Optimized 3D printed reluctance rotor

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REPORT

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Abstract

This research report focuses on the design, optimization, and experimental evaluation of an additively manufactured rotor for a synchronous reluctance machine. Conventional reluctance rotors, typically composed of axially stacked electrical steel sheets, restrict the achievable geometry of flux barriers and end-bridge structures, limiting potential improvements in torque performance and torque ripple reduction. In this work, a finite element model of a reference Siemens SynRM is developed in both COMSOL Multiphysics and Ansys to ensure modelling robustness. Several topology optimization strategies are implemented, targeting increased average torque and reduced torque ripple while maintaining mechanical feasibility. A Helmholtz-filtered SIMP-based material interpolation and MMA optimization scheme is applied to generate new rotor topologies, including variants with and without end bridges. The optimized 2D designs are post-processed, smoothed, and merged into a segmented 3D rotor suitable for additive manufacturing. The resulting topology enables partial elimination of end bridges and axial variation of structural segments. Comparative simulations demonstrate notable improvements in torque characteristics relative to the original rotor. The final rotor is fabricated via additive manufacturing and assembled into the reference machine for subsequent measurement and validation.

Keywords

Synchronous reluctance motor (SynRM), topology optimization, finite element analysis, additive manufacturing, 3D printed rotor, torque ripple reduction, flux barriers, rotor design.