Kinetics of the calcium-evaporation from active CaF_2-slags during pressure electro slag remelting

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Abstract

Due to the low oxygen partial pressure, calcium containing “active” CaF_2-based slags are of growing importance for the electro slag remelting under protective atmosphere at atmospheric or increased pressure. Typical applications are the desoxidation of titanium and super-alloys as well as the protection of Beryllium-containing alloys from oxidation. Since the partial pressure of pure calcium is rather high even at temperatures below the working range of electro slag remelting applications, the evaporation of calcium must be considered, if a controlled calcium content in the slag has to be achieved.

In this work the ternary CaF_2-Ca-CaO-system was modelled using the FactSage 5.4-OptiSage-module and literature data of the binary CaF_2-Ca-, CaF_2-CaO- and CaO-Ca-systems, ternary interactions were not considered according to results of other scientists. The partial pressure of calcium was calculated for typical slag compositions and temperatures. While the evaporation step according to Hertz-Knudsen equation is extremely fast and therefore can’t be the transport limiting step, the transport of calcium in the gas phase by diffusion and convection is much more slowly. Considering the equivalency of heat and mass transfer a model was created to calculate the calcium transport rate.

Although diffusion constant and gas pressure are anti-proportional and therefore, evaporation losses should decrease strongly with increasing pressure, due to the decreasing viscosity of the gas, a higher gas pressure reduces the evaporation losses only marginally. The pressure dependence of the calcium evaporation was experimentally proofed in the range between 1 and 40 bar. A good agreement with the calculation was received.