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## Characterization of copper smelter dust for copper recovery

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### Abstract

The CSD from Palabora mining company's copper-plant in Limpopo, South Africa was characterized by particle size, chemical and morphological analyses. The dust from the electrostatic precipitator (EPS) attached to the reverberatory furnace was collected and used for this study. The results obtained showed that the dust contains particles mainly in the 53  $\mu\text{m}$  size fraction. As regards chemical composition, it is made up of about 18.02 weight % copper, occurring predominantly as cuprospinel and as chalcocopyrite. The major impurities in the dust are 42.97, 11.69, 11.45 and 1.6 weight % of mullite, gypsum, silica and magnetite, respectively with traces of lead and bismuth. Morphologically, the particles range from spherical to irregular in shape, with close association occurring between these spherical minerals suspected to be copper and the tabular shaped minerals likely to be gypsum. Smaller copper particles, 1 to 2  $\mu\text{m}$  size, were also found embedded in larger spherical particles 8 to 10  $\mu\text{m}$  size. The results obtained thus strongly indicate that the CSD as-received is an ultra-fine, copper rich secondary resource that might have been formed in two stages of condensation. Furthermore, the results indicate that physical beneficiation of the CSD in this size fraction of 53  $\mu\text{m}$  may be difficult and solvent extraction with prior froth flotation and leaching may be required to efficiently extract the copper value in it.

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### 1. Introduction

Approximately 5 to 10 wt % of the feed to the flash smelting furnace is released as waste copper smelter dust (CSD) during copper smelting [1]. This dust, does not only play host to impurities like antimony, bismuth, arsenic, lead, zinc, cadmium, selenium, tellurium and compounds thereof [2, 3] that would have contaminated the eventual refined copper; but it also contains substantial amount of copper and as a result, it becomes a matter of necessity that this CSD be treated to recover the copper value it contains so as to establish an efficient processing [4].

This metallurgical waste is basically of two major types, depending on how it is formed during the gas cleaning process: there is the chemically formed dust, which is a product of two dust forming mechanisms, vaporization and condensation in the gas cleaning system; while the other type is the mechanically formed dust, produced as a result of movement of small solid and/or liquid particles with the process gas into the gas cleaning system. However, the need to characterize this dust before deciding to treat it to recover the valued metals it often contains. This dust can be re-circulated in case there are no harmful elements such as Pb, As, Bi, Cd contained in them; otherwise they are subjected to special hydrometallurgical and/or pyrometallurgical processing [5].

The selective separation of this dust, in a manner in which it is collected in different fractions would be appropriate for either recirculation or recovery in special processes and thus significantly improving the chances of getting back metals from the dust. Hence, the amount of dust ending up in deposits could thereby be reduced and valuable metals could be recovered [1, 6].

Based on the environmental legislation being enforced, copper smelter dusts are getting serious attention, due to their high concentrations of toxic elements. The studies on this metallurgical dust can be divided into two groups: those focused on dust characterization [4, 5] and those focused on dust treatment [7]; yet, often considered together.

In the study carried out on Mitsubishi process dusts collected from the electrostatic precipitators (ESP), it was observed that dusts were composed mostly of oxides with some sulphides and lead sulphates. Morphologically, two forms of particles were recognized in the dust; 'spherical' and 'irregular'. The spherical particles revealed high copper, zinc or lead contents, while the irregular particles showed higher iron content. An acid leach and magnetic separation processes were recommended for treating the dusts. However, the valuable metal losses in the magnetic separation were high due to the presence of magnetic copper and zinc ferrites. The work on the noranda process and flash smelter dusts indicate that the dusts formed in these processes are similar to those from the Mitsubishi process. The dust treatment program recommended for these dusts was the same as that proposed for the Mitsubishi process, involving both water and acid leaching followed by sequential precipitation stages [8].

The other dust treatment techniques that have been proposed are all hydrometallurgically based. Most of these processes involve a sulphuric acid leach [9] which is often followed by additional leaching and precipitation stages [10]. In one case scenario, a single, pressurized leaching stage in the presence of chloride ions was used [11], while in another case ammoniacal leach was carried out on pelletised and roasted dusts [12]. In the present study, a general characterization of the CSD from Palabora Mining Company (PMC) was conducted to obtain a broad knowledge of its physical and chemical properties and thus be able to predict the best combination of physical and hydrometallurgical processes to recover its copper value.

## 2. Experimental

### 2.1. Materials

#### 2.1.1. Sample preparation

The copper smelter dust sample was collected over a 7 day period during the smelting operation. The as-received sample was re-weighed and subjected to coning, quartering and riffle splitting sample preparation methods to obtain a true representative of the CSD.

### 2.2 Methods

#### 2.2.1. Particle size analysis

The sieves were weighed empty and arranged using geometric progression based on  $\sqrt{2}$  with the sieve having largest aperture on top. 415 g of the CSD was placed on the topmost screen and the nest of sieve was automatically vibrated using sieve shaker for 15 minutes. The sieves were taken apart and the ore retained on each sieve was weighed. The results obtained are presented in Table 1 and Figure 1.

#### 2.2.2. Chemical analyses

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