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Suspension Force Analysis on 4-pole Radial Hybrid Magnetic Bearing with Independent Magnetic Circuits

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Recently, radial hybrid magnetic bearings (RHMBs), which can suspend the rotor stably by electromagnetic forces in radial two degrees of freedom (2-DOF), have received more and more attentions. Besides, RHMBs have the advantages, such as no wear, no lubrication, long life and free maintenance. Therefore, RHMBs have broad application prospects in industrial rotating machineries, especially in high-speed and ultra-high-speed motorized spindle, flywheel energy storage, vacuum molecular pump, high speed centrifuge and artificial heart pump.

According to the stator structure, RHMBs can be divided into four types, namely 3-pole, 4-pole, 6-pole and 8-pole. Permanent magnets are used to generate the bias flux instead of the excitation windings to reduce loss, volume and weight, and increase the suspension force density. However, due to the flux coupling in the X and Y directions, the error of the suspension force models derived from equivalent magnetic circuit method is large. Consequently, it is difficult to design the control system and achieve high-precision control.

To solve above problems, a novel 4-pole RHMB is proposed, in which X and Y stator cores with curved poles are adopted. One axially magnetized permanent magnet ring is located between the X and Y stator cores to generate the bias flux and separate the control magnetic circuits in the X and Y directions. The structure and suspension mechanism are first analyzed. Then, the mathematical models of the radial suspension force are deduced by EMCM. The electromagnetic performances analysis is carried out to verify the magnetic circuits, suspension mechanism and uncoupled characteristic of the proposed RHMB by finite element analysis software MagNet 3D. The research results have shown that the proposed RHMB has the rational structure and good electromagnetic performances.

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