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Editorial

Magnetic Material Modelling of Electrical Machines

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1. Introduction

As Guest Editors of this Special Issue, it was our responsibility to ensure that the contributions to the issue related to the extensive field of electromechanical energy conversion, with a special focus on the design, materials, and modeling of electrical machines. This way, electromechanical energy conversion was addressed in the context of electrical motors, generators, and actuators. One fundamental aspect related to this conversion process is that its efficiency and effectiveness depend on device design and the materials used. In this context, several aspects should be considered. One is the design process of the referred devices, which is usually carried out through extensive numerical field computations. Nevertheless, to ensure the accuracy of these computations, the quality of the material models that are adopted must be taken into consideration. Another aspect that requires attention is the modeling of properties such as hysteresis, alternating and rotating losses, and demagnetization. The characterization of the materials and their dependency on mechanical qualities such as stresses and temperature must also be considered. Finally, the design of the drives associated with electrical machines, when required, is another aspect that needs to be considered for the development of the optimal global system. The Special Issue addresses these aspects, contributing to a greater optimization of these kinds of systems.

A brief description of the published papers in this Special Issue is presented in the next section as a concise overview of their content.

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2. A Short Review of the Contributions in This Issue

A comparison of seven different methods for determining effective magnetization curves is presented by Tomasz Garbiec and Mariusz Jagiela [1] concerning the use of a field-circuit multi-harmonic model of an induction machine. The accuracy of each method was evaluated by calculating the performance characteristics of a solid-rotor induction machine. The analyses showed that the best practical approach, even for the multi-harmonic case, is to express the effective magnetic permeability as the ratio of the amplitudes of the fundamental harmonics of the magnetic flux density and the magnetic field strength, assuming a sinusoidal variation in the latter.

A new surrogate optimization routine for the design of a direct online (DOL) squirrel cage induction motor is proposed by Aswin Balasubramanian et al. [2]. The motor geometry is optimized to maximize its electromagnetic efficiency while respecting its constraints, such as the output power and the power factor. This novel, efficient, and reliable surrogate optimization routine can be applied to multiple design problems. The proposed clustering technique used in the routine allows for surrogate model accuracy while exploring promising subsets of the design variables range.

Jordi Garcia-Amorós et al. proposed [3] a novel two-phase linear hybrid reluctance actuator with a double-sided segmented stator using laminated U cores and an internal mover with permanent magnets. The permanent magnets are arranged to increase the thrust force of a double-sided linear switched reluctance actuator of the same size, this being the main objective together with achieving a low detente force. A comparative study between the proposed linear hybrid reluctance actuator and a linear permanent magnet actuator of the same size is also presented.

A novel 6/17 E-shaped stator tooth flux switching permanent magnet machine with an added magnet in the upper apex of each dummy slot was proposed by J. Cao et al. [4]. This proposal was derived from the conventional 6/17 E-shaped stator tooth FSPM machine. This structure exhibits several advantages, such as lower torque ripple and lower THD of phase back-EMF.

The importance of electrical machines and their selection in the context of renewable energy applications associated with important infrastructures, such as the case of a water pump, was addressed by Pires et al. [5]. Thus, an 8/6 SRM machine associated with a multilevel converter with fault-tolerant capability was proposed. This converter was designed with the purpose of reducing the cost of these systems and, at the same time, improving their reliability.

Another aspect of the machine addressed in this Special Issue was the problem of torque pulsations. In this ambit, A. Anuchin et al. proposed [6] a continuous control set model predictive control to control the power converter using pulse-width modulation. The solution requires small computation efforts and operates utilizing the assumption that optimal current reference profiles for each torque reference and angular position can be evaluated offline from the magnetization surface of the electrical machine. Thus, knowing the current reference and magnetization surface, the voltage commands for the PWM-driven inverter can be evaluated using simple lookup tables.

One aspect also addressed in this issue was the materials used in the electrical machines. Thus, H. Tiismus et al. presented [7] an additively manufactured soft magnetic transformer core. This was the first time that an electromagnetic device with a fully 3D-printed magnetic core was evaluated in terms of efficiency and performance.

An algorithm to remove the DC drift from the *B-H* curve of an additively manufactured soft ferromagnetic material, based on the sliding mean value subtraction from each cycle of calculated magnetic flux density (*B*) signal, is presented by Bilal Asad et al. in [8]. This is crucial for the accurate estimation of iron losses, and the measurements taken at different flux density values show the effectiveness of the proposed method, whose benefits are presented in the paper.

M. Sato et al. [9] propose a motor in which a composite ring made from a resin material mixed with magnetic powder is mounted on the stator to suppress spatial harmonics. This is a significant method to improve the efficiency of the motor at high speed.

3. Future Developments

Considerable research and investment have been focused on this area. However, despite all of the completed work, there are still many challenges to be faced. One important challenge that needs significant research, development, and investment is related to the integration of electrical machines into existing systems and the new ones that are constantly emerging. The appearance of new materials allows contributions to a greater optimization of this process, which is permanent, and it is expected that it will be continuously developed. This is a fundamental area for the development of more efficient machines. Another fundamental aspect has been the modeling of electrical machines. Nevertheless, there is still much work that needs to be undertaken in this context. Finally, the optimal design of electrical machines in the context of a special application is another aspect that requires further research and study.

4. Conclusions

The articles presented in this Special Issue cover important aspects of electrical machine design and optimization. There are many topics related to electrical machines, but this

Special Issue intends to provide a contribution to the magnetic material modeling of electrical machines to stimulate the community and develop current research, furthering its progress. Therefore, from our perspective, the presented papers will have practical importance for the forthcoming developments in the field of electrical machines.

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