Contribution ID: **979** Contribution code: **THU-PO3-511-10** Type: **Poster**

Research on universal mathematical model and design method of homopolar hybrid magnetic bearing

Thursday, 18 November 2021 10:00 (20 minutes)

The homopolar hybrid magnetic bearing (HHMB) has the characteristics of the same air gap magnetic field direction, simple manufacture and assembly, low hysteresis and eddy current loss because the axial magnetized permanent magnet is often used to provide bias flux. Therefore, the HHMB has often adopted to suspend the rotor of the high-speed motorized spindle to obtain good performances of long life, free maintenance, higher speed and power. Recently, the scholars throughout the world have researched several kinds of HHMBs, such as three-pole AC HHMB, six-pole AC HHMB, nine-pole AC HHMB, four-pole DC HHMB and eight-pole DC HHMB.

The research methods and ideas are similar. However, there is no unified mathematical model and general design method for these HHMBs. Therefore, this paper studies a unified mathematical model and a general design method for HHMBs. Firstly, the general structure and magnetic circuit of the HHMB are analyzed. Meanwhile, the levitation mechanism of the bearing is analyzed. Then, based on the magnetic suction decomposition by the equivalent magnetic circuit method, the mathematical model of the suspension force is obtained. The unified mathematical model of the levitation force is deduced. Take HHMBs with five different types of poles as examples, the finite element analysis software MagNet is employed to establish the levitation force of the HHMB prototypes. According to the given control current and number of poles, the maximum bearing capacity of different structures is obtained. Finally, the finite element analysis results are compared with the theoretical calculation results of mathematical model. The correctness of the unified mathematical model and design method is verified by the research results.

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Session Classification: THU-PO3-511 Maglev and Levitation III