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Multi-body Simulation of a Ball Bearing for Predictive Maintenance

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ABSTRACT

Predictive maintenance of electromechanical powertrain systems relies strongly on big data. Consistently collected data from healthy and faulty operation cases can be exploited, e.g., for training machine learning models which allow to detect and diagnose possible defects before they take place. As the most critical part of the rotating machinery is the bearing, its proper condition monitoring is especially important. However, because of the large scale of bearing-specific faults, traditional experimental measurements often fail to produce enough data in terms of quantity and variation. Hence, the related data is available only to a limited extent.

Computational simulation is a solution that enables the generation of a large amount of synthetic data from physics-based simulation models according to various parameters set by the user. Many commercial software, such as ADAMS and Simpack, offer comprehensive simulation modules particularly for dynamic bearing analysis. These kinds of bearing models, however, typically apply rather simplified primitives only for visualisation purposes and limit the possibilities to further modify the geometries. To our best knowledge, the surface geometry based bearing models have not yet been adopted for fault detection and large-scale data generation purposes.

We present a dynamic multi-body simulation (MBS) model of a ball bearing using Simpack software to generate synthetic data from a healthy and faulty bearing. In the latter, a small hole on the outer ring represents the fault. The model consists of rigid bodies and it employs geometrical contacts between three-dimensional surface geometries. Each rolling element has a contact with both the outer and inner ring. By simulating the bearing rotating at a constant speed, mechanical signals, such as the contact forces and the shaft torque and displacement, were obtained. Furthermore, the output signatures from the healthy bearing simulations were compared to the result from the faulty case.

Our study showed that the MBS model of a ball bearing employing the surface geometry-based contact approach is a viable option for the computational data generation. With this methodology, it was possible to manually adjust the contacting surface geometries and run the simulations without compromising the computational speed or accuracy.

Keywords: MBS, bearing modelling, geometrical contacts, condition monitoring, computational data generation.