaces.
Generally, friction increases with silica filler concentration on wet substrates as well as with velocity. The dry friction however turns out to establish a high velocity plateau that becomes lower but more pronounced with increasing filler amount. Both substrates establish comparable friction coefficients.
As predicted, high amounts of PAOS can reduce friction and also stick-slip on the investigated substrates.
Simulations based on material and surface parameters have been conducted and fit to the experiments with the experimental parameters. The results describe the measurements well, including the plateau. Friction coefficients are accompanied by calculations of true contact area and gap distance, both depending on velocity and filler amount.

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- Messung und Simulation der Reibung von Elastomeren auf festen Substratflächen in Abhängigkeit der Zusammensetzung, Elastomeroberfläche, Temperatur und Geschwindigkeit
- Untersuchung des Stick-Slip-Verhaltens