Application of Codelco-Chile pyrometallurgical techniques at the Nkana smelter, Zambia

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SYNOPSIS

The Zambian copper producer, Zambia Consolidated Copper Mines Ltd. (ZCCM) is presently carrying out a modernisation and optimisation project at its Nkana Smelter. As part of the implementation, ZCCM have entered into a contract with Codelco-Chile for the provision of front end engineering services at the design stage, for detailing by TECHPRO Mining and Metallurgy, as part of an overall retrofit strategy. There is also an Agreement covering the transfer of operating know-how relating to the pyrometallurgical techniques both for oxygen/fuel-oil burners in reverberatory furnaces and for the autogenous smelting of concentrate with the simultaneous conversion of reverberatory furnace matte using oxygen enrichment of the blowing air in a Teniente Converter. These techniques have been developed by El Teniente Division, and have been in use for over a decade at the Division's Caletones Smelter, as well as in other smelters owned by Codelco-Chile and ENAMI, within Chile.

This paper sets out the process parameters for various capacity options considered for the Nkana Smelter, including mass and energy balances, and sizing of basic equipment, as well as some aspects of the general design of the main equipment.

INTRODUCTION

Nkana Smelter, one of the three copper smelters of Zambia Consolidated Copper Mines Ltd. (ZCCM), is typical of the old fashioned copper production process. The smelting of green charge copper concentrates, together with limerock flux and recycled reverts, is carried out in reverberatory furnaces using fossil fuels in end-wall burners. The only recent modification of note was to introduce partial enrichment of the preheated combustion air with oxygen. Primary smelting is then followed by the conversion of matte to blister copper using standard Peirce-Smith converters. The copper is conditioned in rotary furnaces to produce anodes, which are then electro-refined. The complete complex also includes facilities for producing cobalt, and four plants producing sulphuric acid.

Concentrates are supplied from various mines owned by the company; the main concentrators being at Nchanga, Luanshya, Nkana and Konkola.

To implement a far-reaching modernisation and optimisation programme of the Nkana Smelter, ZCCM decided to introduce new technology with the aim of attaining four main objectives:

- improving the energy balance of the smelting circuits.
- optimising the use of available oxygen.
- reducing operating and maintenance costs.
- improving the quality, and so the potential for collection, of the process off-gases for the production of sulphuric acid.

To achieve these objectives, ZCCM carried out a number of cost and feasibility studies to determine the best technical and economic option. TECHPRO Mining and Metallurgy were contracted to investigate in detail modern pyrometallurgical technologies, such as electric smelting and flash smelting, as well as continuous smelting-conversion processes of the "bath smelting" type. The main criterion was that the process must have been successfully operated on an industrial scale in other copper smelters. Also of importance were aspects related to slag
chemistry, impurities, gas treatment, operability, and use of available oxygen, as well as ease of retrofit into an existing operating plant. The result was that Teniente Technology was selected.  

PRESENT EQUIPMENT AND PROCESSES

The Nkana Smelter was first operated in the 1930's. Present scheduled production of primary copper is in the region of 240,000 tpy, although historically production in excess of 330,000 tpy has been attained.

For slag extraction, each furnace has a taphole with launder in the rear wall, from which the slag is removed in pots and taken to a disposal site. The matte is removed in ladles via three tap holes situated in the side wall at the settling zone.

Each furnace has two boilers for waste-heat recovery, two air heaters, four induced-draught fans and two forced-draught fans.

The firing facilities enable the furnaces to operate either with heavy fuel oil, pulverised coal or a mixture of both. The front wall has two pairs of lateral burners and one central burner. This can be seen schematically in figure 2. The maximum heat load in the furnace does not exceed the thermal equivalent of 150 tonnes per day of pulverised coal i.e. 168 GJ/h.

![Figure 1: Original Flow Diagram.](image)

Figure 1 sets out a general flow diagram of the facilities at the Nkana Smelter before the current retrofit.

A detailed description of the smelter has been published previously. However, a brief summary of the original operation is described below.

Reverberatory furnaces

The reverberatory furnace section has five identical units 29.6 m long, 9.1 m wide and 3.3 m high; three or four of these units are usually in operation together at one time, depending on production planning.

Peirce-Smith Converters

The conversion of matte from the reverberatory furnaces is carried out using six Peirce-Smith converters, each of which is 4.0 m in diameter and 9.1 m long. Normally four or five of these are in operation at any one time.