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Editorial

Multi-Factor Coupling Analysis and Optimization Method for High-Quality Electrical Machine Systems

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1. Introduction

As the global energy crisis and environmental pollution become increasingly prominent, the development of new energy resources has become a global consensus. High-quality electrical machine systems used as energy conversion equipment to generate and utilize electric energy have become indispensable and attracted increasing attention in advanced industrial production and transportation electrification. To fulfill the rigorous and personalized requirements of electrical machine systems in different application scenarios, performances and behaviors such as torque density, power density, efficiency, temperature rise, torque fluctuation, dynamic response and other qualities of an electrical machine system need to be accurately calculated and predicted. Meanwhile, the performance and behaviors of electrical machine systems are expected to be upgraded.

Electrical machine systems are complex mutual coupling systems influenced by various factors, such as loss versus temperature, electrical circuits versus magnetic fields, torque versus noise and vibration, and the machine itself versus drive and control system, which have a significant influence on machine system performance. Investigations on these multi-factor coupling analysis are essential to the design and optimization of high-quality electrical machine systems. With this in mind, this Special Issue aims to promote research and development in the area of multi-factor coupling analysis and optimization method for high-quality electrical machine systems.

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2. A Short Review of the Contributions in This Special Issue

This Special Issue received an enthusiastic response and was closed on 30 September 2022, containing three published articles and one review. The following is a brief summary of the contributions in this Special Issue.

In modern bulk material conveying industries, belt conveyors are widely used in the mining, mineral processing and power generation industries because of their strong adaptability, long distance, simple maintenance and easy centralized management. In [1], to address the problems of excessive tension, speed and fluctuation in long-distance traditional single high-power motor centralized drive belt conveyors, a distributed permanent magnet direct-drive belt conveyor system is designed. A mechanical–electrical coupling dynamic model is built to study the control strategy and dynamic behavior. Based on the establishment of the machine and mechanical–electrical coupling dynamic model, the distributed permanent magnet direct-drive belt conveyor can suppress the disturbance caused by local load changes and has better dynamic regulation performance, which was verified by experiments.

Vibration and noise performance of permanent magnet motors directly affects their operational performance indicators, with consequences for, e.g., the stealth and reliability of submarines. In [2], a magnet slotting design method to suppress the vibration caused by the modulation effect of high-order electromagnetic forces in permanent magnet motors is proposed. It was found that varying the auxiliary slotting parameters led to variations of each order of flux density harmonics. By optimizing the slotting parameters, the 70th-order electromagnetic force wave at $10f_e$ was greatly reduced. Both experimental and finite-element results verified the correctness of the noise reduction method.

Asymmetric interior permanent magnet synchronous motors have excellent performance but complicated topological structure, which leads to increasing difficulty in optimization of the rotor topology. In [3], a novel high-resolution encoding and edge smoothing method is proposed for topology optimization of the asymmetric rotor of an interior permanent magnet synchronous motor. The complex rotor structure can be expressed by a high-resolution image-like matrix and then vectorized by the edge-smoothing method. It was found that, by using the topology optimization method, the motor with optimized rotor topology offered better torque performances.

Integrated motor drives have great potential in electric vehicles, electric propulsion aircraft and ship propulsion systems to achieve compact size, high power density, high efficiency and high-cost effectiveness. The authors of [4] investigate and review development and critical technologies of integrated motor drives in terms of structure design, converter, cooling and electro-magnetic interference and opportunities and challenges. In addition, this paper also puts forward the concept of integrated motor drive integration level and establishes a corresponding quantitative method to evaluate integration level. This overview provides a good reference to help clarify and understand the opportunities, challenges and future development of integrated motor drives.

3. Conclusions and Future Works

This Special Issue includes four papers focusing on multi-factor coupling analysis and optimization methods for high-quality electrical machine systems to further improve performances so as to maintain customized demands in the field of new energy resources. These papers present the design of a machine system for practical conveyors, the electromagnetic force and vibration of a permanent magnet motor, a topology optimization method for the asymmetric rotor pole of an interior permanent magnet motor and a comprehensive overview of the integrated motor drives. The Guest Editor would like to thank all colleagues, anonymous reviewers and staff for their effort and time. In future, more investigation on the issues related to harmonic magnetic fields, loss analysis and thermal behavior, as well as the coupling analysis between them, to realize the synergetic effects [5–9] of electrical machine systems is expected to further improve performance.

Conflicts of Interest: The authors declare no conflict of interest.

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