Nonlinear dynamics of asymmetric rotor subjected to rotor-stator contact

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Abstract. The nonlinear dynamics of an asymmetric rotor subjected to the rotor-stator contact effect were investigated. The rotor was mounted on elastic supports and excited by an unbalanced force arising from the eccentricity of its center of gravity. Equations of motion in the two transverse directions of the rotor were obtained. The obtained governing equations of motion were solved numerically to unveil the system's dynamics, such as the transition among periodic, quasi-periodic, and chaotic motions. In particular, the complex dynamics of the system were studied with the help of bifurcation diagrams, phase plain, time history, and power spectrum.

Introduction

Centripetal forces generated by the imbalance can bring a serious hazard to machines. It is not surprising that studying the effects of imbalance on the dynamics of machines has been in mainstream rotor-dynamic research for decades [1]. This excitation can produce a vibration that causes rotor-stator contact [2]. Asymmetricity causes changes in the mode shapes and vibration patterns of the rotor system, therefore, studying the dynamics of asymmetric rotors subjected to rotor-stator contact is significant [3].
The governing equations of motion were derived with the aid of Hamilton principle by employing the Rayleigh beam theory. Impact interaction between the rotor and the stationary outer case was modeled in the form of discontinuous stiffness, and geometrical and inertial nonlinearities due to the inextensibility of the shaft were considered.

Results and discussion

Different tools for dynamical analysis were used to investigate the effects of system parameters on the dynamical characteristics of the rotor. Transition in the dynamical state of the rotor was investigated when the rotating speed, asymmetrricity, damping coefficient, and impact stiffness coefficient were chosen as control parameters.

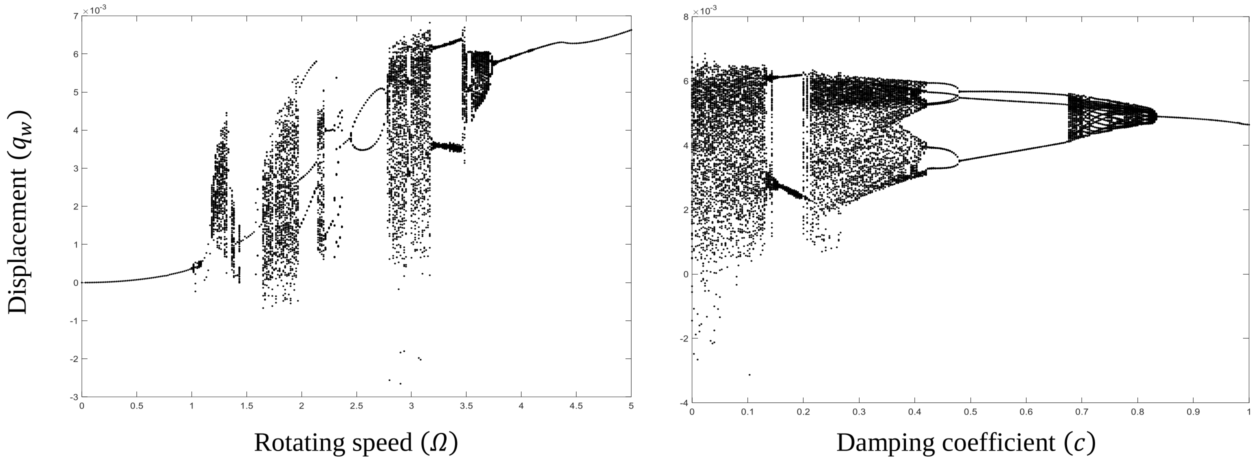

Figure 1: The bifurcation diagram of the maximum displacement of the rotor versus the rotation speed.

When the vibration amplitude of the rotor is smaller than the radial gap, the system vibrates with period-1. By increasing the rotation speed the system experiences quasi-periodic, period-n, and chaotic motion. Moreover, the motion regime changes from chaotic to multi-periodic by increasing the damping coefficient, and the asymmetricity and impact stiffness are also of great importance to the dynamical characteristic of the rotor.

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