Design considerations for the cathode of a fluorine production cell to improve energy efficiency

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The current technology for commercial production of fluorine was reviewed by Rudge (1). 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 (2-4). However, limited attention has been paid to the study of cathode. In a U. S. patent (5), the cathode is louvered to remove the hydrogen bubbles toward the backside of the cathode where the bubbles cannot interfere with the ionic current thus reducing the ohmic voltage loss.

In this work, the cathode is modified by the slits formed on the cathode in order to facilitate the escape of hydrogen bubbles toward the backside of the cathode. A modeling is presented to examine the effects of the cathode configuration, such as the cathode thickness and the number, location, and shape of the slits, on the flow field within the cell and the trajectories of the hydrogen bubbles evolved from the cathode. Based on the modeling, an optimization of the design parameters on the cathode configuration is attempted to enhance the energy efficiency of the fluorine cell.

In Fig. 1, it is shown the schematic of the fluorine cell investigated. The area surrounded by the dotted line in the figure is the computational domain due to the symmetry of the cell configuration. The steady-state flow and temperature fields of the cell with the cathode which has no slits are shown in Fig. 2. The flow field of the cell with the cathode which has six uniformly spaced slits along with the expanded views of the flow fields of some slits are shown in Fig. 3. Based on the flow fields formed in the slits, one can deduce that it is necessary to optimize the locations of the slits, because the first slit from the top of the cathode will serve to enhance the removal of the bubbles toward the backside of the cathode, but the third and fifth slits will not be so effective in removing the bubbles as the first one.

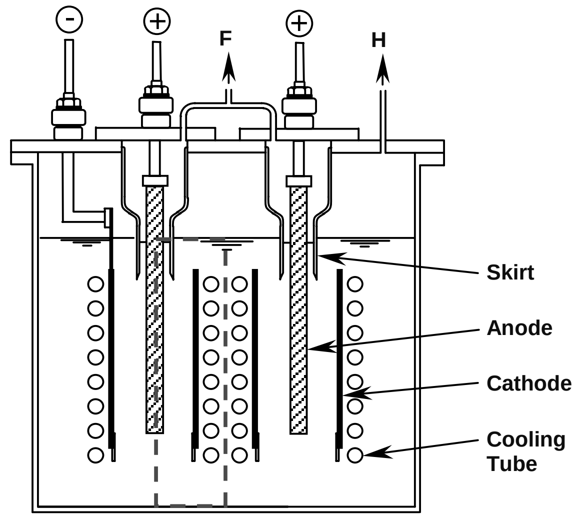

Fig. 1. Schematic diagram of an electrolytic cell for fluorine production.

Fig. 2. Flow field (left-hand side) and temperature field and streamlines (right-hand side) of the cell with the cathode which has no slits.

Fig. 3. Flow field of the cell with the cathode which has six uniformly spaced slits.

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