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Smelter feed quality control

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ABSTRACT

Final concentrates and furnace feeds from Anglo American Platinum are routinely monitored for quality. Merensky Reef, UG-2, and Platreef concentrates are sampled at the concentrators, as well as blended feed at the smelters, and the composition and mineralogy of these samples are determined at Anglo American Research.

This information allows the smelting characteristics of the concentrates to be predicted. Parameters such as the matte fall, spinel formation, and smelting energy requirement can be calculated by modelling.

The concentrates are characterised by chemical analyses for base metals, precious elements and trace elements. Various QEMSCAN techniques are used to determine the mineralogy of the samples and the abundance of gangue minerals and base metal sulphides (BMS), as well as the mineral association, are reported.

1. Introduction

More than 80% of worldwide platinum group element (PGE) reserves are found in South Africa (Jones, 1999; Nell, 2004). The metals are mined from the Bushveld Complex in the North West and Limpopo Provinces, from three major ore types – the Merensky Reef, the Platreef and the UG-2 chromite reef. The mined material passes through the concentrating, smelting and converting process route and values are finally recovered at various refineries (Cramer, 2001).

Anglo American Platinum operates three smelters which process the final product from 15 concentrators and one tailings retreatment plant. At the smelters, material received from the concentrators is blended and fed to the flash driers to remove moisture contained in the concentrates. The blend is conveyed to furnaces where it is melted, and matte and slag are formed. The sulphide matte contains iron, nickel, copper, cobalt and small amounts of PGE. This proceeds to the converters where the iron and sulphur contents are reduced. The slag consists mainly of silicates and oxides and this is largely discarded. The processes of smelting and converting at Anglo American Platinum have been described in detail in the literature (Jacobs, 2006).

A simplified process flow sheet, illustrating the path of a concentrate to the furnaces, is shown in Fig. 1.

As can be seen in Fig. 1, concentrate (or furnace feed) is sampled at two points before it is added to the furnaces. Most Anglo American Platinum concentrators submit monthly composited final concentrate samples to Anglo American Research for chemical and mineralogical examination at least once a year. This forms part of an assessment of the plant efficiency and stability. Flash drier feed samples are also received from the smelters, usually biannually.

2. The influence of feed mineralogy and composition on smelting behaviour

Levels of elements such as calcium, sulphur, magnesium and chromium have to be considered when blending the concentrates for smelter feed, as does their mode of occurrence (mineralogy). Minor to trace elements are also important, especially PGE, base metals, and any element which may cause environmental or process problems in the furnaces or downstream.

The type and modal amount of gangue minerals and BMS in the feed determine the smelting energy requirement (SER), matte fall, sulphur emission, and liquidus temperature during smelting. The mineralogy of the samples, therefore, must be input into any modelling program that is to predict these properties.

Chromium chemistry and mineralogy is used in addition to predict the level of slag spinel formation in the furnaces. Selected examples of the effect of concentrate composition and mineralogy are discussed in the following sections. The formulae of the minerals mentioned in this paper are given in Table A1 of Appendix A.

2.1. Base metal chemistry and mineralogy

Apart from the platinum group metals, nickel, copper and cobalt are also produced and marketed by Anglo American Platinum. The

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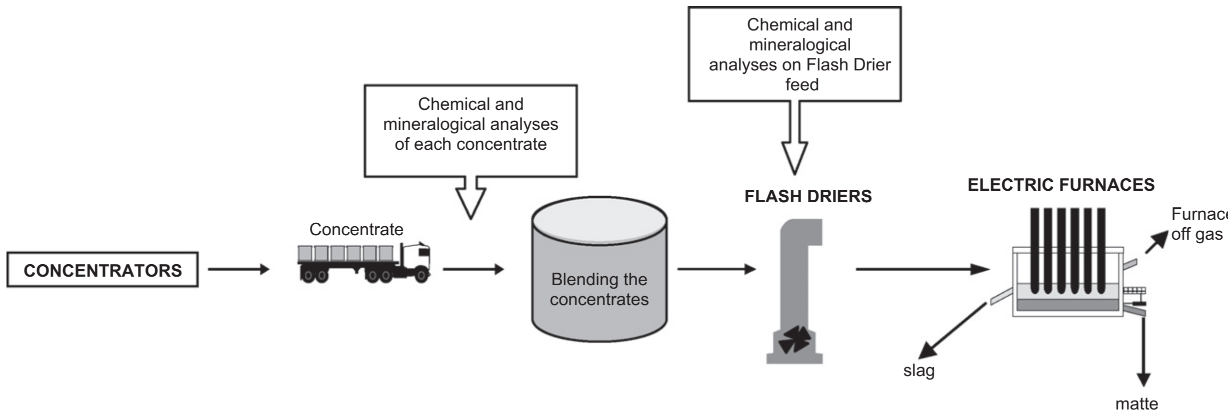

Fig. 1. Smelter feed quality control process flow sheet. Sampling points for chemical and mineralogical analysis are also shown.

