1 General Informations

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2 Thesis title and keywords

3D multi-physical modeling and optimal design of PEMFC Stacks

Keywords: PEMFC, PEMFC 3D printing manufacturing, multi-physical modeling, optimal design of PEPMFC stacks, PEMFC control.

3 Thesis subject

In recent years, the private and public specialists have consistently considered the Proton Exchange Membrane Fuel cells (PEMFC) the best candidate for zero emission transportation. This is because the PEMFC ensures a green cycle of energy production when supplied with hydrogen produced from environmentally friendly energy sources (such as the sun and the wind). Indeed, it operates at a relatively low operating temperature (50-100 ° C) combined with a solid polymer membrane preventing any risk of leakage. Also, the power density offered by on-board PEMFC hybridized power sources exceed other technologies such as electrochemical batteries. In addition, with the advent of 3D printing manufacturing technologies for PEMFC stacks, there are promising prospects in terms of power density improvement thanks to the numerous possible geometric shapes of such devices thus produced. The PEMFC is a very complex device because of multi-physical phenomenon involved in its operation, namely electricity, chemistry, fluidics, thermodynamics and mechanics. This complexity is accentuated in the context of manufacturing stacks through 3D printing by pushing the logic of optimization to the extreme integrating a multi-objective criterion (power density, heat exchange, humidity management, fluid flow, ... etc.). Multi-physical modeling as well as generic, fast and precise numerical simulation are essential issues in the design and control of PEMFC stacks and one of the most important research activities of the FCLAB.

The present thesis will focus on 3D multi-physical modeling of PEMFC stacks in order to design them for automotive applications. The finite element method, the analytical method and that of the impedances networks will be combined to propose such model. The geometrical dimensions as well as the physical parameters (3D distributions of temperature, gas pressures, humidity) of the stack must be taken into account in the modeling process. After validation of the proposed model, an optimal sizing methodology for PEMFC stack will be developed and applied to build a reduced-scale prototype using 3D printing technology available at the host laboratory.

4 Expected Collaborations

This work will continue the existing collaboration between UTBM (https://www.utbm.fr/) and its academic and private partners in the goal to apply for French and European projects calls within the BPI, H2020 and FCH-JU programs.

5 Background

The proposed candidate will use using multi physical modeling process to build accurate 3D model of PEMFC for numerical simulation, design and control needs. Moreover, the candidate will have to get strong skill in electrical, mechanical and chemical engineering so that He –She- will be force of proposal in theory and in practice.

6 References

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