CFD Modeling of Alumina Diffusion and Distribution in Aluminum Smelting Cells

Xiaozhen Liu, Youjian Yang, Zhaowen Wang, Wenju Tao, Tuofu Li, and Zhibin Zhao

Extended Abstract

In aluminum smelting cells, alumina distribution and the time needed to reach concentration equilibrium after feeding are critical to smelting performance. The aim of this work is to build a numerical model to acquire the alumina distribution from the feeder to other areas and the time needed to reach the equilibrium. The model contains four flat anodes and the metal pad is not included. A square feeder is located at the intersection of the anode gaps and the central channel. Bubbles are injected into the model under the whole anode bottom and release at the gas-bath interface. When the bubble-driven flow field reaches steady state, alumina particles are fed into the model through the feeder, and dispersed alumina particles transported from the feeding zone to other areas with the flow field. The Volume of Fluid (VOF) model is used to track the CO₂ bubbles and the gas-bath interface; the Discrete Phase Model (DPM) is adopted to simulate the transport of alumina particles. The turbulent flow is solved by the standard k - ϵ model, and the effect of turbulent dispersion on particle trajectories is considered by stochastic tracking. This model is realized in ANSYS FLUENT.

It was found that at least 20 s are needed after gas injection for the flow field to reach the steady state. Because the DPM model is resource demanding, only 10 g alumina particles of 5 mm diameter were added to the model from 40 to 40.5 s. Since alumina particles act as tracers, the density of alumina was set as the electrolyte density to ignore the

influence of the density on alumina distribution. To quantify the results, the flow zone was divided into 32 zones and 29 parts in the transversal and longitudinal divisions respectively. The DPM concentration was monitored; the variance of the concentration was used to estimate the time required for the fed alumina to achieve equilibrium.

Generally, the DPM concentrations in slices near the feeder first increase and then rapidly decline, while in other slices first gradually increase and then fluctuate around their average values. Alumina particles are more likely to accumulate in the anode gaps than elsewhere, and from there tend to travel to the side channels. Additionally, the alumina gradient in the transversal direction of the model exceeds that in the longitudinal direction. It takes more than 20 min for the alumina to reach the concentration equilibrium after feeding. Compared to results from water models and industrial tests, more than 30 min are needed to reach equilibrium. One of the reasons for this can be the omission of bath temperature changes, which determines the alumina agglomeration size and density. Another reason is that the model does not take the alumina dissolution into consideration. Due to the slow dissolution of alumina lumps in industrial cells, it should take longer time to reach the equilibrium across the cell. This model also has other limitations, as well such as the omission of the heat and mass transfer, MHD forces and the metal pad circulation. These factors as well as the influence of the dose mass should be included in future work.

X. Liu · Y. Yang · Z. Wang (✉) · W. Tao · T. Li · Z. Zhao
Shenyang, China
e-mail: wangzw@smm.neu.edu.cn