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Review

Application of active magnetic bearings in flexible rotordynamic systems – A state-of-the-art review

R. Siva Srinivas [a], R. Tiwari [a,*], Ch. Kannababu [b]

[a] Department of Mechanical Engineering, Indian Institute of Technology, Guwahati 781 039, India
[b] Aero Engine Research and Design Centre, Hindustan Aeronautics Limited, Bangalore 560 093, India

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ABSTRACT

In this paper a critical review of literature on applications of Active Magnetic Bearings (AMBs) systems in flexible rotordynamic systems have been presented. AMBs find various applications in rotating machinery; however, this paper mainly focuses on works in vibration suppression and associated with the condition monitoring using AMBs. It briefly introduces reader to the AMB working principle, provides details of various hardware components of a typical rotor-AMB test rig, and presents a background of traditional methods of vibration suppression in flexible rotors and the condition monitoring. It then moves on to summarize the basic features of AMB integrated flexible rotor test rigs available in literature with necessary instrumentation and its main objectives. A couple of lookup tables provide summary of important information of test rigs in papers within the scope of this article. Finally, future directions in AMB research within the paper's scope have been suggested.

Contents

* Corresponding author.
E-mail address: rtiwari@iitg.ernet.in (R. Tiwari).

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1. Introduction

This section presents an introduction to Active Magnetic Bearings (AMBs) and its basic principles that will pave a way for understanding of the subsequent literature review.

1.1. Working principle of AMBs

AMBs are typically used as bearings, and have the unique feature of *no contact* between the stationary housing called the stator and the rotating target called the rotor. A non-rotating rotor is first lifted into air by AMBs i.e., it acts as pure bearing, and then the drive rotates it up to desired operating speed. During run-up AMBs act as a controller, suppressing unwanted high level of vibration, especially during resonances and instabilities. During transients and rundown, the rotor lands on touch-down bearings [1]. AMBs can only produce attractive forces, therefore, a closed loop controller with additional hardware components are required to maintain stable operation. Primarily, AMBs offer advantages such as high attainable rotating speed, tunable bearing rotordynamic parameters, no wear, and no lubrication system, low losses, and wide operating temperature range, lower power consumption compared to fluid film and rolling element bearing and electronic control [2,3].

The schematic representation of the components of AMBs and its working principle is shown in Fig. 1. A magnetic bearing system consists of four basic components: magnetic actuator, controller, power amplifier, and shaft position (proximity) sensor. The non-contact proximity sensor sends measured signal to the controller when there is a change in rotor position. The controller sends correction signal to power amplifier, which then sends appropriate current correction to electromagnet coils. Electromagnets create magnetic flux to attract the rotor back to its equilibrium position. This process happens in real time thus levitating the rotor during its operation.

1.2. AMB actuators

AMBs exert forces on the rotor without direct physical contact by generating attractive forces using electromagnets. The simplest AMB stator consists of two electric coils facing each other. At least three coils are necessary for a complete radial magnetic bearing in order to generate forces in two perpendicular directions and the most common design uses four independent coils [4]. Expressions for static and dynamic load capacities of magnetic bearings have been given in [5].

Radial AMBs are grouped into two primary structural configurations based on magnetic polarities of the stator relative to the rotor. If the stator poles in a given rotor transverse plane have the same magnetic polarities, then it is termed as

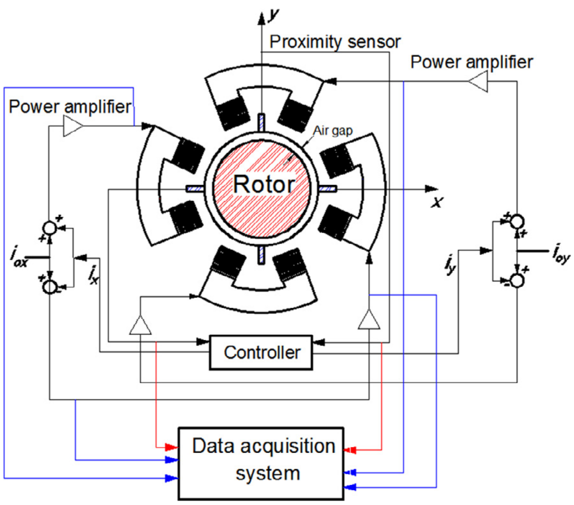

Fig. 1. Working principle of AMB–rotor system.