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Experimental comparison of the nonlinear dynamic behavior of a rigid rotor interacting with two types of different radial backup bearings: Ball & Pinned

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Abstract

Rotors on magnetic bearings rely on external controls to guarantee stability and are designed in case of partial or total failures, when impacts happen and potentially lead to a breakdown. Therefore backup bearings are indispensable. In such rotor-stator interactions the main undesired phenomenon is the backward whirl. The current work investigates the experimental behavior of a horizontal rigid rotor interacting laterally with two types of backup bearings during run up testing. The experimental data is analyzed by orbit analysis, spectrum analyzers, and force magnitudes collected by sensors installed. It is shown experimentally the nonlinear behavior of the rotor-bearing system and the elimination of backward whirl. The advantages and drawbacks of each type of backup bearing are given.

Keywords: Rotordynamics, Backup Bearings, Experimental nonlinear dynamics, dry friction whirl

1. Introduction

Developments in the field of rotordynamics have increased the important role of mechanical devices required by safety measures to protect the rotating machines, thanks mainly to the recent advances in magnetic bearings. These machines have still not been used in many industrial applications due to safety concerns among others. Therefore a lot of effort and research has been done to understand the consequences of the interaction between the rotor and the backup bearing for improving the quality and thus the safety properties of such elements. The safety bearing consists usually of a bearing with a slightly smaller clearance than that of the magnetic bearing, thus avoiding contact on the final one.

Johnson [1] was one of the first to publish a study on rotors with clearance. His model describes two cases, one undamped and another damped, with the rotor impacting on a circular surface, but he did not include the friction force itself. His investigation was more related to equilibria stability and whether the solutions of the synchronous whirl are positive. The friction force was added in the work of Black [2], whose 2D model presented a whirling and whipping effect caused by the friction coefficient when the rotor is in contact with the surface. Szcygielski [3] performed an analytical and experimental comparison of a gyro pendulum. His results showed good agreement with his piecewise linear model for impacts on the mechanical model. Lingener [4] and Crandall [5] published their findings confirming

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