Post-resonance backward whirl analysis of accelerating cracked overhung rotor system using fatigue crack model

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Abstract. Propagation of fatigue cracks or bearing-induced damages in overhung rotor systems that are exposed to recurrent transitions through the critical forward whirl rotational speeds during startup and coast down operations could excite several zones of backward whirl rotational speeds. These backward whirl zones can either precede the critical forward whirl speed, and thus known as pre-resonance backward whirl (Pr-BW), or immediately follows the critical forward whirl speed and thus renowned as a post-resonance backward whirl (Po-BW). The Po-BW is a new type of backward whirl in essence it possesses different dynamic characteristics compared with the Pr-BW. A state-of-art review is addressed in the subject paper for overhung rotor system using parametric analysis by employing breathing crack function. Finite element (FE) model and full spectrum analysis (FSA) are employed for analysis of Po-BW. This work is presumed to potentially advance the current state-of-art for rotor's fault diagnostics and prognostics.

Introduction

Crack induced damage could result in catastrophic failure. In most cases, and subject to economy of scale, this could potentially form a serious environmental, health, and safety (EHS) implications. Therefore, there is a conscientious need to explore various initiatives to develop and enhance early fault detection methods.

Since early 1960's, there have been many attempts to evaluate and explore various vibration patterns that form potential indication of rotor's crack presence. In a very recent years, a new type of BW have been captured during shaft transient runup or coast-down operation [1]–[4]. The new type of BW is revealed to have different dynamic characteristics than the conventional Campbell Diagram-based which is well-reflected in the literature for steady-state rotor. In the present work, state-of-art is pursued by studying such phenomena on an overhung rotor-bearing-disk system along with employing fatigue-based breathing crack model. Finite Element Model is used to develop Linear-Time-Variant (LTV) equations of motions of the cracked rotor systems along with considering different bearings condition scenarios including anisotropic and isotropic bearings for accelerated overhung rotor system. The same will also be established on an intact-rotor system in order to map dynamical variation on the behavior of Pr-BW and Po-BW phenomena. Thus, establishing a reference platform to distinguish between cracked and crack-free rotors. In addition, the full spectrum analysis (FSA) is also employed to verify the existence of these BW zones.

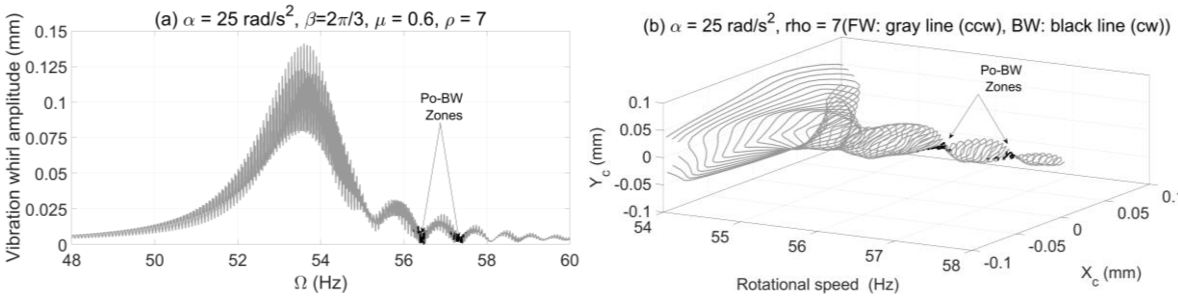

Figure 1: Whirl response and the Po-BW zones of cracked rotor system at with anisotropic bearings (a) and corresponding 3D at (b)

Results and discussion

By implementing parametric analysis, a preliminary result reveals that Pr-BW intensity and recurrence in overhung rotor is least impacted if compared to Po-BW at various crack depth and acceleration rates. Further, the same correlation was also noticed at different bearings conditions. In addition, it was also noticed that the intensity and recurrence of Po-BW zones is substantially influenced by the location of cracked cross-section with respect to side-nodded location of overhung rotor's disk. This can simply assist in locating the fault subject to further enhanced and extended review.

References

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