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On backward whirl excitation in linear-time-variant intact and cracked rotor systems

Tariq Alzarooni, Mohammad AL-Shudeifat, Oleg Shiryavev, Chandrasekhar Nataraj

Abstract: In a recent study of intact and cracked rotor systems with an open crack model and anisotropic bearings, capturing of BW phenomena immediately after the passage through the critical forward whirl speeds has been numerically and experimentally confirmed. Accordingly, this phenomena is further investigated here for rotor systems with a breathing crack model. The Finite Element Model (FEM) is used to develop the linear-time-variant (LTV) equations of motion of the considered cracked rotor systems in which startup acceleration is considered. In addition to incorporating the breathing crack, the effect of both bearings scenarios; anisotropic and isotropic, on the excitation of this BW phenomena is also examined. In addition, the dynamic transient response during startup is evaluated at various unbalance force vector orientations with respect to the crack opening direction. It is found that the variation in unbalance force vector angle with respect to crack opening direction has a significant impact on the extent of BW zones. It is also observed that, at wide range of unbalance force vector angles, the BW whirl zones are always associated with an abrupt drop in whirl amplitudes. The dynamic transient response is also evaluated at various angular acceleration rates where the appearance of BW zones is more prominent in the case of anisotropic bearing model. It is found that the BW zones are captured at nearly all ranges of crack depth ratios for the anisotropic bearing case. However, these zone are only captured at relatively high crack depths for the isotropic bearing case.

[1)] Tariq Alzarooni, M.Sc. (Ph.D. student): Ph.D Student, Khalifa University, United Arab Emirates (AE), tariq.alzarooni@ku.ac.ae.

[2)] Mohammad AL-Shudeifat, Associate Professor: Associate Professor and Associate Chair, Aerospace Engineering Department, Khalifa University, United Arab Emirates (AE), mohd.shudeifat@ku.ac.ae.

[3)] Oleg Shiryavev, Ph.D.: Assistant Professor, University of Alaska Anchorage, AK, United States (US), oshiryavev@alaska.edu.

[4)] Chandrasekhar Nataraj, Professor: Professor, Villanova University, Villanova, United States (US), nataraj@villanova.edu.