Effect of Rub-Impact on Backward Whirl Excitation in a Cracked Rotor System

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Abstract. The effect of appearance of multiple faults on backward whirl excitation in a rotor system is investigated here. The breathing crack is one of the common faults which is activated here by the non-synchronous whirl of the shaft in the vicinity of the resonance zone. Therefore, the effect of the breathing crack at the presence of rub-impact on backward whirling in the neighbourhood of resonance speed is investigated in this study for steady-state operation. The Jeffcott rotor model is employed here with both breathing crack and rub impact are incorporated. It is observed that the appearance of breathing crack at the presence of rub-impact has a substantial effect on backward whirl excitation in the resonance zone.

Introduction

The breathing crack model that depends on nonsynchronous whirl in the vicinity of resonance zone in [1] was found to excite the post-resonance backward whirl (Po-BW) in vertical cracked rotor system. This Po-BW phenomena was firstly observed at the transient numerical and experimental whirl response of rotor systems with open crack model in [2] and later in a rotor system with snubbing contact in [3]. Therefore, the current study investigates the effect of appearance of the breathing crack model in [1] at the presence of rub-impact on backward whirl excitation in the vicinity of resonance zone.

Results and discussion

The breathing crack model in [1] is employed here with Jeffcott rotor model of which the physical parameters are given in Table 1. Accordingly, the mathematical equations of motion of the rotor with both crack and rub-impact are numerically solved for the whirl response at steady-state running. Compared with the case of a crack free system with rub-impact in Figure 1a, it is observed in Figure 1b that the propagation of a breathing crack with small crack depth at the presence of rub-impact has strong impact on the whirl response and backward whirl excitation at resonance zone. Alternation between forward and backward whirling at resonance zone is also observed. However, individual appearance of either rub-impact or breathing crack has shown weaker impact on the resonance backward whirl excitation.

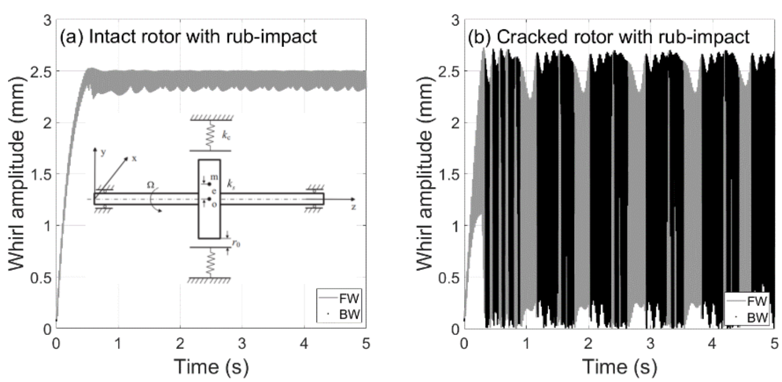

Figure 1 Intact rotor with rub-impact in (a) and with rub-impact and breathing crack in (b) at $\Omega = 55$ rad/s , stiffness ratio $k_c / k_s = 10$, clearance $r_0 = 2.5$ mm and normalized crack depth $\mu = 0.1$.

Table 1 System physical parameters

Description	Value
Length of the rotor, L	700 mm
Radius of the rotor, R	9.5 mm
Density of the shaft, ρ_s	7850 kg/m^3
Modulus of elasticity, E	2×10^{11} N/m^2
Mass unbalance, $m \cdot e$	1×10^{-4} kg$\cdot$m
Disk radius r_d	140 mm

References

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[2] AL-Shudeifat, M. A. (2019) New Backward Whirl Phenomena in Intact and Cracked Rotor Systems. *J. Sound Vib.* **443**: 124–138.

[3] Al-Shudeifat, M. A., Friswell, M., Shiryayev, O., and Nataraj, C. (2020) On Post-Resonance Backward Whirl in an Overhung Rotor with Snubbing Contact. *Nonlinear Dyn.* **101**: 741–754.