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Levitation characteristics analysis of a novel bearingless switched reluctance motor

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Switched reluctance motors (SRMs) have many excellent advantages of inherent simple structure, good fault tolerance, high rotating speed, high power and robustness. Magnetic bearing (MB) preserves the characteristics of no friction, no lubrication, free maintenance and long life. Bearingless switched reluctance motor (BSRM) integrates the functions of the SRM and MB. Therefore, the BSRM is especially suitable for special operating environments, such as high-speed and high-temperature applications. However, the suspension windings and the toque windings of the traditional BSRM are wound on the stator poles together to obtain suspension force and torque simultaneously. Consequently, there is a strong coupling between torque and radial suspension force, which makes the control system complex and difficult to achieve high-precision operation of BSRM.

To solve the coupling problem and obtain large suspension force and torque density, a novel BSRM with independent torque and suspension magnetic circuit and axial arranged torque cores is studied. The suspension wingdings and the toque windings are wound on the stator poles and toque poles, respectively. Consequently, the control flux and torque flux are independent of each other. The natural decoupling between torque and suspension force is realized. Moreover, a DC amplifier is adopted to drive the radial suspension of the proposed BSRM, which has simple control.

The basic structure and suspension principle of the propose BSRM are first introduced, and then, the mathematical models of radial suspension forces are derived. Based on the finite element analysis (FEA), electromagnetic properties of the BSRM are also analyzed and studied in detail, including flux field distributions, radial suspension forces and force-current relationships. The research results have shown that structure of BSRM is reasonable, and the magnetic circuit and mathematical model are correct.

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