Quantitative Wear Prediction Based on Persson Contact Mechanics

Ruibin Xu*[1,2] and Bo Persson†[1,2]

[1]Forschungszentrum Jülich = Research Center Juelich – Germany
[2]Lanzhou Institute of Chemical Physics, Chinese academy of science – China

Abstract

We present a comprehensive experimental and theoretical study on the wear mechanisms of rubber and polymer materials, leveraging the newly developed sliding wear theory (Persson wear theory), which extends Persson contact mechanics to quantitatively predict wear rates and particle size distributions. The study investigates the wear of rubber on surfaces such as concrete and sandpaper, as well as the wear of PMMA on surfaces with varying roughness, including polished steel, sandpaper, and ceramic tiles. Experimental results demonstrate excellent agreement with theoretical predictions, highlighting the versatility and accuracy of the Persson wear theory.

A key finding is the identification of distinct wear mechanisms based on surface roughness. For rough surfaces, wear is driven by shear-stress-induced crack propagation, while for smoother surfaces with roughness below a critical threshold, shear stress is insufficient to drive crack propagation, and wear originates from alternative mechanisms. This provides crucial insights into the origins of wear across materials and conditions.

As the first quantitative theory of wear mechanisms, Persson wear theory is able to predict wear rate and particle size distributions. It offers practical tools for assessing wear-related phenomena, such as the environmental impacts of wear particles, and paves the way for sustainable material design and improved surface engineering strategies.

*Speaker
†Corresponding author: b.persson@fz-juelich.de

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