POSTDOC SUBJECT

Fast magnetic tomography system for fuel cells

As a research and technology organization, CEA-Liten is heavily involved in developing new technologies for the energy transition. The institute is particularly active in the development of hydrogen technology in general, and low-temperature fuel cells in particular.

The improvement of fuel cell lifespan is crucial to enable their widespread adoption. System-level observation allows for their characterization during the design phase and optimization during the operational phase. Currently, the most commonly used measurements, such as the impedance of a cell stack stage, allow for the estimation of specific internal states but do not provide information on the spatial distribution of this state within the observed cell. Recent studies [1-2] have shown the interest in using magnetic field measurements to detect and locate current density heterogeneities in a bipolar plate. Current solutions rely on moving fluxgate sensors [3]. These solutions are difficult to integrate and do not allow dynamic phenomena to be observed.

Leveraging recent magneto-resistive sensors technology, the candidate will design and develop an innovative acquisition architecture to enable the creation of a real-time tomography system. During the project, the Post-Doc activities will include:

- Deployment of the static sensors matrixes.
- Design and development of an embedded system architecture suitable for the simultaneous and synchronous acquisition of data from multiple sensors to ensure the temporal consistency of measurements.
- Contribution to the development of specific numerical resolution methods to enable real-time processing for the detection and localisation of current density heterogeneities.
- Dissemination of results through the publication of articles and lectures at international conferences.

The goal is to develop a TRL 4 demonstrator in the laboratory to demonstrate a proof of concept on a low-temperature fuel cell stack. This will include four measurement boards with several dozen of synchronized magnetic sensors for simultaneous acquisitions. Experimental results and a description of the instrumentation system will be published. Historical data will be used to validate current density resolution algorithms and compare their performance to solutions based on Physics Informed Neural Network [3]. Estimated current density results will be used for an additional publication.

The instrumentation system will be integrated into a CEA test bench dedicated to optimal control, transient observation, fault detection [4] and exploration of defect propagation phenomena. This approach will offer dynamic and non-invasive observation of current distribution in the fuel cell, thereby improving the understanding of its operation and facilitating the optimization of its performance and lifespan.

Interested? Apply online now. We look forward to getting to know you!

[1] Lyes Ifrek. Identification des défauts d'une pile à combustible par la mesure du champmagnétique externe : vers la détermination de défauts locaux. Energie électrique. Université GrenobleAlpes, 2017. Français.NNT:2017GREAT076 tel-01744201. https://theses.hal.science/tel-01744201

[2] Freisem, L.; Olivier Chadebec; Gilles Cauffet; Yann Bultel; Rosini, S. Fuel Cell Stack Magnetic Tomography with Adjoint Method. 2024, 1–2. https://doi.org/10.1109/cefc61729.2024.10585971.

[3] A. Bawab, S. Giurgea, D. Depernet, and D. Hissel, "An Innovative PEMFC Magnetic Field Emulator to Validate the Ability of a Magnetic Field Analyzer to Detect 3D Faults," Hydrogen, vol. 4, no. 1, pp. 22–41, Jan. 2023, doi: https://doi.org/10.3390/hydrogen4010003.

[4] C. Pettorossi, V. Heiries, M. Gerard and S. Rosini, "Addressing Data Scarcity in PEMFC Fault Diagnosis Using Adversarial Learning," 2024 IEEE International Conference on Prognostics and Health Management (ICPHM), Spokane, WA, USA, 2024, pp. 393-398, doi: https://doi.org/10.1109/ICPHM61352.2024.10627464.

[5] Sani, M.; Piffard, M.; Heiries, V. Fault Detection for PEM Fuel Cells via Analytical Redundancy: A Critical Review and Prospects. Energies 2023, 16, 5446. https://doi.org/10.3390/en16145446