



Contents lists available at ScienceDirect

## Minerals Engineering

journal homepage: [www.elsevier.com/locate/mineng](http://www.elsevier.com/locate/mineng)

## The pros and cons of reductive matte smelting for PGMs

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## ARTICLE INFO

## Article history:

Available online 7 April 2011

## Keywords:

Pyrometallurgy  
 Extractive metallurgy  
 Precious metal ores  
 Reduction  
 Roasting

## ABSTRACT

Platinum group metals (PGMs) are traditionally smelted in electric furnaces where the valuable metals are collected in a base-metal sulphide matte. An alternative to this process is the ConRoast process that uses reductive alloy smelting in a DC arc furnace to collect the valuable metals in an iron-rich alloy. Reductive smelting of feed materials containing PGMs, using carbon as a reducing agent, can be used to obtain high PGM and base-metal recoveries and to ensure the solubility of chromium in slags.

Based on work carried out in Mintek's 3 MW DC arc furnace at throughputs of over 1000 tons per month, it was found that PGMs could be collected effectively, and that the chromium problem could be managed. However, if matte is present in the furnace, there remains a significant risk of furnace failure. Furthermore, the PGM 'lockup' (inventory inside the furnace) in a process that used reductive matte smelting of UG2 concentrates was much greater than that of reductive alloy smelting. Further differences exist in the better working environment and lower emissions of SO<sub>2</sub> in the case of the ConRoast process.

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## 1. Introduction

Matte smelting in an electric furnace has been the established route for the treatment of PGM (platinum group metals) ore concentrates since 1969, when the six-in-line furnace took over from the blast furnace. The separation of the base-metal sulphides (forming the PGM-containing matte) from the oxide minerals (which make up the slag) is essentially a simple melting operation. Mostert and Roberts (1973) explained that the reasons for moving away from the blast furnace included the labour-intensive nature of the smelting operation, the rising price of coke, and the changes in legislation regarding gaseous emissions. The introduction of anti-pollution laws meant that it would be costly to control the emission of a very large volume of gas containing between 1% and 2% sulphur dioxide that resulted from the typical concentrate of that era containing 15% Fe, 6% Ni + Cu, 8.5–10% S, and 110–150 g/t PGMs.

The products of PGM mining today look very different from those of 40 years ago, and process changes are required in the smelting of PGM ore concentrates in order to accommodate the increasing amounts of UG2 concentrates that are being produced in the South African Bushveld Complex. These concentrates contain much higher levels of chromium oxides and much lower levels of base-metal sulphides than the previously typical concentrates from the Merensky reef.

The ConRoast process, previously described by Jones (2002) Jones (2009), is an alternative to matte smelting that does not require sulphur to collect the valuable metals, but instead collects the PGMs and base metals in an iron-rich alloy. This proposed solution to the problem of smelting UG2 (and other) concentrates involves roasting of the concentrates to remove most of the sulphur prior to smelting, followed by reductive alloy smelting in a DC arc furnace. This process is unconstrained by the amount of chromium present in the feed, is much environmentally cleaner in terms of sulphur emissions, is much less prone to failure of furnace containment, and achieves very high recoveries of PGMs. The resulting alloy can be treated further either hydrometallurgically, or pyrometallurgically by converting to remove the iron to produce a product very similar to a conventional converter matte.

The challenges facing PGM smelters today can be summarised in terms of three major problems.

## 1.1. The sulphur problem

The emission of SO<sub>2</sub> (sulphur dioxide) from furnaces and converters is hard to avoid when using a sulphur-based matte-smelting process. However, the ConRoast process does not rely on the presence of sulphur, as it smelts essentially sulphur-free (or low-sulphur) material in a DC arc furnace and collects the valuable metals in an iron alloy. Sulphur can be removed, prior to smelting, using a fluidized-bed roaster which is a well-enclosed vessel that produces a steady continuous stream of SO<sub>2</sub> that can be used for the production of sulphuric acid (if the concentration and scale warrant this course of action). Compared to the traditional matte-smelting process, emissions of SO<sub>2</sub> can be orders of magni-

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