

Improvement of Rotor Performance under Rubbing Conditions through Active Auxiliary Bearings

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Abstract

Rotor-to-stator rubs may occur under the changing operation environments, i.e., loss of blade or subjected to an extreme outside excitation, and is a serious malfunction in the operation of a rotating machine, which can seriously degrade the performance and can even lead to a complete failure of the machine. It is highly expected that a rotating machine can possess the capability to adapt to the changing environments and to optimize the performance. For instance, when rotor-to-stator rubs occur in a rotating machine, i.e., in case of the loss of a fan blade in a jet engine, the machine can automatically accommodate the deterioration and avoid the unstable, damaging operation modes so as to allow the operating personnel to have enough time to shut down the machine safely and prevent the machine from a hazardous situation.

In this paper a new concept is proposed, in which active auxiliary bearings are used to enhance the capability of adaptation of a rotating machine under the rubbing conditions. To demonstrate the feasibility of this idea, a model of a Jeffcott rotor with an active auxiliary bearing is studied. Based on the analytic investigation of the dynamics and stability of the passive system, which includes both the dynamics of the stator (auxiliary bearing) and the deformation on the contact surface between rotor and stator, two control methods with a PD-controller and an optimal controller respectively are proposed. It is shown by simulations when adjusting the physical characteristics of the active auxiliary bearing, one can avoid the occurrence of heavy rubs, which produce very large contact forces, during the rotor-to-stator rubs. This can greatly reduce the severity and damage of rubbing on the machine and allows the machine to be brought safely to rest. Moreover, it is also possible, as shown, to eliminate the induced rotor-to-stator rub through the control of the active auxiliary bearing.