FUNDAMENTAL ASPECTS OF ALLOY SMELTING IN A DC ARC FURNACE

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ABSTRACT

DC arc furnaces have been applied to a number of smelting processes, including the reductive smelting of chromite ore fines to produce ferrochromium, the smelting of ilmenite to produce titania slag and pig iron, the recovery of cobalt from non-ferrous smelter slags, stainless steel dust smelting, battery recycling, and nickel laterite smelting.

The recovery of base metals and platinum group metals (PGMs) in a reductive smelting process is a function of the recovery of iron (which indicates the extent of reduction). A recovery equation has been developed that is characterised by a single parameter ($K\gamma$) for each metal that can either be fitted empirically to the data, or expressed in terms of the equilibrium constant and the ratios of the activity coefficients involved.

The DC arc furnace has been modelled electrically as an arc in series with a layer of slag. The voltage is non-linear with respect to the current. Equations have been developed (and confirmed by measurement) to describe how the arc voltage varies as a function of arc length and current. The voltage distribution across a molten slag bath requires the solution of Laplace's equation for a geometry that includes the depression in the molten slag caused by the impingement of the arc jet. Aspect ratios of the arc depression were determined photographically.

Equations have been developed for the calculation of the mean residence time in a continuously-fed batch-tapped furnace, and this has been illustrated using a novel graphical depiction. The mean residence time is directly proportional to the tap-to-tap time, and is increased by increasing the volume of material retained in the furnace between taps.

The ConRoast process treats dead-roasted nickel sulfide or PGM concentrates by reductive smelting in a DC arc furnace, where an iron-based alloy is used to collect the valuable metals. This process results in much lower sulfur dioxide emissions, the ability to accept high chromite contents, and improved furnace containment. The ConRoast process has been demonstrated by smelting 50 000 tons of PGM-containing feed materials at Mintek over a period of operation of about five years.