




Pyrometallurgical Processes and Equipment

MINTEK has been closely involved with the South African pyrometallurgical industry since the 1970s, and is a world leader in the development and implementation of DC arc furnace processes for smelting, fuming, re-melting and slag-cleaning. Processes have been developed for ferro-alloys, non-ferrous metals, precious-metals concentrate smelting, and metallurgical waste treatment.

Other more general services include:

Evaluation of metallurgical products and related materials - Investigations include the physical and phase-chemical characterisation of metallurgical products and related materials. Examples include the analysis of failed refractories, the determination of liquidus temperatures, and the characterisation of reaction products.

Phase equilibrium studies - These deal with liquid-gas interactions at high temperature (i.e. the interactions between slags, glasses, oxide melts, alloys, mattes, etc.). Investigations are generally conducted on samples prepared in the division's laboratories using equipment that is able to accurately control both temperature and atmosphere (in order to control the oxygen partial pressure). A recent project involved a study of the partitioning and solubility of chromium in silicate liquids.

Solid-state studies - Solid-state reactions (solid-solid or solid-gas interactions) at high temperature are involved in processes such as roasting, calcining, oxidation, reduction, and the generation of volatiles. These reactions can be studied using materials prepared in the section's furnace facilities, or products submitted for analysis. Examples include the calcining behaviour of sulphide ores, the reduction mechanism of chromite, the generation of volatiles during the pyrometallurgical treatment of furnace dusts or leach residues, and the metallurgical performance (reactivity) of carbonaceous reductants.

Metallurgical monitoring and modelling -It is not easy to assess the performance of many pyrometallurgical processes based on normal plant data and mass balances. Mintek has special expertise in sample collection and the metallurgical monitoring of pyrometallurgical unit operations. In addition, the data can be used to model the performance of the operations. Examples include the deportment of elements between process streams, or the solubility of chromium in matte smelting furnaces.

Equipment

Feed preparation and pre-treatment

- 0.2 t/h and 2 t/h externally heated rotary kilns for drying, roasting and calcining.
- 5 t/h flash drying plant with pneumatic conveying of product.
- 10 kg/h fluid-bed chorination pilot plant.

Smelting

- Pilot-scale AC-arc furnace (300 kVA) for conventional smelting testwork at feed rates up to 1 t/d.
- Pilot-scale DC-arc furnaces from 100 kVA to 3.2 MVA (50 kg/h to 2 t/h feed).
- A demonstration-scale DC arc furnace of 4.25m diameter with a power rating of 3MW (5.6 MVA).
- Feed rates of up to 3 t/h can be achieved,at power fluxes up to 700 kW/m2. All the furnaces are fully equipped with control,

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instrumentation, data-logging systems and off-gas handling plants (including SO2 scrubbers).

Converting

- Top-blown rotary converter with a 15 litre liquid capacity.
- Induction furnace with top-lance of up 2 litre capacity.

Metal condensation

- Zinc condenser up to 300kg/h (lead-splash type).
- Magnesium condenser up to 100 kg/h.

Metal Distillation

- Zinc/cadmium distillation up to 100 kg/h.
- Laboratory Facilities.
- Mintek has a range of sophisticated laboratory-scale muffle, tube, quench, induction, rotary kiln and fluidized bed furnaces and peripheral equipment, all of which are equipped for operation under stringently controlled conditions.

Modelling and simulation

- Process flowsheeting and techno-economic studies are carried out using Mintek's Pyrosim software for the calculation of steady-state mass and energy balances in pyrometallurgical processes. FACT data bases are also utilised for thermodynamic studies. Models of the dynamic and steady state behaviour of the DC arc are available and provide scale-up data for commercial implementation.

Processes implemented industrially

A DC-arc smelting process for the production of ferrochromium from 100% < 6mm ore, anthracite and fluxes. Three furnaces have been installed in South Africa (28 MW, 40 MW and 60 MW).

A DC-arc smelting route for producing high titania slag and pig iron from ilmenite concentrates was developed in conjunction with Anglo American Corporation (now Exxaro Resources). The process has been implemented at an industrial scale (25 MW and 35 MW).

Recoveries of 98 per cent for nickel and over 80 per cent for cobalt from non-ferrous furnace and converter slags have been demonstrated using DC arc technology up to 2 MW scale. This technology has been implemented at Chambishi Metals in Zambia at the 40 MW scale.

About 1 700 t of stainless steel plant dust was smelted at 1.4 MW to recover chromium, nickel and iron into an alloy for recycling. This technology has been implemented industrially at a 20 MW scale.

Processes developed to pilot scale

The major process requirements for successfully producing zinc from electric arc furnace (EAF) dusts have been established and demonstrated at a 1.3 MW scale. About 50 t of material was treated, producing Prime Western (PW) grade zinc metal and a slag that conforms to US Environmental Protection Agency (EPA) disposal criteria.

More than 1 000 t of lead blast-furnace slag have been treated at a 1 to 2 MW scale to yield disposable slag and PW grade zinc from a DC furnace linked to an ISP lead-splash condenser.

Smelting of calcined nickel laterite fines has been successfully demonstrated at up to 3 MW and 3.5 t/h, with better than conventional levels of nickel recovery at 25 to 35 per cent FeNi grades.

More than 2 500 t of off-grade ferro-manganese fines have been re-melted and refined in the DC arc furnace, at a rate of about 30 t/day, to yield a saleable, lumpy medium-carbon product.

The technical viability of continuously fuming and condensing high-purity magnesium metal from calcined dolomite at atmospheric pressure has been demonstrated in a purpose-designed 100 kg/h pilot plant.

Several large-scale smelting projects have been undertaken to treat a process stream containing PGMs and elevated chromium levels, recovering the precious metals into an iron alloy for recycling. More than 50 kt of this material has been processed at feed rate of up to 1 400 t/month. The work was undertaken to demonstrate the smelting step in the DC arc-based ConRoast process for recovering PGMs from concentrates.

Deliverable technologies

Melting of metal and alloy fines and dusts in an environmentally acceptable manner, using DC-arc furnace technology up to 10 MW. Service work to test amenability is available on a pilot plant scale. Examples include nickel, chromium, manganese, vanadium, and silicon-containing alloys.

Toll smelting services

These facilities are available to provide toll-smelting services. Materials are typically treated at a rate of 500 to 2 000 t/month for periods of 6 to 36 months.

Specialists

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