Nonlinear dynamic behaviour of a rotor-foundation system coupled through passive magnetic bearings with magnetic anisotropy - Theory and experiment - DTU Orbit (08/11/2017)

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In this work, the nonlinear dynamic behaviour of a vertical rigid rotor interacting with a flexible foundation by means of two passive magnetic bearings is quantified and evaluated. The quantification is based on theoretical and experimental investigation of the non-uniformity (anisotropy) of the magnetic field and the weak nonlinearity of the magnetic forces. Through mathematical modelling the nonlinear equations of motion are established for describing the shaft and bearing housing lateral dynamics coupled via the nonlinear and non-uniform magnetic forces. The equations of motion are solved in the frequency domain by the methods of Finite Difference and pseudo-arclength continuation. The theoretical findings are validated against experiments carried out using a dedicated test-rig and a special device for characterisation of the magnetic anisotropy.The characterisation of the magnetic anisotropy shows that it can be quantified as magnetic eccentricities having an amplitude and a phase, which result in linear and parametric excitation. The magnetic eccentricities are also determined using the steady-state response of the rotor–bearing system due to forcing from the magnetic anisotropies and several levels of mass imbalance. Discrepancies in the results from the two methods in terms of magnetic eccentricity magnitude are due to additional geometric eccentricities in the shaft. The steady-state system response shows clear nonlinear phenomena, e.g. bent resonance peaks, jump phenomena and nonlinear cross-coupling between the two orthogonal directions, especially during counter-phase motion between shaft and bearings. The clear nonlinear behaviour is facilitated by the lack of damping resulting in relatively large vibrations. The overall nonlinear dynamic behaviour is well captured by the theoretical model, thereby validating the modelling approach.

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