

PROCEEDINGS

Nonlinear Dynamics of Clearance Joints with Wear-Induced Time-Varying Contact Profiles

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ABSTRACT

Wear evolution in revolute clearance joints introduces time-varying geometric changes of the bushing and pin that significantly affect the nonlinear dynamic behavior of multibody systems. In such systems, contact nonlinearity combined with continuously evolving profiles leads to strong non-smooth and time-dependent dynamic responses, posing challenges for accurate modeling and prediction. Conventional contact models often lose accuracy or even fail when the joint profiles deviate from ideal geometries during long-term operation.

This work proposes a computational framework for analyzing wear evolution and its influence on the nonlinear dynamics of clearance joints with complex and evolving contact geometries. The boundaries of the pin and bushing are discretized into a set of contact nodes, enabling robust contact detection and kinematic analysis for noncircular profiles. A physically consistent wear updating strategy is introduced, where the wear depth is applied along the local surface normal direction at the contact point rather than the centroid-contact direction used in conventional approaches. After each wear increment, the joint profiles are reconstructed to ensure geometric continuity and numerical stability during long-term simulations. This procedure enables continuous profile evolution and allows the coupled wear of both the pin and the bushing to be simulated simultaneously.

The proposed approach is applied to a planar slider-crank mechanism with revolute clearance joints. Numerical results show that wear-induced profile evolution introduces pronounced time-varying nonlinearities, significantly altering the system dynamic response. In particular, the coupled wear of the pin and bushing leads to more substantial changes in dynamic behavior compared to single-sided wear. The proposed framework provides an effective tool for investigating nonlinear dynamic responses of multibody systems with evolving contact interfaces.

KEYWORDS

Nonlinear dynamics; clearance joints; wear evolution; contact nonlinearity; multibody systems

Funding Statement: This work is supported by National Natural Science Foundation of China (Grant No. 12302484) and the National Key Research and Development Program of China (2022YFB4601700). The authors acknowledge the financial support from the China Scholarship Council (Grant No. 202406280023 and 202406280022) for the joint PhD training in Singapore.

Conflicts of Interest: The authors declare no conflicts of interest to report regarding the present study.



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