THESES AVAILABLE starting from September 2020

MRT FUEL CELL & BATTERY

TO APPLY IS NECESSARY TO SEND BY JULY 22nd AN EMAIL TO PROF. A. CASALEGNO AND THE STAFF IN CHARGE OF THE ACTIVITY, INCLUDING CURRICULUM VITAE AND TRACK RECORD OF EXAMS, RANKING SOME PREFERENCES. THE ASSIGNEMENT OF THE THESIS WILL BE DONE AFTER AN INTERVIEW, THAT WILL BE SCHEDULED BY THE END OF JULY.

1 Lifetime estimation of primary lithium-ION battery in real-life application

Keywords: primary LIB; capacity; modelling; experimental
Staff in charge for the activity : Claudio Rabissi, Matteo Zago
Other staff involved : Andrea Casalegno, Gabriele Sordi
Supporting project : industrial project starting in 2020.
Experimental facilities available : 1 multi-channel battery cycler + 2 test chambers

Project description: $LiSOCl_2$ primary battery are largely adopted in long lifetime applications, which could require up to fifteen years before the complete discharge. For this reason, accurate estimation of battery remaining capacity is of fundamental importance to schedule operation and maintenance activities and it requires the understanding of the battery processes and the influence of operating conditions, such as environmental temperature and load profile. The activity aims at developing an innovative methodology: combining a simplified simulation of battery behavior with an ad-hoc developed experimental protocol, it will be possible to estimate battery remaining capacity and identify optimal operating conditions for its maximization.

Description of the activities:
i) Literature review on the topic;
ii) Development of simplified physical-based model, to be properly calibrated by means of appositely developed experimental measurements;
iii) Experimental aging tests on provided samples for methodology application and validation;
iv) Extension of the methodology at different environmental temperature and load profiles.

Start : September 2020.
Available positions : one student
Expected duration: 9 months
Expected Work Load : full time.

2 Vanadium Redox Flow Batteries (VRFB) for energy storage: design and development of innovative barriers

keywords : barrier; cross-contamination; self-discharge; VRFB.
Staff in charge for the activity : Matteo Zago.
Other staff involved : Marco Cecchetti.
Supporting projects/partners: University of Connecticut.
Experimental facilities available : 1 flow battery test bench with segmented cell and reference electrodes.

Project description: This thesis work will mainly consist in the design, optimization and testing of innovative barrier layers to improve membrane selectivity in Vanadium Redox Flow Batteries. The barrier layer reduces the self-discharge of the battery due to cross-contamination and permits a reduction of membrane thickness, thus system costs. Results from previous works showed a reduction of both self-discharge (7 times), permitting to obtain a coulombic efficiency higher than 99.8%. Moreover, the adoption of thinner membrane implies a 25% reduction of stack specific cost. This work aims to definitely break the bottleneck of mebrane ion/proton selectivity, with a consequent great potential on redox flow battery commercialization. The candidate will perform both experimental and modelling activities to design, characterize and improve the barrier layer. The activities will consists in:
(i) Set-up of segmented cell with reference electrodes;
(ii) 25 cm^2 single cell testing to evaluate the influence of barrier and membrane properties on VRFB self-discharge and performance;
(iii) Design and testing of barriers with locally optimized properties;
(iv) Simplified model development to support the interpretation of experimental data and barrier design.

Start : September 2020.
Available positions : one student
Expected duration : 9 months
Non disclosure agreement : required.
Expected Work Load : full time.

3 OpenFoam analysis of advanced flow fields for automotive application

keywords :
Staff in charge for the activity : Luca Marocco.
Other staff involved : Andrea Baricci; Riccardo Mereu; Andrea Casalegno
Supporting projects/partners: Energy for motion.

Project description: Hydrogen PEM fuel cells for automotive applications are limited at high power density by the geometry of the gas distributor. Large effort has been dedicated to the development of innovative geometries that allow for even oxygen distribution over the active surface. In this work, this problem is addressed by CFD analysis in OpenFoam code. The tasks required in this project are:
(i) Implementation of transport equation to simulate charge transport in OpenFoam
(ii) Validation of implemented model against a reference case and available experimental data
(iii) Simulation of innovative geometries

Start : September 2020.
Available positions : one student
Expected duration : 6 months
Non disclosure agreement : required.
Expected Work Load : full time.

