POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 37th cycle

Research Area n. 2 - Sustainable Mobility

THEMATIC Research Field: OPTIMAL DESIGN FOR ELECTRIC MOTORS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Electric machine designers today mostly rely on relatively simple models for initial sizing and topology selection. Typically, the motor parameters are selected by using electromagnetic analysis only. Multi-physics analysis is used just in the validation stage. Recent progress in the area of electric machines for automotive applications, including new materials, new manufacturing technologies, new power electronics and new conceptual topologies, require a systematic design approach to ensure adequate performance and/or reduced cost for new products. A multidisciplinary approach is needed. The design conflict between electromagnetic, thermal, mechanical, and even manufacturing requirements has to be managed. Multiple objectives for drive cycle efficiency, mass, inertia, cost have to be taken into account. The problem is very complex due to the presence of a large number of design and manufacturing constraints. Pareto-optimality allows to identify a family of best designs. It also provides a fair basis for the comparison of different machine topologies. Artificial intelligence (AI) illustrates the ability of machines to simulate human mental prowess. Artificial Neural Networks can be constructed and applied to perform efficiently complex optimisation tasks as the one addressed.
Methods and techniques that will be developed and used to carry out the	It will be shown that systematic optimisation methods and

research	artificial intelligence tools integrated with validated multi-physics model of the electric machine can manage the complexity associated with product (and process) design problems very efficiently.Systematic optimal AI model based approaches are ideally suited to manage the complexity related to the solution of product design problems. The various methods and tools need to be integrated, this play a major role in advancing the state of the art in product (and process) design. There are many design variables to be defined in an electric machine, from discrete to continuous, differentiable to non-differentiable. In general, three principal groups, including analytical, numerical, and Artificial Intelligence (AI) models, have been used to study the behaviour of the system. Electromagnetic, power electronics, thermal, mechanical, noise, vibration, fluid dynamics aspects have to be implemented in the multi-physics model. The study will put special focus on the NVH behaviour of the electric motor. Numerical approaches like finite element method and finite difference method will be applied to evaluate the behaviour of electric motors in various conditions. Some recent AI techniques, like deep learning approaches, will be employed in optimisation as global approximation tools. Experimental tests will be performed for models validation.
Educational objectives	The Ph.D. candidate will be trained on advanced methods for the design and testing of automotive electric motors. The candidate will learn how to deal with complex design problems, how to define specific KPIs and to properly evaluate them after testing. He/she will learn to manage research as well as to coordinate small research groups. Soft skills like dissemination, communication and outreach management will be taught during the PhD course.
Job opportunities	Car manufacturers, Tier 1 suppliers, structures/organizations aimed at innovation and/or research and technical development, high-tech SMEs. The last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared to Master of Science holders in the same field.

Composition of the research group	3 Full Professors 3 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Proff. di Gerlando, Gobbi, Manzoni, Mastinu

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	564.01 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Funding for educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences); funding per PhD student per year:

2nd year: per student 1.534 euros
3rd year: per student 1.534 euros

Teaching assistantship: availability of funding in recognition of support to teaching activities by the PhD student; there are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

Computer availability:
1st year: individual use
2nd year: individual use
3rd year: individual use

Desk availability:
1st year: individual use

2nd year: individual use
3rd year: individual use