ICT PHD

Research project for a PhD curriculum in ICT –Industrial Applications of ICT

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Proposed Title of the research: High reliable and sustainable Electrical machines for vehicle electrification

Keywords: (5) Electrical machines, power density, Sustainability, Torque density, Green transportation

Research objectives: --(max 10 rows)

In the last years, to meet the challenging requirements of modern green transport applications, the trend is to increase the fundamental operating frequencies of electrical machines, leading to smaller and lighter motors and generators. In addition to this, the components' manufacturing process need to be oriented to the concepts of recyclability, sustainability and reuse, to reduce the environmental impact of the automotive sector and favour the development of sustainable models. In this context, aluminium form-wound (hairpin) windings and multi three-phase e-machines are promising candidates.
The objectives proposed for this research project are therefore set as follows:

- Selection of best material candidates to replace copper for windings, considering electric and rare earth materials for magnets in electrical machines, considering thermal and mechanical properties.
- Development and implementation of fast and accurate multi-physics analytical and/or numerical models for the design, analysis, and optimization of multi three-phase e-machines.
- Control of multi three-phase electrical machines.

Proposed research activity -- (max 10 rows)

Form-wound (hairpin) windings and multi three-phase e-machines are promising candidates for electric motors, as they offer higher fill factors, reduced low-frequency losses, reduced end winding lengths, improved reliability, better cooling capabilities, etc. Nevertheless, at high-frequency operations they present high copper losses, and this aspect limits the application of hairpin windings below a certain speed / frequency range.
Aiming to reduce the production costs, decrease the environmental impact and improve recyclability, copper could be replaced by a cheaper material, potentially enabling a more sustainable design and production of electrical machines equipping hairpin windings. In light of this, aluminium alloys are surely good candidates: besides featuring a lower cost than the copper, it also has a lower specific weight which can help in achieving the ever-stringent compactness requirements of the more electric transport. On the other hand, aluminium has a higher electric resistivity than copper, which results in an increased low-frequency resistance. However, when the high frequency phenomena are in place, the potential of using materials different from copper has not been sufficiently exploited in hairpin technologies, especially if innovative manufacturing processes are envisaged.

Supporting research projects (and Department)

The successful candidates will become part of the MeltingLab research team, working of electrical machines and converters of the University of Modena and Reggio Emilia. The candidate will be involved in the activities of the project TRANSFORM, an EU funded project which aims at the development of an industrial chain in Europe for the application of wide-bandgap devices in power electronics and control of electrical machines.

Possible connections with research groups, companies, universities.

The project will see the involvement of the University of Nottingham UK (UoN), which will participate in the study and electromagnetic analysis of the proposed electrical machine. Dual Degree with UoN is possible as well.