Modeling of the trajectories of hydrogen bubbles in a fluorine production cell based on hydrodynamic diffusion

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The current technology for commercial production of fluorine was reviewed by Rudge (1) and Hough(2). Although there is considerable variation in the details of cell design, a typical fluorine cell has a rectangular cell body with a number of rectangular carbon anodes and the steel cathode plates suspended from the cell cover. Monel or steel skirts are used to separate the hydrogen and fluorine produced by electrolysis. The main cause of failure in such cells is related to the anodes. A lot of works have been done to investigate the mechanism of the so-called “anode effects” and “polarization” and to avoid the difficulties related to the carbon anode (3-5). However, limited attention has been paid to the study of cathode. Yun et al.(6) examined the effect of the configuration of the slits formed on the cathode on the escape of the hydrogen bubbles toward the backside of the cathode to reduce the ohmic voltage loss between the electrodes. They obtained the fluid velocity and temperature field and the trajectory of a single hydrogen bubble evolving from the cathode in a fluorine production cell by using the finite element method.

This work is a continuation of the previous one (6) in a sense that the behaviors of multiple bubbles are modeled instead of a single bubble based on the concept of hydrodynamic diffusion (7). The effects of all the details of the cathode configuration, such as the cathode thickness and the size, inclination, locations, and number of the slits on the flow field within the cell and the trajectories of the hydrogen bubbles evolved from the cathode are examined. The trajectories of fluorine bubbles were not considered, because the fluorine bubbles evolving from the anode do not break up away from the electrode surface, but slip up the electrode surface under the influence of buoyancy forces (1). Based on the model, one can optimize the cathode configuration of the fluorine cell to enhance the energy efficiency of the cell.

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