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REDOX CELL HYDRODYNAMICS MODELLING - SIMULATION AND EXPERIMENTAL VALIDATION

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ABSTRACT: An electrochemical reactor is an assembly capable of withstanding an electrochemical reaction of practical application. It consists of electrodes surrounded by a volume of liquid electrolyte. Major difficulty and challenge involved in this modeling is the fact that real experimentation with high acid flows is extremely difficult to perform. To overcome them, some assumptions are proposed in order to achieve a computational model suitable to be used as virtual laboratory for redox batteries designers. A model is proposed to analyze the flow of the liquid electrolyte in an electrochemical reactor. Numerical and experimental analyses of such flow in a prototype of a real reactor are proposed. Good hydraulic behaviors will be shown in the majority of the volume, even if there are zones with practically no velocities or with recirculations. These volumes are used to define the parameters that indicate the hydraulic operation. This article describes the experimental and numerical modeling applied to a particular Iron Flow Cell prototype. The experimental validation has shown little numerical errors, smaller than 2.25%. This methodological research provides a very powerful calibrated tool which will help engineers in the future in decision-making in order to optimize real designs.

Keywords: computational fluid mechanics, hydraulic experiment, electrolyte distribution, electrolytic reactor, REDOX iron flow cell

1. INTRODUCTION

The energy storage technologies will play a crucial role in the near future under the use of efficient energy sources and renewable energy such as wind and solar. This sort of energy usually suffers from intermittent problems in distributed generation systems. Researches are achieving elements for storing energy to be released when needed consumers (Rychcik and Skyllas-Kazacos, 1987; Dell and Rand, 2001). In a large scale, this energy storage could alleviate the unpredictability of energy sources by promoting its accumulation over time (Joerissen et al., 2004; Yang et al., 2011).

One of the most promising among these technologies is the redox flow battery (RFB), as a candidate for the energy storage medium on a large scale (Ponce de Leon et al., 2006). These batteries store energy in solutions containing different redox couples. The reversible electrodic processes are carried out on the surfaces of the electrodes (porous or not), which in turn can be inert or can catalyze the electrode reaction. Redox technologies are excellent candidates for large energy storage and semi-redox for medium quantities for domestic uses (Weber et al., 2011). The amount of energy stored by these devices depends on the amount of accumulated electrolyte, while the power is dependent on the electrode surface. The power stage cannot be separated from the stage of energy storage, as it is directly related to the active mass of the electrode, as the limiting reagent for accumulation is the same electrode (Frias-Ferrer, 2004).

Therefore, the output voltages and capacities of this sort of batteries can be modulated by connecting multiple storage cells and using different sized reservoirs. This makes them very appropriate as potential system for distributed energy storage, whose requirements depend on the distribution needs of each system.

For certain renewable energy storage, electrochemical solutions are well suited. They are just electrical inputs and outputs, and power and storage capacity can be modularly changed and can be installed relatively close to the consumption points (Frias-Ferrer, 2004). In the 70s the first class of electrolyte batteries appeard. The first batteries used zinc as anodic material, combined with oxygen, chlorine or bromine. Thaler (1974) proposed the actual redox prototype. In 1980 Hagedorn et al. (1980) published the first results obtained on prototypes. Since then, different cell prototypes have been

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