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Technical note

Control strategy for a Teniente Converter

L.G. Bergh [a,*], P. Chacana [b], C. Carrasco [b]

[a] Chemical Engineering Department, Santa Maria University, P.O. Box 110-V, Valparaiso, Chile
[b] Caletones Smelter, El Teniente Division, Millan 1020, Rancagua, Codelco-Chile, Chile

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Abstract

A diagnosis of the actual distributed control and measurements system for a Teniente Converter, processing copper concentrates, is presented. Besides the importance of this converter in Caletones Smelter, there is a number of unsolved problems related to lack of instrumentation, lack of process knowledge, odd operating practices, and lack of procedures to process data to aid management and operating decisions. In general, process control of some local objectives are frequently achieved. A proposal to implement a supervisory control strategy for Teniente Converters, in harmony with other process units in the smelter, is presented.

Keywords: Pyrometallurgy; Process control; Expert systems; Sulphide ores

1. Introduction

A diagnosis of the instrumentation and control system of a copper concentrate converter (Caletones Smelter, 1977) at Caletones Smelter, Chile, is presented. The origin of large variations in copper content of white metal and slug has been investigated. A control strategy was developed, in order to organize and coordinate the use of converter supplies to improve products quality. The strategy also considered the interaction with other process units and production goals. Similar works have not been discussed in the literature (Jämsä-Jounela, 2001).

2. Teniente converters in Caletones Smelter

Caletones Smelter is located at the Andes Cordillera, 42 km from Rancagua, at 1556 m over sea level, in Chile. Each day, over 3,800 tones of dried copper concentrate are fed into two Teniente converters (TC), obtaining two products: white metal and slag. The white metal is then processed in four Peirce Smith Converters (PSC), obtaining blister copper. The slag from TCs is processed in four slag cleaning furnaces (SCF). Two products are obtained: the matte that is returned to the TCs or PSCs, and the final slag that is dumped in the slag deposit.

Dried concentrate is pneumatically conveyed to the TC. Annular air is supplied to aid in the distribution of concentrate as it enters the converter. Reverts and flux are fed into the converter through a small bin, aid by blown air (‘garr gun’). Air and oxygen are combined to produce an enriched air stream, blown into the TC. The calculation of the oxygen flow rate is based on the combined air flow rates. A flow diagram showing all the input and output variables, and the local control system, are illustrated in Fig. 1.

The slag and white metal are discontinuously removed from opposite ends, and collected in ladles for further processing. Slag and white metal level measurements are manually taken every three hours. Approximately

* Corresponding author.
E-mail address: luis.bergh@usm.cl (L.G. Bergh).

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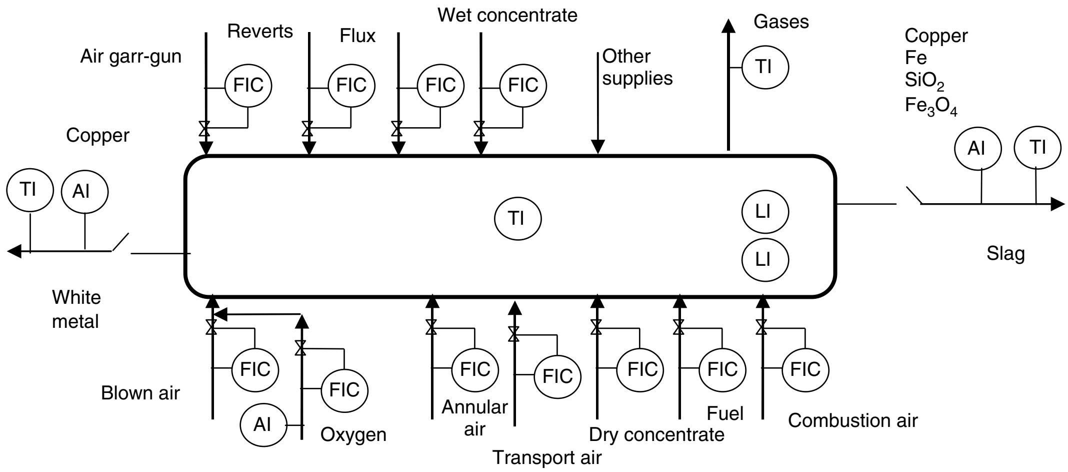

Fig. 1. Simplified TC flow and instrumentation diagram.

17 ladles of slag and 7 ladles of white metal are removed from the TC each shift. Hot gases exit the TC through an open port at the top of the converter. Gases are cooled, passed through an electrostatic precipitator and sent to a gas handling plant for processing.

The TC process is a semi-continuous and autogenuous reactor. A chalcopyrite concentrate first is thermally decomposed (Eqs. (1) and (2)), and then iron sulphide (Eqs. (3) and (4)) and sulphur (Eq. (5)) are oxidised, and the iron oxide (Eqs. (6) and (7)) form a fayellite slag in the presence of silica. The main reactions are:

$$4CuFeS_2 \rightarrow 2Cu_2S + FeS + S_2 \quad (1)$$

$$2FeS_2 \rightarrow 2FeS + S_2 \quad (2)$$

$$3FeS + 5O_2 \rightarrow Fe_3O_4 + 3SO_2 \quad (3)$$

$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2 \quad (4)$$

$$S_2 + 2O_2 \rightarrow 2SO_2 \quad (5)$$

$$2FeO + SiO_2 \rightarrow 2FeO \cdot SiO_2 \quad (6)$$

$$6FeO + O_2 \rightarrow 2Fe_3O_4 \quad (7)$$

The copper quality targets for the white metal and slag are 75% and 9% respectively. Approximately 3 samples per shift of the white metal are taken and analyzed for copper concentration. Slag samples are taken and analyzed each time slag is removed from the converter. The sample is moisture and chemically analyzed.

The current control system is comprised of a number of single loop controllers. Set points of the converter manipulated variables are determined by operators based on the current state of operations. The scheme for controlling the white metal and slag copper content is quite complex. Operators can manipulate several variables to affect the copper content in both the white metal and slag, including: air, oxygen, concentrate, reverts and flux flow rates.

3. Diagnosis

The current control scheme contains no coordination of concentrate flow, air flow and oxygen flow rates. The flux flow controller set point is determined by operators based on results of the slag chemical analysis, in particular the Fe and SiO_2 contents. A target Fe/SiO_2 ratio of approximately 1.6 is desirable in order to decrease slag viscosity and improve downstream copper recovery. The reverts controller set point is determined by operators based primarily on the slag temperature measurement. Reverts are used to cool the internal converter load. There is no automatic strategy in the current control system to maximize concentrate flow rate or reverts flow rate to maintain the copper concentrate in the white metal and slag. In order to show the effect of operator decisions, two sets of operating data for some months ago are shown in Fig. 2. The first set on the left was for an abnormal operation with large variability on the final objective variables, while the second set, on the right, corresponded to a better operation. Each period is two days long.

In general, it was found large product variability and a considerable recycle of products. The nature of the process propagates disturbances created in one process operation to others, increasing unnecessarily the recycling of intermediate products off specifications.

4. Supervisory control strategy

To improve the product quality and to decrease material recycling a better administration of local con-