

A Review on Electromagnetic Bearing

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ABSTRACT: The use of bearings is essential to all types of machines, in that they provide the function of supporting another piece or component in a desired position. Two major types include radial and axial bearings. A further classification can be made into active, passive and hybrid bearing. More than thirty years of research and application have led to active magnetic bearings (AMB). Active magnetic bearing can support a shaft, rotor without any physical contact and enables the user to precisely control shaft or rotor position and vibration as a function of time and other parameters. This frictionless and programmable feature have made AMB suitable to meeting the demand for higher speed, higher efficiency and reliability of rotating machinery in many industrial application including flywheel energy storage, momentum wheels, turbo machineries, precision machineries. Other features of AMB, such as the absence of contamination by lubrication or mechanical wear, low energy consumption and low maintenance cost are prevailing now. Short introduction to the components and working principles of AMB, which requires the basic understanding of rotor dynamics, electromagnetism, power electronics and control theories. AMB is typical mechatronics product. Furthermore, the use AMB as key to smart machinery allows the integration of machine into control of a whole production process and to manage safety and maintenance issues.

I. INTRODUCTION

Active magnetic bearing levitates the rotating shaft by controlled electromagnetic force applied in radial as well as axial direction. It is somewhat similar to hydrodynamic bearing in which shaft gets lift up due to rotary motion and property of fluid. It is analogous to principle of maglev train where train mass is supported by opposing magnetic force thereby saving all energy loss in friction.

In conversional contact type bearing lubrication is required most often, which ultimately increases operating cost. Bearing fails due to fatigue failure. As in magnetic bearing there is no direct contact between rotor and casing or housing no need of lubrication also wear will not come into picture. This is safer side of magnetic bearing.

II. LITERATURE REVIEW

Shubham Naikwad et al. [1] has briefly reviewed AMB technology including its advantages, components, working principles, cost and performance. Some design and implementation issues have been also discussed.

R. K. Nakum, B. S. Patel, J.P. Hadiya et al. [2] has made an experimental comparison of permanent magnetic bearing and deep grooved ball bearing. They conclude that there is a need of experimental investigation to explore performance of PMB.

R. Tiwari, F. Dohnal, R. Markert et al. [3] has described an extended field balancing procedure for flexible rotor fully levitated by active magnetic bearing.

K. P. Lijesh, Harish Hirani et al. [4] carried out optimization of eight pole radial active magnetic bearing. They have worked out design and formulation of 8 pole radial active magnetic bearing. Experiments were conducted to establish the constrains related to temperature rise. The winding constraint equations in terms of wire diameter, number of turns, and dimensions of pole have been derived and constraints related to current by measuring magnetic flux density with increase temperature have been established.

F. Y. Saket, M. N. Sahinkaya, P.S. Keogh et al. [5] has presented their theory on measurement and calibration of rotor/touchdown bearing contact in active magnetic bearing. They have designed A rotor/AMB test rig with a flexible rotor. The system has two radial AMBs with strain measurement setup.

T. Ludvig, M. Kuczmann et al. [6] has presented a paper which deals with the analysis of an Active Magnetic Bearing system by the Finite Element Method and the magnetic vector potential formulation. This work proposes an optimal shape and dimensions of the legs of stator and air gap.

Weiyu Zhang, Huangqiu Zhu et al. [7] has presented a research paper which gives comprehensive overview of different bearing topologies of RMBs with different stator poles that differ in their construction, the driving mode of electromagnets, power consumption, cost, magnetic circuits, and symmetry. RMBs with different poles and couplings between the two bearing axes in the radial direction responsible for cross-coupling generation are compared.

Amin Noshadi, Ali Zolfagharian et al. [8] has studies the robust stabilization and harmonic disturbance rejection of a flexible shaft and an AMB system. Firstly, a H1 loop-shaping method is utilized to stabilize the flexible shaft while the system is stationary. Then, an inner-loop is introduced to the feedback loop to minimize vibration performance measures while the shaft is in rotation at various rotational speeds.

III. PRINCIPLE OPERATION OF ACTIVE MAGNETIC BEARING

Active magnetic bearing (AMB) works on the electromagnetic suspension principles. A charged body cannot rest in stable equilibrium when placed in a pure electrostatic field or magneto static field. In these kinds of fields an unstable equilibrium condition may exists, also static fields may provide to fail the stability, electromagnet suspension works by continually altering the current sent to electromagnets to change the strength of the magnetic field and allows a suitable levitation to occur. In EMS a feedback loop which continuously adjusts one or more electromagnets to correct the objects motion is used to cancel the instability. A set of power amplifiers which supply current to the electromagnets, a controller and gap sensors with associated electronics to provide the feedback required to control the position of the rotor within the gap. The power amplifier supplies equal bias current to two pairs of electromagnets on opposite sides of the rotor.[1]

