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Study on Friction Behavior of Soft Material Based on Predictive Modeling and Interfacial Tribometry

Huixin Wei and Baopeng Liao*

School of Infrastructure Engineering, Nanchang University, Nanchang, 330031, China

*Corresponding Author: Baopeng Liao. Email: liaobaopeng@ncu.edu.cn

ABSTRACT

Friction behavior at soft-hard material interfaces plays a pivotal role in applications spanning biomedical devices, robotics, and tactile systems. While theoretical frameworks and experimental characterization methods have advanced, it is still difficult to unravel interfacial mechanisms. In this study, a theoretical model is firstly developed to predict static-to-sliding transitions by analyzing geometric evolution and stick-slip dynamics at soft material interfaces. The model quantitatively determines the threshold force for slip initiation, offering predictive insights into The sliding behavior of the interface. Second, an innovative tribometry platform is introduced, combining synchronized optical visualization, mechanical loading, and automated image processing. High-speed imaging captures real-time contact zone evolution, while edge detection algorithms and 2D digital image correlation (DIC) enable quantitative mapping of displacement-dependent boundary and full-field strain patterns. Finally, critical deformation patterns including contact boundaries, displacement and strain during static friction are utilized to study stick-slip mechanism. By correlating predictive models with experimentally obtained deformation, this work opens different pathways for designing adaptive soft-material-based systems with precisely tuned frictional responses.

KEYWORDS

Static friction; area of contact zone; soft substrate; digital image correlation; contact displacement; strain

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