Optimal Design of PMa-synRM for electric propulsion system considering wide operation range and demagnetization

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Background

- Synchronous reluctance motor (SynRM) has advantages on torque density, price of manufacturing, and cost robustness.
- However, SynRM has lack of linkage flux produced by field magnet, since it does not contain permanent magnet.
- Permanent magnet assisted synchronous motor (PMa-synRM) enables increasing operation region by supplementing reasonable amount of permanent magnet.
- PMa-synRM can guarantee higher torque density, wide operation region compared with SynRM with considerate design.

Objectives

- Conducting optimal design considering wide operation range, torque density and torque ripple.
- Demagnetization of the permanent magnet is considered as well by optimizing position of the permanent magnet.

Permanent Magnet Position Optimization

- Optimizing position of permanent magnet by considering combination of the magnet set with the number of the PM less than 8.
- PM combination of Top 10 ranks according to the equation of decision are shown below.
- The role of PM is providing reasonable field flux to widen operating region and preventing flux to penetrate through the air layers.
- Magnets located at the side [1, 3, 5, 7, 9] are more effective than those at the center [1, 2, 3, 4, 5, 6, 7, 8]
- Magnets located at the end of the layer [3, 4, 5, 6] are vulnerable to the demagnetization.

Design Validation

- Finally, optimally designed model produces about 15% more torque, 12% more torque density with 14.0% of torque ripple.
- Designed model is robust to the demagnetization at 180 degrees calcis with N38UH permanent magnet.
- Operating range is dramatically increased at high speed region as intended.
- Designed motor produces 19% of alignment torque, and 81% of reluctance torque at base speed.