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Nonlinear dynamic behaviors of a rod fastening rotor supported by fixed–tilting pad journal bearings

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ABSTRACT

A rod fastening rotor with the fixed–tilting pad journal bearings support is modeled. The rotor is connected by rods, where the rods and connection surfaces of disks are considered as resistance bending springs with nonlinearity, and the inertia of the tilting pads is considered in the modeling. The nonlinear oil film forces of the fixed–tilting pad journal bearings are obtained by the database method. The nonlinear dynamic behaviors and bifurcation of the rotor-bearing system is investigated by the orbit diagrams, the time series, the frequency spectrum diagrams, and the Poincaré maps. The comparison of the orbits between the rod fastening rotor and integral rotor system is implemented, and the results reveal that the rod fastening rotor system is more stable than the integral rotor system. The orbits of the rotor system and the pendulum angles of pads are also studied at different preloads and pivot ratios.

1. Introduction

A rotor-bearing system is an important component in rotating machines. Recently, nonlinear dynamic behaviors and stability of the integral rotor-bearing system have been widely studied [1–6]. Wang et al. [1] established a model of a rub-impact rotor-bearing system. The nonlinear behaviors of the rub-impact rotor-bearing system were analyzed by the Floquet theory. Based on the Precise integration method, the nonlinear dynamic behaviors of the gyroscopic rotor–gas bearing system with double time delays were studied by Zhang et al. [2]. The results showed that the response amplitudes of the system with time delay control are reduced, and the motion of the rotor–gas bearing system is more stable. Xie et al. [3] investigated nonlinear dynamic behaviors of the flexible rotor-bearing system with two unbalanced disks. Bifurcation and chaos of the system were analyzed by calculating the maximum Lyapunov exponents, and the numerical results were in good agreement with the experimental results. Lu et al. [4] studied the stability and nonlinear responses of the rigid rotor system with elliptical sliding bearing supports. The bifurcation behaviors were analyzed by the method which is a combination of the predictor–corrector mechanism and the Newton–Raphson method. Bifurcation characteristics of flexible rotor-bearing systems were investigated by Wang et al. [5]. The results showed that the rotor stiffness has a significant influence on the bifurcation. Wang et al. [6] studied nonlinear behaviors of the rotor-bearing system regarding interaction between blades

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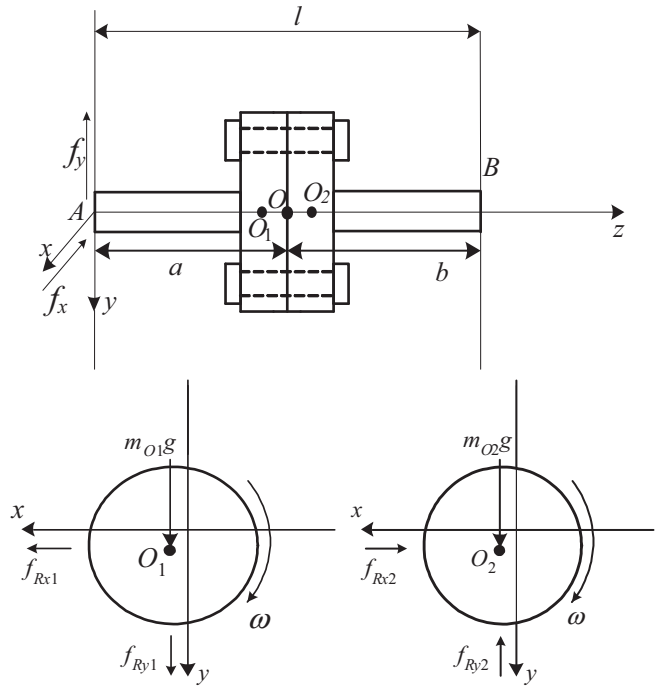

Fig. 1. Dynamic model of a rod fastening rotor and its coordinates.

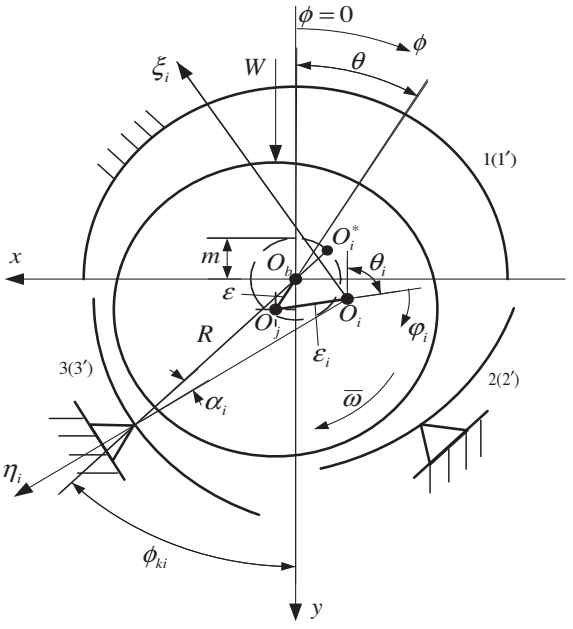

Fig. 2. Geometry diagram of a fixed–tilting pad combination journal bearing.

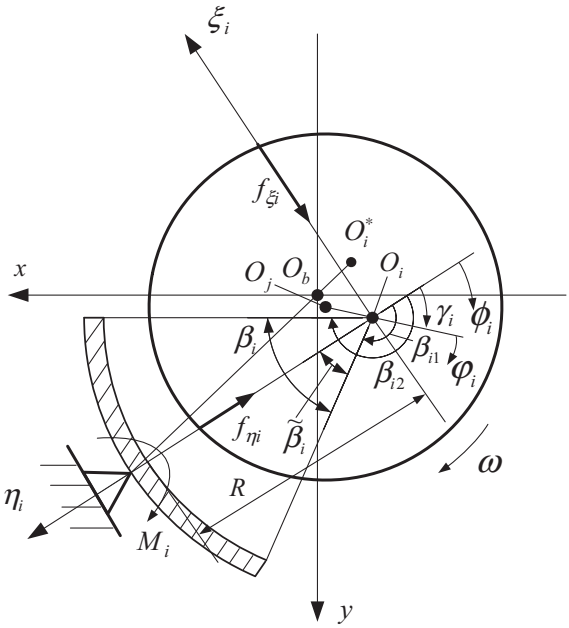

Fig. 3. Calculation coordinate of the *i*th pad.

and the rotor. The blades were modeled as pendulums. The results showed that the blade/rotor-bearing system exhibited rich nonlinear dynamic behaviors, and the effect of the nonlinear behaviors of the rotor on the blade vibration was also studied.

The studies above concentrated on the integral rotor-bearing system. A rod fastening rotor-bearing system has many advantages, such as light weight, ease of cooling, ease in assembly, etc. The rod fastening rotors have been widely used in gas turbine and aero-engine. Cheng et al.