Rare-earth Free Motor Design using Bi-state Magnetic Material Core

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The rare-earth permanent magnet motors can achieve high power density. However, the rare-earth materials are mostly out of control, and there is a problem in that the prices and the supply is unstable according to the international situation. In order to overcome this problem, researches on the rare-earth-free motors such as an induction motor, a wound field synchronous motor, and a motor using a non-rare-earth permanent magnet became main interest. Since ferrite permanent magnets, which are representative non-rare-earth permanent magnets, have a residual induction of 1/3 of the rare-earth permanent magnets, the induced electromotive force and the magnetic torque are reduced. One of the solutions is to arrange permanent magnets with several layers to increase reluctance torque by increasing the difference of d-q axis inductance. This kind of motor is called multi-layer IPMSM. However, multi-layer IPMSM requires ribs and bridges to support mechanical structure of the motor. When using conventional electric steel sheets, ribs and bridges can cause leakage flux and this leakage flux causes the motor to increase in size. On the other hand, the Bi-state magnetic material (BSMM) has low permeability and saturation magnetic flux density as compared with conventional electric steel sheet, but when the heat treatment is performed on a specific part, the part has non-magnetic properties. By using this BSMM in the rotor, it is possible to reduce leakage flux in ribs and bridges, and to reduce size.

In this presentation, we study the effectiveness of rare-earth-free motors using BSMM rotor comparing with rare-earth permanent magnet motors.