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Hybrid Parallel Inner-Magnet Machine

A novel hybrid rotating electrical machine topology leverages both permanent magnets and a field winding to provide the low losses of magnet-based systems with the necessary output voltage regulation for efficient power generation.

A typical approach to power generation includes the use of a wound rotor synchronous machine (WRSM), containing a field winding on the rotor used to regulate the output voltage of the system. However, the ability to regulate the voltage comes at the cost of additional losses associated to the field winding current. On the other hand, a permanent magnet synchronous machine (PMSM) containing magnets on the rotor may be used, wherein the losses are typically lower than in a WRSM. However, output voltage regulation requires the use of a power converter with controllable switches, increasing system complexity and reducing the overall robustness. A hybrid machine, containing a field winding and magnets, provides the potential to leverage the advantages of both approaches, in that the magnets provide a low-loss flux source and the field winding provides the ability to regulate the voltage.

Researchers at Purdue University have developed a topology for a hybrid rotating electrical machine containing a field winding and permanent magnets on the rotor. The rotor pole of the machine is comprised of a permanent magnet interior to two steel components, all of which are surrounded by the rotor field winding. The magnet and the steel components extend from the rotor backiron to the air-gap. In recent years, the design of electrical machinery has changed significantly due to the development of multi-objective optimization techniques, allowing complex systems to be design based on competing objectives. A particular machine design is evaluated based on the machine mass and total loss. The performance of a machine topology is obtained from a family of designs on the Pareto-optimal front that provide the overall mass vs. loss tradeoff. It can be shown that the hybrid parallel inner-magnet (HPI) machine topology outperforms alternative hybrid topologies, as well as the traditional wound rotor synchronous machine (WRSM).

Advantages:

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Category
Energy & Power Systems/Power Generation

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-Hybrid design that utilizes field winding and magnets

-Low-loss flux source

-Voltage regulation capabilities

Potential Applications:

-Power generation

TRL: 5

Intellectual Property:

Provisional-Patent, 2014-03-25, United States | Utility Patent, 2015-03-25, United States | CON-Patent, 2017-09-01, United States | CON-Patent, 2018-06-18, United States | CON-Patent, 2019-04-15, United States

Keywords: Hybrid rotating electrical machine, wound rotor synchronous machine, permanent magnet synchronous machine, field winding, voltage regulation, low-loss flux source, power generation, HPI machine, electrical machinery, multi-objective optimization