Kinetic and total mass transfer of a pollutant between two electromagnetically stirred molten layers

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Abstract

In ladle metallurgical processing, two liquid layers a metallic layer below a salty or oxide layer are separated by an interface where mass exchanges occur by the way of a chemical redox reaction. Mass transfers associated with such reaction are strongly dependent on the stirring of each phase as well of their interface.

To work on metal/salt couples of interest to industry, we built a facility to control and measure the full kinetic mass transfer of pollutants from one layer to another. Indeed, by means of induction, a cold crucible reactor can melt, confine and stir, without any physical contact, liquids at very high temperature, with opportunities for continuous treatment.

We use an experimental system able to melt separately metal and salt. Once these elements are molten and brought into contact, a sampling system is used. The experimenter chooses the sampling times. Then, the collected samples and the final metal and salt ingots are analyzed by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPAES) to measure various element concentration During the experiments, both temperature and, intensity and frequency of the inducting current are continuously measured.

In conjunction, a numerical simulation of the experimental reactor is done. We calculate the flows in both salty and metallic layers taking into account of all the present phenomena in each liquid phase (i.e. electromagnetic stirring, buoyancy, turbulence) as well as at the interface (i.e electromagnetic shaping, viscous shear driving). The implementation of all the couplings needed for a complete simulation is presented. A focus is done on the numerical description of the shear stress near the free interface. Concentrations of the various elements are calculated as postprocessing.

Comparisons of experimental and numerically simulated results are done and presenting an excellent agreement.

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