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Nonlinear effects caused by coupling misalignment in rotors equipped with journal bearings

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ABSTRACT

Misalignment is one of the most common sources of trouble of rotating machinery when rigid couplings connect the shafts. Ideal alignment of the shafts is difficult to be obtained and rotors may present angular and/or parallel misalignment (defined also as radial misalignment or offset). During a complete shaft revolution, a periodical change of the bearings load occurs in hyperstatic shaft-lines, if coupling misalignment between the shafts is excessive. If the rotating machine is equipped with fluid-film journal bearings, the change of the loads on the bearing causes also the variation of their instantaneous dynamic characteristics, i.e. damping and stiffness, and the complete system cannot be considered any longer as linear.

Despite misalignment is often observed in the practice, there are relatively few studies about this phenomenon in literature and their results are sometimes conflicting. The authors aim at modeling accurately this phenomenon, for the first time in this paper, and giving pertinent diagnostic information. The proposed method is suitable for every type of shaft-line supported by journal bearings. A finite element model is used for the hyperstatic shaft-line, while bearing characteristics are calculated by integrating Reynolds equation as a function of the instantaneous load acting on the bearings, caused also by the coupling misalignment. The results obtained by applying the proposed method are shown by means of the simulation, in the time domain, of the dynamical response of a hyperstatic shaft-line. Nonlinear effects are highlighted and the spectral components of the system response are analyzed, in order to give diagnostic information about the signature of this type of fault.

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1. Introduction

In her comprehensive book about Rotordynamics, Muszyńska [1] observed that rotor misalignment could be considered as the second most common malfunction after unbalance. She remarked also that this interesting topic was not object of much attention by researchers.

The authors of this paper share her position and want to contribute by presenting a paper aimed at explaining the reason of the presence of superharmonic components, i.e. of nonlinear behavior, in rotor vibration spectrum as a consequence of rigid coupling misalignment, owing to wrong assembly or imperfect flange machining, of an hyperstatic shaft-line equipped with journal bearings. The method is suitable to be applied to every type of shaft-line.

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Symbols0entraining velocity of the oil entraining velocity of the oil system (rotor + barings + foundation) (rotor + barings + foundation) (rotor + barings + foundation) (rotor + barings - foundation) (rotor rodes)0(rotor + barings + foundation) (rotor + barings + foundation) (rotor + barings + foundation) (rotor rodes)(rotor rodes) (rotor rodes)(rotor + barings + foundation) (rotor rode (rotor rodes)(rotor rodes) (rotor rode)(rotor + barings + foundation) (rotor rode(rotor rode) (rotor rode)(rotor + barings + foundation) (rotor rode(rotor rode) (rotor rode)(rotor + barings + foundation) (rotor rode)(rotor rode)<	Nomenclature		r_u	radius of the unbalance mass
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R vector of the static reactions on the bearings (r) rotor	р	oil pressure in the journal bearing	(f)	foundation
	R	vector of the static reactions on the bearings	(<i>r</i>)	rotor

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