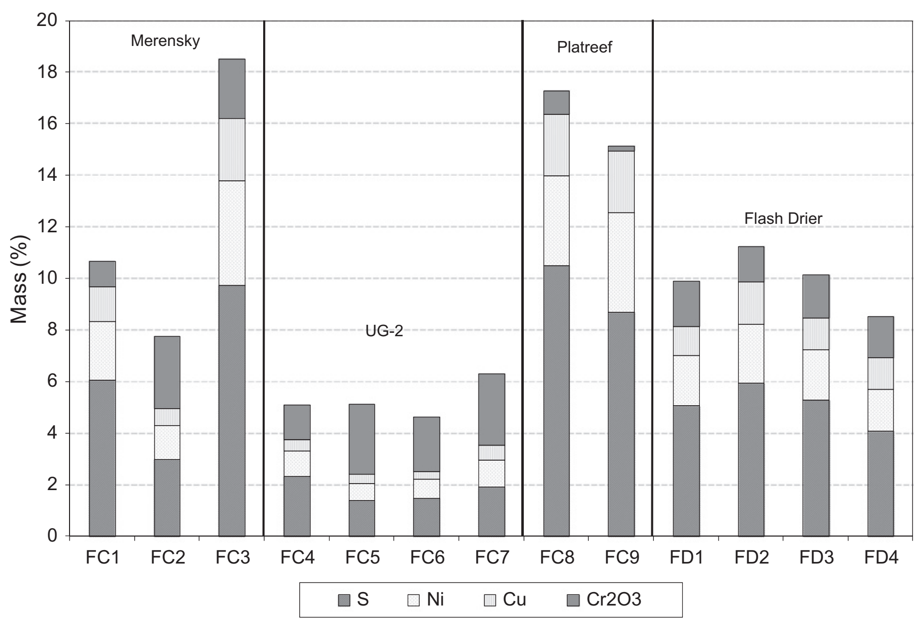

Fig. 2. A plot showing the variation of sulphur, base metals (Ni and Cu) and Cr_2O_3 levels in selected final concentrates and FD feed samples. The relatively high levels of chromium in some of the Merensky concentrators are probably due to UG-2 treatment which overspills to other available concentrators.

main mode of occurrence of these elements in the concentrate is in sulphide minerals, but they are also contained in trace amounts in silicates and oxides. Other phases reported as BMS are the iron sulphides pyrrhotite and pyrite.

The nickel to copper ratio plays an important role in the furnace feed, as an imbalance can affect the downstream processing. For example, the value of Ni/Cu for 2009 concentrates varied from 1.5 to 2.0 (Merensky and Platreef) and 1.7 to 2.4 (UG-2).

Nickel and copper levels, as well as those of sulphur and Cr_2O_3, are shown in Fig. 2, and an example of BMS distribution is shown in Fig. 6.

2.2. Sulphur

Sulphur occurs exclusively as sulphide minerals in ores and concentrates from Anglo American Platinum. The variation in sulphur levels in selected final concentrates and FD feeds is shown in Fig. 2. During the smelting process, sufficient sulphur is needed for a reasonable matte fall, as this is required to collect the valuable elements. Sulphur levels should be carefully controlled, as, apart from insufficient value collection, low sulphur addition may lead to higher matte alloy content and to tapping problems. Too high a sulphur addition can lead to excessive sulphur vapour emission (Andrews and Den Hoed, 2011).

2.3. Chromium and chromite levels

Chromium occurs predominantly in chromite, and so derives mainly from the UG-2 concentrates.

Concentrates high in chromium cause problems during smelting because high-melting chromium-rich spinel crystallizes out of the slag and forms a layer at the slag/matte interface. This impedes matte fall and reduces recovery (Nell, 2004). Building-up of the spinel layer may also reduce the effective furnace volume, and increase slag viscosity to the point of causing tapping problems. Once Cr_2O_3 levels exceed around 2% in furnace slag it becomes saturated and spinel will eventually crystallize. This situation can be avoided by blending feed concentrates to reduce the amount of chromite going into the furnaces.

A plot of Cr_2O_3 levels (along with sulphur, nickel and copper) is shown in Fig. 2, and an image of high-chromium slag in which slag spinel has formed is shown in Fig. 3.