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A Computational Study of Vibration Attenuation of the Rotor System with Magnetorheological Squeeze Film Dampers

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Abstract: The rotor vibrations are significantly influenced by the damping elements, which are added between the outer race of a rolling bearing and the stationary part. The primary aim of this study is to investigate the nonlinear behaviour of a squeeze film magnetorheological damper designed for attenuation of the lateral vibration of a rotor system. The hydraulic forces produced by squeezing the magnetorheological oil film have a nonlinear character and strongly depend on the viscosity of the lubricating fluid, the supply current in the damper, and the kinematics of journal motion. The pressure distribution in the damper is described by a modified Reynolds equation for a magnetorheological oil modelled as Bingham or the bilinear theoretical material. The harmonic balance method with the arc-length parameterization is proposed to obtain higher-order approximation periodic solutions of a motion equation build-up for the rigid and the flexible model of a rotor system. The computations of the irregular oscillations were carried out by using the 4th order Runge-Kutta method. The vibration stability of the motion was assessed by the 2n-pass method and the turning and bifurcation points for a solution branch over varying system parameters were identified. The phase trajectory, power spectrum, Poincaré maps, and the bifurcation diagrams are used to analyse the investigated rotor system. The computational analysis demonstrates that the different material models of a magnetorheological oil have a small impact on the numerical results. Moreover, the numerical simulations show that the vibration is dependent on the speed of the rotor rotation and the amount of damping in the magnetorheological damper, and that complex dynamic behaviour can exist. This is characterized by periodic, subharmonic, and irregular oscillations of the rotor.

Keywords: rotor, magnetorheological squeeze film damper, harmonic balance method, stability analysis, irregular vibration