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Improvement of Reluctance Torque in Fault-Tolerant Permanent-Magnet Machines with Fractional-slot Concentrated-Windings

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Fault-tolerant permanent-magnet (FTPM) machines provided high efficiency, good fault-tolerant capability and high reliability. The electromagnetic torque of FTPM machine contains both permanent magnet (PM) and reluctance torques. At high speed operation condition, high reluctance torque can not only help prevent machines out of control when using flux weakening control method but also contribute to widen the speed range. However, the existing FTPM machines suffer from the relatively low reluctance torque. In this paper, a new rotor structure for FTPM machines with fractional-slot concentrated-windings is designed to improve the reluctance torque. In the proposed FTPM machine, new rotor structure has been designed. One of the keys of the new rotor structure is the division between each pole. The flux barriers are added between divisions to decrease the unbalance armature reaction. Besides, the two-layer interior magnets are set in oriented direction and the special designed flux barrier between two layer magnets is introduced into the machine. Therefore, this proposed rotor structure can effectively decrease the permeance of D-axis without any effect on the permeance of Q-axis, thus improving the reluctance torque greatly. In order to verify the proposed FTPM machine, finite-element analysis is employed to analyze the electromagnetic performance. The D-Q axis flux distributions of the proposed and existing FTPM machines have been analyzed respectively. It shows that the proposed rotor topology can significantly decrease both the unbalance armature reaction and the permeance of D-axis. Compared with existing FTPM machine, the reluctance torque of the proposed one is enhanced by about 22.15% with little torque loss, only approximately 3.2%. Besides, the proposed FTPM machine presents wider speed range and provides higher efficiency in field-weakening range than the existing one.

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