Rotor-bearing system integrated with shape memory alloy springs for ensuring adaptable dynamics and damping enhancement-Theory and experiment - DTU Orbit (08/11/2017)

Rotor-bearing system integrated with shape memory alloy springs for ensuring adaptable dynamics and damping enhancement-Theory and experiment

Helical pseudoelastic shape memory alloy (SMA) springs are integrated into a dynamic system consisting of a rigid rotor supported by passive magnetic bearings. The aim is to determine the utility of SMAs for vibration attenuation via their mechanical hysteresis, and for adaptation of the dynamic behaviour via their temperature dependent stiffness properties. The SMA performance, in terms of vibration attenuation and adaptability, is compared to a benchmark configuration of the system having steel springs instead of SMA springs.A theoretical multidisciplinary approach is used to quantify the weakly nonlinear coupled dynamics of the rotor-bearing system. The nonlinear forces from the thermomechanical shape memory alloy springs and from the passive magnetic bearings are coupled to the rotor and bearing housing dynamics. The equations of motion describing rotor tilt and bearing housing lateral motion are solved in the time domain. The SMA behaviour is also described by the complex modulus to form approximative equations of motion, which are solved in the frequency domain using continuation techniques.Transient responses, ramp-ups and steady-state frequency responses of the system are investigated experimentally and numerically. By using the proper SMA temperature, vibration reductions up to around 50 percent can be achieved using SMAs instead of steel. Regarding system adaptability, both the critical speeds, the mode shapes and the modes' sensitivity to disturbances (e.g. imbalance) highly depend on the SMA temperature. Examples show that vibration reduction at constant rotational speeds up to around 75 percent can be achieved by changing the SMA temperature, primarily because of stiffness change, whereas hysteresis only limits large vibrations. The model is able to capture and explain the experimental dynamic behaviour. (C) 2016 Elsevier Ltd. All rights reserved.

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