French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of 15 engineering schools/universities. The document also provides information about the supervisor. Please contact the PhD supervisor by email for further information regarding your application.

Supervisor information	
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PhD information	
Title	Unified modeling formalism for optimal design of electrical energy convertion devices
Main topics regards to CSC list (3 topics at maximum)	V- Energy and environment V-4 New technology of high-performance energy economics

Required skills in science and engineering	Major in Electrical Engineering, background in applied mathematics and physics. Numerical modelling of applied multi-physic and multi-scale phenomena

Subject description (two pages maximum including biblio)

Resume :

Transportation and development of renewable energies lead to complex electromechanical conversion chains with multi-physical and multi-scale nature. The characteristics of the device to be modeled to strongly influence the form of their mathematical representation and their modeling. The objective of this thesis is therefore to address the problem of ODE / PDE coupled modeling and numerical simulation with multi-physical and multi-scale problems. Scope of application is energy conversion chains with different physical domain (electrical, magnetic, thermal, mechanical, aging, ...). This generic approach can permit to increase global efficiency and cost of complex electrical application (Fuel Cell Electrical vehicle, Multisources renewable systems, advance power electronics, induction heating and charging processes, NDT….)

PhD Title: Unified modeling formalism for optimal design of electrical energy convertion devices

Recent energy convertion technologies need complex and multi-physical conversion chains. Such multiphysics systems are generally driven by different dynamics and are related to different physical phenomena. Likewise, the nature of the devic to be modeled strongly influences the form of its mathematical representation. Thus, while the dynamic behavior of the power converter can be represented by a set of ordinary differential equations (ODE) or algebraic equations (DAE), its thermal model can require models based on partial differential equations (PDE). Same problem can occur for the modeling of coils, transformers or electrical drives, which can in addition lead to strong inter-domain couplings (for example electromagnetic-thermal-mechanical). These coupled ODE / PDE modeling problems are not new and a large number of studies exist and aim essentially at looking for coupling formulations able to facilitate the work of the numerical solver [1,2,3]. In [4], an important work of analysis and formulation of PDE problems is proposed, where components are described by simple EDOs (passive components for example) with more complex semiconductor components, modeled from EDP. In [1] and [2], coupled modeling is applied to the temporal simulation of organic cells and blood circulation. For each of these works, the methods implemented are strongly related to the nature of the addressed problems. In this sense, there does not seem to be any work specifically dealing with the ODE / PDE coupling methods applied to electromechanical energy conversion chains and their singularities. Moreover, if the coupling between a power converter and an electromagnetic system can find operational responses in the studies mentioned above, the fact remains that the problem of numerical simulation of these systems, with very great disparities in the time scales, still require an important work that one propose to address in this thesis project (Model order reduction, homogenization, …). This transversal project will rely on the complementary skills of the members of IREENA laboratory

Bibliography

[1] Quarteroni, A., & Veneziani, A. (2003). Analysis of a geometrical multiscale model based on the coupling of ODE and PDE for blood flow simulations. Multiscale Modeling & Simulation, 1(2), 173-195.

[2] Gerecht, D. (2015). Adaptive Finite Element Simulation of Coupled PDE/ODE Systems Modeling Intercellular Signaling (Doctoral dissertation).
[3] Tang, S., & Xie, C. (2011). Stabilization for a coupled PDE–ODE control system. Journal of the Franklin Institute, 348(8), 2142-2155.
[4] Tischendorf, C. (2003). Coupled systems of differential algebraic and partial differential equations in circuit and device simulation. Modeling and numerical analysis.
[5] Hmam, S., Olivier, J.C., Bourguet, S., Loron, L (2017). Efficient multirate simulation techniques for multi-physics systems with different time scales: application on an all-electric ferry design. IET Electrical Systems in Transportation 7 (1), 23-31.