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Mon-Af-Po1.21-09 [96]: Design and Optimization of A Novel Axial-Radial Flux Permanent Magnet Machine for Higher Power Density and Lower Cogging Torque

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A novel axial-radial flux permanent magnet machine (ARFPMM) is proposed to improve the performance of PM machine. The ARFPMM is capable to reach higher torque density and lower cogging torque than traditional axial and radial PM machine when designed properly. To reach higher performance, T-type SMC core, reluctance rotor, and PM rotor are applied. The T-type stator core is made of soft magnetic composite (SMC) which allows 3-D flux path and plays an important role in both axial and radial flux path simultaneously. As a part of radial flux path, reluctance rotor makes full use of the radial space and produces synchronous reluctance torque. The PM rotor exists as a part of axial flux path and produces PM synchronous torque. 3-D FEM simulation costs significant time for computation. An effective method of decoupling axial and radial flux path is adopted. A 2-D FEM model is built to investigate the influence of two reluctance rotors with different structure. Comparison study is carried out between the two reluctance rotors on average torque and torque ripple. The optimum current phase angle is confirmed for the optimum reluctance rotor. Bidirectional PM skewing technique is applied to reduce the cogging torque. The influence of PM skewing mode, magnet pole-arc ratio, skew angle, and position angle is analyzed and the regularity is confirmed. Based on the analysis above, a response surface methodology (RSM) model is established, and genetic algorithm (GA) is adopt to optimize the cogging torque. A 3-D FEM model is built to verify the validity of RSM and GA. The result shows that the cogging torque is reduced by 90% compared with the initial design. The optimization results show that the ARFPMM can increase output torque by making full use of the axial and radial space. In terms of cogging torque, an optimum combination of magnet pole-arc ratio, skew angle, and position angle can be found using RSM and GA, while the other performance remain nearly invariable.

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