4 Characterization of a planar membrane humidifier for automotive application

keyword : Humidifier, PEM Fuel Cell System, Air Humidification, FCEV
Staff in charge for the activity: Stefano De Antonellis
Other staff involved : Andrea Baricci, Amedeo Grimaldi
Supporting project : no specific funded project.
Experimental facilities available : AirLab and MRT experimental facilities .

Project description: The thesis will consist in the experimental analysis of water transport through PFSA membranes, aiming at the design and development of a humidifier module for fuel cell vehicle. The activities will consist in:

(i) Experimental characterization and analysis of innovative membrane materials;
(ii) Development and calibration of a multidimensional, transient model of a planar membrane humidifier;
(iii) Design, manufacturing and characterization of a small-size humidifier module;
(iv) Implementation of the humidifier model inside a system model of a fuel cell powered electric power train.

Start : September 2020.
Available positions : one student
Expected duration : 6-9 months
Non disclosure agreement : not required.
Expected Work Load : full time.

5 Electrode preparation and characterization for fuel cell application

Keywords: PEMFC; hydrogen; experimental; catalyst layer.
Staff in charge for the activity : Andrea Casalegno
Other staff involved : Claudio Oldani (Solvay), Daniele Facchi (Solvay)
Supporting project : no project; activity will be carried out mostly at Solvay (Bollate).

Project description: In collaboration with Solvay specialty polymers, we would like to propose a Master's degree thesis work for two candidates in the field of electrode preparation and characterization for fuel cell application.
The activity will encompass the development and characterization of suitable ink formulations for fuel cell electrodes, their preparation and electrochemical characterization at MEA level (polarization curve, EIS).
Particular attention will be focused on catalyst activity and on oxygen permeability through the catalyst layer ionomer. Materials studied will be different Aquivion commercial as well as advanced grades.

Start : September-October 2020.
Available positions : two students
Expected duration: 9 months
Expected Work Load : full time.

6 Membrane preparation and characterization for flow battery application

Keywords: flow battery; experimental; membrane.
Staff in charge for the activity : Matteo Zago
Other staff involved : Claudio Oldani (Solvay), Daniele Facchi (Solvay)
Supporting project : no project; activity will be carried out mostly at Solvay (Bollate).

Project description: In collaboration with Solvay specialty polymers, we would like to propose a Master's degree thesis work for one candidate in the field of membrane preparation and characterization for flow battery application (RFB). One of the main technological issues hindering RFB commercialization is the capacity loss induced by the undesired transport of ions across the ion-exchange membrane (i.e., cross-contamination): depending on the nominal operating condition, the choice of a suitable membrane for RFB application results from the trade-off between low ion permeability and high proton conductivity. The activity will encompass the development and characterization of suitable polymer formulations for flow battery membrane, their preparation and electrochemical characterization at single cell level. Particular attention will be focused on the evaluation of membrane conductivity in function of ions concentration. Materials studied will be different Aquivion commercial as well as advanced grades.

Start : September-October 2020.
Available positions : one students
Expected duration: 9 months
Expected Work Load : full time.

7 Hydrogen polymer fuel cells modelling: simulation of dynamic operation

keywords : PEMFC, modeling, degradation, water management, dynamic operation.
Staff in charge for the activity : Andrea Baricci.
Other staff involved : Amedeo Grimaldi.
Supporting project : Industrial project with autmotive company.
Experimental facilities available : none.

Project description: This thesis work will focus on the development and improvement of a fuel cell system dynamic model in Simulink. The activities will consist in:
(i) Implementation of relevant transient effects inside the stack model, related to water management and degradation phenomena, and successive dynamic validation;
(ii) Integration of the improved stack model inside a sytem model, working on anode recirculation loop and hybridization of the system, and simulation of different driving cycles.

Start :September 2020.
Available positions : one student
Expected duration : 9 months
Non disclosure agreement : required.
Expected Work Load : full time.