A Review of Design and Optimization of Radial Active Magnetic Bearing for Vibration Control

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***Abstract*—The active magnetic bearing (AMB) systems consist of a shaft / rotor which floats in a magnetic field controlled by position feedback. Active radial magnetic bearings use electromagnetic principles to provide radial support for loads. Compared to traditional bearings, it has received a lot of attention due to its special characteristics and various advantages. Vibration caused by rotor imbalance is one of the most common problems faced by rotating machines. For rotating machines to function effectively, most rotor shaft systems need to reduce vibration. In this study, we will look at various adjustments made by researchers to control the vibrations of the system. Compared to traditional oil bearings, which are passive and absorb energy, the magnetic bearing assistance system is active and can excite any mode within the bandwidth of the controller. One of the optimized methods is the switching fluctuation of the excitation current of the AMB tooth. It is implemented to generate torque in the opposite direction, which is synchronized with the rotor imbalance. Also, various parameters have been changed to change the design of AMB.**

Keywords*— Active, Passive, Radial Magnetic Bearing, Electromagnetism, Vibration, Excitation.

I. INTRODUCTION

To Active magnetic bearings (AMBs) are mechatronic devices that use magnetic force to levitate the rotor without contacting components. Magnetic bearings are used to support the load of magnetic levitation. Active magnetic bearing systems apply controlled radial and axial electromagnetic forces to the rotor to levitate and hold the rotating shaft in place. Active magnetic bearings are actually the most frequently used principle of magnetic suspension.

The A typical AMB is made up of the following elements:

1) Stator
2) Rotor
3) Sensors
4) Electromagnets

The main advantage of the bearing is that it runs without any surface contact with the stator, hence the operation is friction less. Other advantages of magnetic bearings are that they are oil free and hence require less maintenance and they can be used in harsh environments. Magnetic bearings can run at higher speeds without any occurrences of mechanical wear. Because the active magnetic bearings provide higher bearing surface speeds, the rotor can obtain greater dynamic stiffness and stability.

II. WORKING PRINCIPLE

Active magnetic bearings (AMB) work on the principle of electromagnetic suspension. Electromagnetic suspension is the magnetic levitation of an object achieved by continuously varying the strength of the magnetic field generated by the electromagnet using a feedback loop, i.e. a control unit. The electromagnet suspension system works by continuously varying the current sent to the electromagnet to change the strength of the magnetic field and allow suitable flight to occur. In EMS, a feedback loop that continuously adjusts one or more electromagnets to correct the movement of objects is used to eliminate instability. A power amplifier supplies current to the electromagnet, controller, and gap/position sensor with associated electronics to provide the feedback necessary to control the rotor position. in the gap. The controller uses microprocessor to keep the whole system running stably.

The persistence of the report is to explore an efficacy of the front metallic bumper in frontal collision and to improve the structural design of the Bumper so that it should minimize people's injury which are inside vehicle.

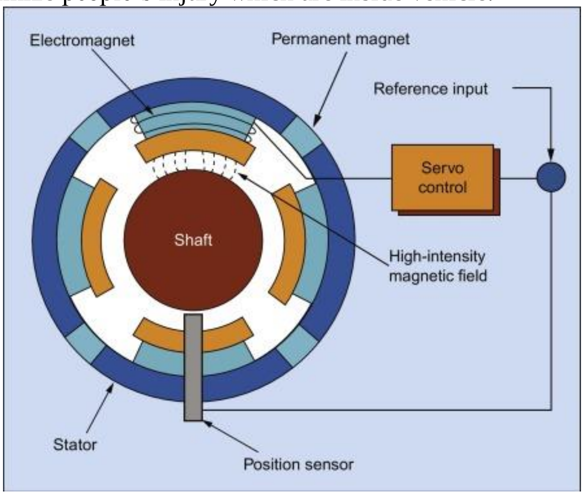

Fig. 1. Components of Active Magnetic Bearing

In Fig. 1 shows relative positioning of the metallic as well as plastic bumper which is surrounded by the peripheral parts in a typical sedan car. As I explained that there are two bumpers Plastic and Metallic bumper. Plastic bumper is placed at exterior side of the vehicle whose function is to act as casing for metallic bumper as well as not to show inside components, also who faces maximum of contact with the surrounding, whereas Metallic bumper which is mounted inside of the car whose primary function is to absorb maximum of frontal impact in the crash scenario and to protect from severity of the injuries to the humans as well as damage to the components [3].

III. CASE STUDY

An important way to improve the performance of magnetic bearings is to use permanent magnets (PM). Two of the first published papers on radial magnetic bearings with PM bias used a two-planar structure. In general, permanent magnet materials have very high permeability and act as an air gap, so it is best not to route the primary EM flux path through the permanent magnet. Traditional PM preload bearings are typically designed to significantly separate the PM and EM flux paths, except that they provide a uniform PM flux to the poles and air gaps. The unipolar radial AMB uses the PM bias on the back iron where the PM connects two sets of EM poles. This has the advantage of not directing the EM flux to the PM material (Lee et al., 1994, Fukata and Yutani 1998, Murphy et al., 2004). Another form of this design is to place the PM component on a rotating shaft.

The list of production costs for AMBs includes the following:

1) Active Magnetic Bearing actuators
2) Auxiliary bearings systems
3) Analog to Digital and Digital to Analog components
4) Digital signal processor
5) Wirings and Sensors
6) Software for digital control and
7) Power amplifiers.