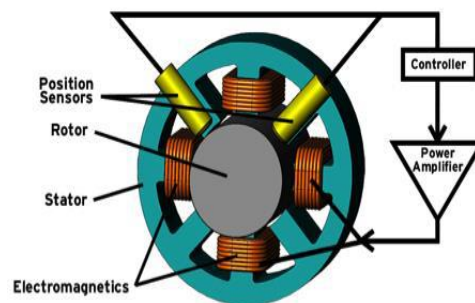


Figure 1: Elements of AMB[1]

IV. COMPARISON BETWEEN CONVENTIONAL AND MAGNETIC BEARING

BALL BEARING

A ball bearing is a rolling-element bearing that uses balls to reduce friction and maintain the partition between the bearing races. The purpose of a ball bearing is to support load and reduce rotational friction. It can be achieved by races having the balls and transmit the loads through the balls. One race is stationary outer race and the other rotating inner race. Ball bearing having lower load capacity compare to roller bearings.[2]

MAGNETIC BEARING

Modern technology in rotating machinery tends towards high-speed, high-accuracy and high-efficiency. Magnetic bearings are contactless suspension devices. There is no contact between stator and rotor therefore less resistance between the rotating part and its supporting parts.[2]

V. BALANCING OF SHAFT

The conventional influence coefficient method considers a set of balancing planes and another set of measuring planes as shown in Fig 2. In the balancing planes sets of trial masses are placed alternately and the corresponding unbalance responses are measured at the measuring planes. For rotors mounted on AMBs there are sets of balancing planes as for the conventional method, however, measuring planes are at AMB locations itself. Here, measurements are taken of the unbalance displacement responses and of the current supplied to AMBs.[3]

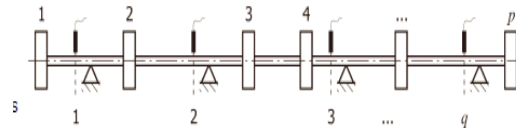


Figure 2: Rotor system with balancing plane[3]

Active magnetic bearings (AMBs), made of eight poles find their wider usage in flywheel energy storage systems, turbomolecular vacuum pump, artificial heart blood pump, etc., due to their built-in fault diagnostics, vibration free operation, and friction and wear characteristics. Each pair of pole makes an electromagnet consists of iron-core and copper-winding. On passing the current through the copperwire of electromagnet, it attracts the rotor. Using four pairs of electromagnets, the motion of rotor in horizontal and vertical (x and y) directions can be controlled. [4]

VI. ANALYSIS OF 4 AND 8 POLE BEARINGS

The design of the so called four pole bearing, which contains four electromagnets, has been started as a case study. However, the analyzed model does not proved to be the best solution. That is why, we have focused on the eight poles bearing, which seemed to be a good solution This setup contains eight electromagnets, and they work in pairs: there are four-four electromagnets in the dimension x and y . With this kind of setup the shaft could be positioned accurately. [6]

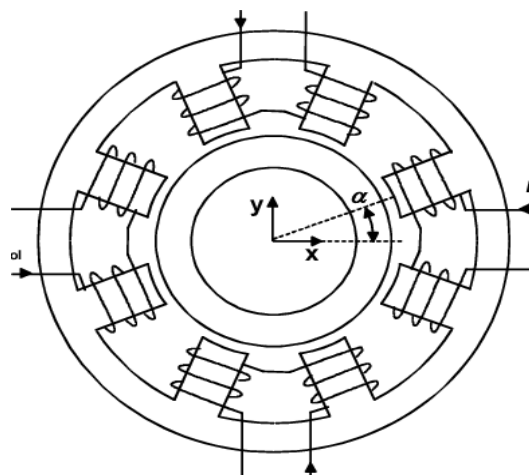


Figure 3: 8 Pole magnetic bearing [8]

Most RMBs currently installed are based on four electromagnets, of which the simplest magnetic bearing is the 4-pole RMB, the structure and its magnetic circuit are shown in Fig. 3. However, the most commonly used RMB in many industrial applications is the heteropolar 8-pole RMB, as shown in Fig. 3. The 8-pole RMBs includes the heteropolar and homopolar 8-pole RMBs. The two 8-pole structures will both form four independent magnetic loops with four independent coils, which results in nearly uncoupled magnetic forces in four directions.[6-8]

VII. CONCLUSION

Hereby we studied a concept of magnetic bearing. We also designed primary model of hybrid magnetic bearing. Advances in magnetic material, control have contributed to the realization of completely non-contacting relating systems employing magnetic bearings to eliminate the last remaining wear our prone elements. Current efforts are being directed more towards reducing the size, weight and complexity of these devices to achieve complete



acceptance. AMB systems are relatively more expensive than conventional mechanical bearing; therefore the massive used of AMB in industries is still prohibited despite of the many benefits offered.

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