Electrochemical Modeling of Copper Electrorefining in Lab Scale and Pilot Plant Scale

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Abstract

Pyrochemical reprocessing is a non-aqueous method for reprocessing spent metallic fuels. Electrorefining is an important step in pyrochemical reprocessing. Ambient temperature electrorefiner (ATER) is a facility to demonstrate the various mechanisms and associated interlocks. Here the electrolysis of copper in acidified copper sulphate electrolyte will be carried out to demonstrate the electrorefining process. Laboratory scale experiments were also conducted in this regard to understand the copper electrorefining process. Several experimental runs were conducted and the current densities and quantity of copper deposited were determined. Electrodeposition of copper was also numerically simulated using COMSOL Multiphysics' Electrodeposition Module. The current density in each case was calculated and compared with the experimental current densities. The experimental and theoretical current densities for various operating conditions were compared, and there was close agreement in the results. Since the results were matching the numerical model was thus validated.
Based on the above results, the modeling of electrorefining of copper was done for the as built ATER vessel. The current density for the cathode geometry and the time required for deposition of one batch of copper was also estimated.

The numerical model for the lab scale simulation is shown in Figure 1.

Anode was modeled as porous electrode with 0.4 porosity, and 0.4V was the applied voltage. Cathode was modeled as solid cathode. Electrolyte conductivity was 44 S/m, and the exchange current density was taken as 16A/m2. The simulation is time dependent, and was executed for 3600s with a time step of 600s. Meshing of the geometry is done by quadrilateral meshes. The electrolyte current density on the cathode surface was evaluated and compared with the experimental results.

After validation, the same module was used to simulate copper electrorefining in pilot plant (ATER) scale. The numerical model of the pilot plant scale is shown in Figure 2.

The current density distribution around the cathode is shown in Figure 3. The average current density for this system is around 151A/m2. Accordingly the time taken to deposit of 5 kg of copper on the solid cathode would be 19 days.

Figures used in the abstract

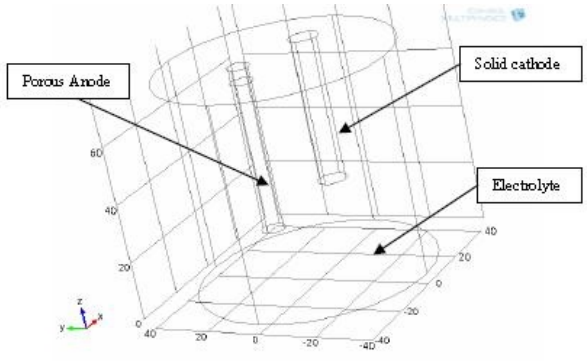

Figure 1: Theoretical model of lab scale copper electrorefining

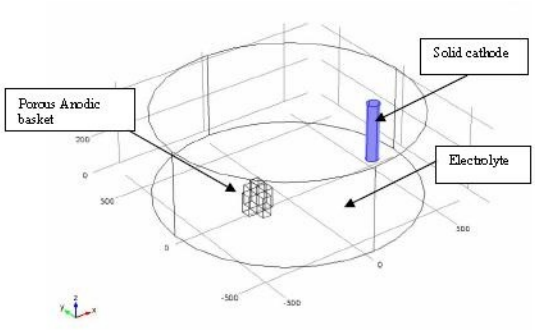

Figure 2: Geometrical model of ATER for copper electrorefining

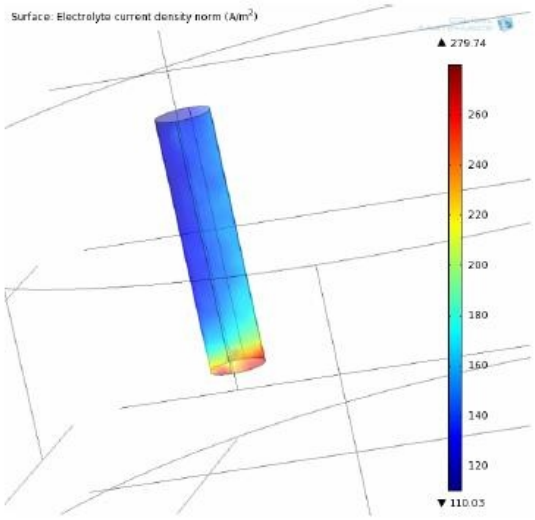

Figure 3: Current density distribution around the cathode