DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Recyclable Electrical Machine Designs with 3D Flux and Non-Traditional Materials

Location: Pontoppidanstræde 101, room 1.001

Time: Thursday 14 November at 13.00

PhD defendant: Adolfo Garcia Gonzalez

Supervisor: Associate Professor Peter Omand Rasmussen

Moderator: Associate Professor Kaiyuan Lu

Opponents: Associate Professor Lasse Schmidt, Dept. of Energy Technology, Aalborg University (Chairman)
President and CEO Bogi Bech Jensen, Glasir – Torshavn College, the Faroe Islands
Professor Yujing Liu, Head of Electrical Machines and Power Electronics, Chalmers University of Technology, Sweden

All are welcome. The defence will be in English.

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Abstract:

Permanent Magnet (PM) machines are important in the electrification of transportation for the reduction of CO2 emissions and reducing global warming. In order to maintain the increasing demand for Hybrid and Electrical Vehicles ((H)EVs) a stable supply of Rare Earth Elements (REEs) used in the production of PMs is required. Nowadays, some REEs (e.g. Neodymium and Dysprosium) are classified as critical raw materials by the European Commission, due to the high risk in their supply. Such a risk was demonstrated in 2011 when the REE crisis reached its peak with the dramatic increase of the prices of REEs, specially Dysprosium, when export quotas were introduced from the main producing country, China.

With the current economic and political scenarios at global level, the probability of having a similar crisis as in 2011 remains high. Hence, securing the supply of REEs is still of major relevance and have increased awareness in recent years. Despite of being a subject of extensive research, recycling of PMs remains a challenging task. Some of the existing technologies either have poor efficiency or are highly polluting. Consequently, the European Training Network for the Design and Recycling of Rare-Earth Permanent Magnet Motors and Generators in Hybrid and Full Electric Vehicles (DEMETER) project was created. DEMETER project works toward the evaluation an improvement of the recycling routes of REEs in (H)EVs. Additionally, it intends to develop innovative techniques for the production of PMs, and both life-cycle assessment and life-cycle costing of PMs with recycled REEs.

Regardless of the recycling method, separation and classification of PM material are important steps in order to start a recycling process. Therefore, the improvement of the recycling methods would be insufficient unless the electrical machines are designed so that the access to the PMs is facilitated once the End of Life of the machine is reached and the motor is scrapped. Hence, this thesis work proposes an alternative machine topology. Such machine consists of a hybrid rotor structure in conjunction with a modular stator. The Finite Element Method (FEM) has been used to create a design that has subsequently been validated with measurements from a manufactured prototype. Although the performance of the prototype was substantially lower in comparison to a Synchronous Permanent Magnet Surface Mounted (SPMSM) machine, from the recyclability perspective it is considered that the proposed structure has a potential as glue is not required for the assembly of PMs on the rotor. In addition, the 3D nature of the flux in the magnetic system allows the use of non-traditional materials (e.g. iron based amorphous laminations, SMC, grain oriented electrical sheet, etc.). Finally, a recyclability index has been developed to provide a quantitative evaluation of the recyclability of PM electrical machines in the context of e-mobility.