PhD Position on Mathematical Modeling of Redox Flow Batteries

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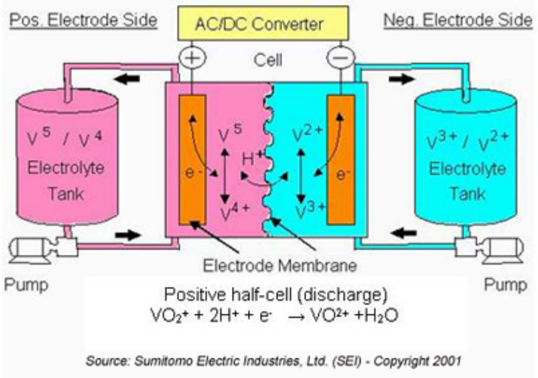
Carlos III University of Madrid (UC3M) is a relatively small, innovative, public university, providing teaching of the highest quality and focused primarily on research. The mission of UC3M is to contribute to the improvement of society through teaching of the highest quality and cutting-edge research in line with stringent international guidelines. UC3M is included in the QS Top 50 Under 50, a ranking of the world's top 50 universities established within the last 50 years.

The Fluid Mechanics Research Group of the Department of Thermal and Fluids Engineering at UC3M carries out research on a wide variety of topics in fluid mechanics and combustion, encompassing theoretical, numerical and experimental studies.

Background and motivation: Renewable-energy sources, such as solar and wind, are being deployed in larger numbers than ever before, but these sources are intermittent and often unpredictable. Analysis suggests that an electric grid could become destabilized if non-dispatchable renewable energy exceeds 20% of the energy-generation capacity without energy storage. As this level of deployment is being expected in the near future worldwide, there is a pressing need for grid-connected energy storage technologies to complement and enable renewable standards [1,2].

Among other electrochemical energy storage systems, redox flow batteries (RFBs) exhibit very high potential due to their ability to store large (i.e., grid-scale) amounts of electrical energy relatively cheaply and efficiently, as well as their high localization flexibility. A flow battery is a type of rechargeable battery where rechargeability is provided by two chemical components dissolved in liquids contained within the system and most commonly separated by a membrane. Redox flow batteries also offer greater flexibility to independently tailor power rating and energy rating for a given application than other electrochemical means for storing electrical energy. Redox flow batteries are suitable for energy storage applications with power ratings from 10’s of kW to 10’s of MW and storage durations of 2 to 10 hours. [3].



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Project: This project aims to enhance the current understanding of the fluid dynamical aspects affecting the design and operation of innovative energy storage systems, such as 1) membraneless flow batteries operating with immiscible redox electrolytes and 2) micro-fluidic redox flow batteries based on laminar flows, but also of 3) state-of-the-art solutions. The specific targets of this project are to increase our understanding of the dynamics of the free surface coupled with the complex mass and charge transport processes that take place in membraneless flow batteries, and to devise new designs for improved flow, mass and charge transport in micro-fluidic flow batteries, proposing in both cases ways to improve the overall system's efficiency. Detailed modeling and optimization of existing devices will also be carried out, including optimization of electrochemically reactive flow in porous media based on detailed knowledge of the porous structure. These goals will be achieved through a methodology that combines theoretical analysis with mathematical modeling and numerical integration, as well as validation of the developed models with experimental results provided by our project partners. The PhD candidate will also collaborate with the experimental team based at IMDEA Energy Institute, whose work will serve 1) to provide useful data on the redox-flow pair properties, such as densities, thermal conductivities, solute diffusivities, surface tensions, etc., both as a function of temperature and of solute concentration, and 2) to validate the mathematical models developed at UC3M. This will enable the development of predictive tools that could be used to optimize the design and operation of the devices under study.

Project partners: PVH ENERGY STORAGE [4], IMDEA Energy [5], b5tech.

Conditions: The group is looking for a self-motivated PhD student with background in fluid mechanics and, if possible, in electrochemistry. Doctoral studies extend over a 4-year period during which the PhD student will receive a salary as an employee of the department. Doctoral students are expected to engage in full-time study and research, and to participate actively in the department’s activities. The candidate should have finished his/her Master’s studies by January 2018. See here for more information.

Funding: Carlos III University of Madrid & IMDEA Energy Institute, under European Research Council ERC Consolidator grant "MFreeB (Membrane-Free Redox Flow Batteries)". In a couple of months there will be a call for PhD Candidates at UC3M. The student will start his/her work around February 2018.

Placement: Department of Thermal and Fluids Engineering at Carlos III University of Madrid.

Type of employment: Full time, 4 years.

Number of positions for this Project: 1

Town/Province/Country: Leganés/Madrid/Spain https://goo.gl/maps/rJgWpMmTMyx

References:

[1] Weber, A. Z., Mench, M. M., Meyers, J. P., Ross, P. N., Gostick, J. T., & Liu, Q. (2011). Redox flow batteries: a review. Journal of Applied Electrochemistry, 41(10), 1137. http://link.springer.com/article/10.1007/s10800-011-0348-2

[2] Alotto, P., Guarnieri, M., & Moro, F. (2014). Redox flow batteries for the storage of renewable energy: A review. Renewable and Sustainable Energy Reviews, 29, 325-335.

[3] http://energystorage.org/energy-storage/storage-technology-comparisons/flow-batteries

[4] http://pvhardware.com/products-overview/, https://www.youtube.com/watch?v=7yCHA_XtkAs

[5] http://www.energy.imdea.org/