Engineering Applications of Computational Fluid Mechanics Vol. 8, No. 3, pp. 435–446 (2014)

REDOX CELL HYDRODYNAMIC MODELLING: TOWARDS REAL IMPROVED GEOMETRY BASED ON CFD ANALYSIS

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ABSTRACT: Redox cell is an assembly consisting of electrodes surrounded by a volume of electrolyte (liquid). The redox cell device stores electrical energy with full of high acid flows and this acidity causes big difficulties for physical modeling. To overcome this problem, numerical and experimental analysis of those flows in a real redox cell have been developed and here described. A methodology to improve redox cell performance based on the analysis of the electrolyte flow is proposed. Improvements in the flow uniformity are achieved by means of the definition of some designed parameters based on CFD analysis. The depicted methodology is applied to a specific redox cell geometry for improving authors´ previous designs. This article quantifies parameters for this particular case and the proposed improvements. The considered CFD model is also validated with experimental data using a real scale cell built in transparent material. The convergence between experimental and numerical results is fairly good. Finally, the geometry designed based on this proposed methodology presents 0% dead zones or recirculations in the membrane area, which will definitely improve the overall interchange efficiency of the cell. This validated methodology is presented for a real future design strategy of these sorts of devices.

Keywords: CFD, hydraulic experiment, electrolyte distribution, electrolytic reactor, REDOX iron flow cell.

1. INTRODUCTION

Flow batteries are a sort of devices used to storage electricity in which two chemical components dissolved in liquids are presented and separated by a membrane (Mellentine, 2011). In these devices, ion exchange occurs through the membrane while both liquids circulate in their own respective space.

These sorts of devices are crucial for storing energy (Chen, et al., 2009). Storing is especially important in renewable energy uses that represents a significant percentage of the installed power capacity in the future. In this sense, Electric Energy Store Systems (EESS) are very important for future developments in energy grids (Eyer, et al., 2004) as they become a necessity in the renewable sources energy management due to the great variability of this sort of sources (Kondoh, et al., 2010; Jörissen, 2009).

Among all the EESS, electrochemical batteries are one of the most commonly used (Reddy, 2002) as they are very adaptable and efficient. Besides, many types of technologies have been applied in batteries: lead-acid batteries (Vazquez, et al., 2010), sodium/sulfur batteries (Walawalkar and Apt, 2008), flow batteries (Leadbetter and Swan, 2012; Parker, 2009; Escudero-González and López-Jiménez, in press), nickel-cadmium (Shukla, et al., 2001) and lithium ion (Rahman, et al., 2012). Among all these types of technologies, in this article, an iron flow battery (redox cell) (Ponce de Leon, et al., 2006) will be analyzed in order to determine a real optimized geometry. This optimization is based on the achievement of a uniform velocity of the liquid electrolyte flow dissolving the present chemical species in the redox cell.

Uniformity of the electrolyte flow is crucial for ensuring the performance of the redox cell. If the flow is reversed or the velocity is negligible in any part of the redox cell, the efficiency of the whole redox cell will decrease (Bengoa, et al., 1997; Wragg and Leontaritis, 1997). Furthermore, a deep analysis on the electrolyte flow velocity field is determinant for the design of the geometry inside the redox cell. In this sense, the work presented in this article is the following part of what was described in 2013 (Escudero-González, et al., 2013). In the previous paper, the authors applied a CFD model in order to analyze the electrolyte velocity field inside the redox cell. In that particular case, a prototype of a redox cell in a scaled model was analyzed by means of a

Received: 14 Feb. 2014; Revised: 12 Apr. 2014; Accepted: 22 May 2014

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