Of these components, the most costly item is usually a high quality pulse-width modulated class-D power amplifier in which 10 amplifiers are generally required for a 5-axis active magnetic bearing suspension. The price of an amplifier is directly related to the output power needed by this amplifier. Therefore, the objective of studying the cost is to make a reduction in the cost of the amplifier. Other expensive items are active magnetic bearing sensors and actuators. Generally, the cost of an AMB actuator is directly related to bearing size. That means, smaller the bearing, lower will be the cost. This is right until the desired bearings are extremely small. Sensors used are typically inductive position sensors and used to provide feedback control signals to the controller. Typically there are two sensors on each control axis, with two sensors used on opposite sides of the AMB in differential mode. Therefore, 10 sensors are commonly used in 5-axis AMB control system. In the case of sensors, sensor accuracy and reliability are the most important factors in cost. The final items in the cost calculation are the digital control software, cabling and digital signal processor.
The reference signal is set to zero in the AMB system to align the rotor within the axes of the rotor. Hence this particular input feed can be discounted in the controller function. The director used here is a digital electronic device. Therefore the position signal coming out from the differential sensor in the voltage form is required to be changed into digital form before sending it to the system controller. An analog to digital converter is used for taken as 2a=45.

Active materials like piezoelectric material, magneto-strictive material, electromagnetic actuator and micro fiber carbon are also used for the vibration control of rotating parts. Piezoelectric material property to improve charge when mechanically stressed is utilized to bring control of vibration in moving parts. It is used as actuator as well as sensor in the system. Magnetostictive materials are like ferromagnetic material. Materials like cobalt, nickel and iron aremagnetostictive materials and therefore change in the shape and size occurs when they are magnetized

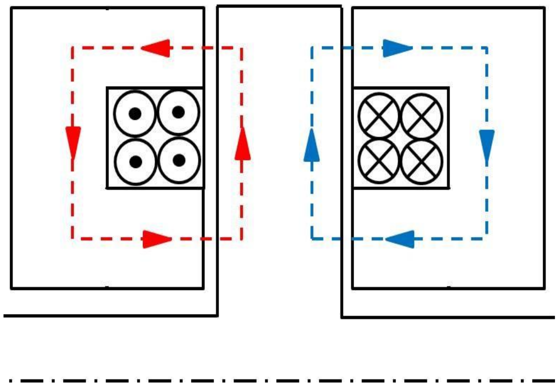

Fig. 2. Typical all electromagnetic thrust bearing design concept with magnetic fluxpaths

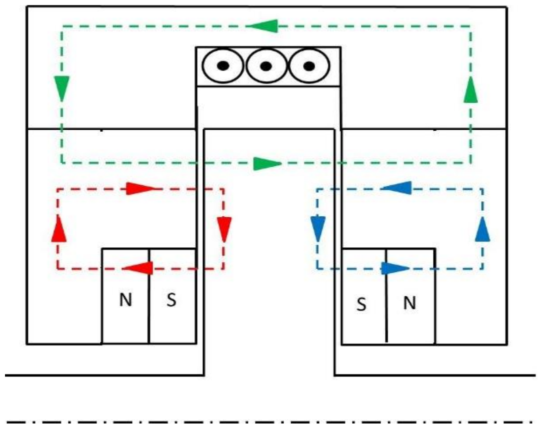

Fig. 3. New PM bias thrust bearing design concept with magnetic flux paths

There are many possible satisfactory solutions when optimizing the radial AMB design. Some algorithms are suitable to find optimum parameters in the whole design space by generating a set of points at each iteration, like Genetic Algorithms (GA). On the other hand, some methodologies are more convenient to find solutions in the local design space, like Sequential Quadratic Programming (SQP), Interior-point, Trust-region and Pattern Search (PS) strategies.

The drawbacks of AMBs include high cost, large size, low load capacity, requiring backup bearings, and requiring expert knowledge to operate them (e.g. for controller tuning). AMBs have been receiving increased attention in industry because of the advantages mentioned above that they display in comparison with conventional bearings. They are used extensively in rotor system applications, especially in conditions where conventional bearing systems fail. Various applications that utilize AMBs have been found in turbocompressors, machine tool spindles, energy storage flywheel systems, blood pumps, etc

By using optimization approaches for controller design, additional complex criteria in the time and frequency domains can be considered. The designer is able to use this advantage to integrate system-, sensor-, actuator-, and requirement-specific criteria. The key to dealing with such a complex design, with a large number of design parameters as well as criteria to be fulfilled, is the utilization of a heuristic multi-objective optimization algorithm, such as the Multi-Objective Genetic Algorithm (MOGA). An advantage is that the MOGA allows one to solve a multi-objective optimization problem with little knowledge or information about the objective system to be optimized. The MOGA has been applied successfully to diverse engineering optimization problems as well as controller design tasks and the optimization of AMB systems.

The number of controller parameters to be designed and optimized also appears as a challenge. More design parameters allow more Degrees of Freedom (DOFs) for system design and optimization, but also increase the optimization complexity. Not all design parameters have a strong influence on the optimization results. Such parameters may therefore be neglected in the optimization process.

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IV. Conclusion

New methods have been developed to design and build inexpensive magnetic bearings with PM preload for both thrust and radial bearings. PM components are placed on the polar iron-based material so that the PM bias flux is guided and coupled with the EM flux at one or the other air gap, increasing the load capacity of both the thrust and radial bearings improve. This approach leads to significant cost savings for AMB systems.

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