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Fromreide, Mads; **Gómez, Dolores**; **Halvorsen, Svenn Anton**; **Herland, Egil Vålandsmyr**; **Salgado, Pilar**

Reduced 2D/1D mathematical models for analyzing inductive effects in submerged arc furnaces. (English) Zbl 1481.78014

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Summary: Mathematical models have been developed to investigate the quantitative behaviour of the current and power distributions in large submerged arc furnaces, usually fed by a low-frequency alternating source. Reduced 2D and 1D models will be used to investigate the electrical behaviour inside the furnace; in particular, these models will allow us to explain the inductive effects between the different regions and to compare the use of genuine AC models vs. DC approximations. The merits and limitations of the reduced models will be analyzed in terms of geometrical and physical parameters. The models are based on three-phase submerged arc furnaces for ferromanganese production, which are characterized by coke enriched regions (coke beds) under the electrodes. Mathematical analysis and computer simulations show how AC differs from the simpler direct current (DC). If the electrode-electrode distance is large, the current will mainly run horizontally between the electrodes. The unidimensional AC model shows that the distribution in the coke bed is largely influenced by the (parallel) currents in the metal. On the other hand, the corresponding DC model will predict constant current and power distributions here. Two-dimensional simulations reveal that this AC property will be preserved qualitatively also for realistic electrode-electrode distances. Hence, if there is a significant power contribution from horizontal currents in the coke bed (or slag), DC models should be avoided.

MSC:

78A55 Technical applications of optics and electromagnetic theory

78-10 Mathematical modeling or simulation for problems pertaining to optics and electromagnetic theory

Keywords:

metallurgy; submerged arc furnaces; induction; proximity effects; analytical 1D models; dimensional aanalysis

Software:

MaxFEM

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