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Mon-Mo-Po1.06-01 [63]: Electromagnetic Performance Analysis of an Axial Flux Partitioned Stator Hybrid-excited less-rare-earth PM synchronous Machine

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In recent years, axial flux hybrid-excited permanent magnet machines with high power density, high efficiency and compact structure have the potential application prospect in the electrical vehicles. Besides, due to the rare earth resource crisis, the less-rare-earth permanent magnet machines have been taken much attention. In this paper, an axial flux partitioned stator hybrid-excited less-rare-earth permanent magnet synchronous machine (APHLPSM) which combines the structure of hybrid excitation and hybrid permanent magnet is proposed. The stator of the machine is divided into two parts, which are the armature stator and the excitation stator and the rotor locates between the two stators. The armature stator includes the armature teeth and the excitation teeth, by adopting the DC field windings wound on the excitation teeth as the auxiliary excitation source, the flux-regulation capability of the machine can be achieved. The design of the stator partition alleviates the space conflict in stator-PM machines and eases the difficulty of the current control in conventional axial flux double-stator machines. The excitation stator contains three-layer PMs, where two types of PMs of ferrite and NdFeB are reasonably combined, which not only guarantees the required power but also reduces the cost.
In the first part of the paper, the power volume equation is deduced, and the initial design parameters are given. Based on the finite element method (FEM), the electromagnetic performances, including air-gap flux density, back-EMF, cogging torque, and torque, are investigated. Then, the influence of the key structure parameters of the NdFeB and ferrite PMs on the electromagnetic performances are discussed, and the flux-regulation of the AFPHSM machine is also studied in the different DC excitation conditions. Moreover, a multi-objective optimization method is applied to optimize the APHLPSM machine, where the electromagnetic performances and the flux-regulation capabilities are considered. Finally, the optimization design results will be compared with that of the initial design to validate the effectiveness of the multi-objective optimization method. It will also verify the validity of the novel AFPHSM machine.

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