

ICT PHD

Research project for a PhD curriculum in ICT – Electronics and Telecommunication

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Proposed Title of the research:

Design of High efficiency and sustainability oriented electrical machines

Keywords – (5)

Electrical machines, Green transportation, power density, Sustainability, Torque density

Research objectives: – (max 10 rows)

In the last years, the need for high power density and efficiency has become a central concern for electrical machines in the green transportation sector. In addition to this, the components' manufacturing process need to be oriented to the concepts of recyclability and reuse to reduce the environmental impact of the automotive sector. This project aims at investigating new materials and innovative manufacturing processes for electrical machines, proposing windings structures that can increase the efficiency and improve sustainability.

Proposed research activity – (max 10 rows)

Form-wound (hairpin) windings are promising candidates for electric motors, as they offer higher fill factors, reduced low-frequency losses, reduced end winding lengths, improved cooling capabilities, etc., than random-wound windings. 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. Moreover, production costs are still rather elevated especially when very high volumes are involved, since copper (i.e. the material typically used for hairpin windings) is relatively expensive. 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. Considering this, aluminium alloys are surely good candidates. In this respect, additive manufacturing represents an enabling technology, which can permit to realize non-conventional geometries for the hairpin winding, specifically designed to limit the effect of the electromagnetic field at high frequency and thus increase the efficiency.

The objectives proposed for this research project are therefore set as follows:

- Selection of best material candidates to replace copper for electrical machines windings, considering electric, thermal and mechanical properties.
- Development and implementation of fast and accurate multi-physics analytical and/or numerical models for the design, analysis and optimisation of machines equipping hairpin windings
- prototyping in additive manufacturing of the winding structures and experimental verification.

Supporting research projects (and Department)

This project will be carried out at the Department of Engineering “Enzo Ferrari” and will be supported by research funds provided by Silk EV.

Possible connections with research groups, companies, universities.

The project will see the involvement of the Silk EV, and the University of Nottingham UK (UNO), which will participate in the study and electromagnetic analysis of the proposed winding structure.