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Flow field characterization in the vicinity of vertical plane electrodes in a bench-scale zinc electrowinning cell

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Abstract: Characteristics of flow fields in the vicinity of vertical plane electrodes in a bench-scale zinc electrolysis cell were visualized using particle image velocimetry (PIV). Two experimental conditions, f_N (current density = 0 A m^{-2}) and f_W (current density = 440 A m^{-2}), were applied to investigate and compare the pump-induced and bubble-induced flows. The flow patterns in the selected region changed from vortex topology in f_N to smooth streamlines in f_W. In the presence of rising electrogenerated bubbles, the average velocity of the electrolyte between electrodes increased around 9 times. Based on the spatial velocity variation in f_W, the average thicknesses of the bubble diffusion regions near the anode and the cathode were 3.59 mm and 3.78 mm, respectively, where the local turbulence was significantly stronger than that in the bulk region. It is noteworthy that near the anode surface, the turbulence intensity increased linearly (R=0.99) upwards from the anode bottom, indicating that the local turbulent two-phase flow might be attributed to the accumulated perturbations from individual bubbles. The drag effect of the bubble curtains was the main driving force to renew the electrolyte within electrode gap rather than the electrolyte feeding into cell in the zinc electrowinning system.

Keywords: particle image velocimetry (PIV); flow field; two-phase flow; zinc electrowinning