SCALING LAWS AND INSTABILITIES IN ELECTRIC FIELD-ENHANCED SMELTING AND REFINING OF STEEL

A. Powell and D. Dussault

In electric field-enhanced smelting of iron from slag, liquid iron formation at the cathode exhibits a Mullins-Sekerka instability, leading to the growth of fingers and enhancing the reaction rate. However, the liquid state of the growing iron phase leads to expression of this instability which is qualitatively different from the classical example of growth of dendrites in solidification. As the molten iron fingers grow into the slag, there is a surface tension-induced instability which leads to breakup into droplets, and this breakup is accelerated by the higher inward Lorentz force in narrower regions due to higher current density. And if growth is directed downward, there is a buoyancy instability due to the higher density of iron than slag. These instabilities and their scaling behavior are treated analytically, and presented along with preliminary results from numerical models using a diffuse interface method.