Andreas Filzwieser, Thomas Prietl, Per-Lennart Nystedt, Peter Olsson

Implementation of the RHI COP KIN System in Peirce-Smith-Converters

Gas stirring systems, through the furnace bottom, have been used in various metal industries for more than 30 years. The gas is purged through different types of plugs, including porous plugs, multihole plugs, and single pipe plugs. In the steel and aluminium industry, stirring the metal bath is a common practise. However, in the copper industry whilst more gas stirring systems are being installed they are mainly in anode furnaces or holding furnaces. This paper describes the first use of a COP KIN System [1, 2] in a Peirce-Smith-Converter (PS-Converter) at the Boliden copper plant, Rönnskär, Sweden.

Introduction

The reasons for using a bottom gas stirring system vary depending on the furnace, process and gas used (inert gas or process gas). In general, there are three main reasons to use such a system:

1. The increased thermal and analytical homogenization of the molten bath due to the increased agitation effect.
2. The increased surface layer between the slag and the metal bath.
3. The presence of inert gas bubbles in the molten bath.

These effects can result in the following advantages:

>> decreased fuel and auxiliary material consumption
>> decreased slag overheating
>> decreased refractory wear
>> uniform chemical purity
>> decreased boundary layer
>> increased diffusion controlled reaction
>> increased metal recovery
>> decreased highly oxidized slag
>> decreased partial pressure of SO_2
>> decreased partial pressure of H_2O
>> decreased partial pressure of CO
>> system equilibrium reached more quickly

However, it is important to note the advantages listed above are specific to the particular process.

COP KIN System Implementation in PS-Converters

Target

In the early part of the 20th century the PS-Converter was developed. Currently, nearly 100 years later, the PS-Converter remains the dominant copper converting technology. At Boliden to convert matte, with a copper content of approximately 60%, into blister (99.0-99.5% Cu), eight steps need to be performed:

1. Charging
2. First slag blowing
3. First slag tapping
4. Matte blowing
5. Second slag tapping
6. Copper blowing
7. Tapping copperoxidic slag
8. Copper tapping

The implementation of the COP KIN System in a PS-Converter will have the following benefits on the various process steps:

Charging:

Normally, from the time the first ladle of matte is poured into the converter, to the start of the first slag blowing the converter is not used as a metallurgical reactor. However, with the option to inject air through porous plugs the iron slagging reaction will start immediately and the converter will be in operation from the very beginning.

First slag blowing and matte blowing:

The benefit of the COP KIN System during these two steps is not as significant, although the dead zone opposite the tuyeres will be agitated and the above mentioned advantages will be applicable in the converter process.

First and second slag tapping:

Using the COP KIN System it is possible to individually control the flow rate of each plug. Running the plugs near the endwalls at a maximum flow rate and all the other plugs at a minimum flow rate will create slag movement to the charging door. This will result in an easier slag removal combined with an improved separation of slag and white metal. Particularly during the second slag tapping, the removal of most of the fayalitic slag is important because the less fayalitic slag remaining in the converter, the more effective the slag work during the copper blowing will be, and the lower the amount of copperoxidic slag that will be produced.

Copper blowing:

In the second period of the converting process, termed copper blowing, white metal is converted into blister copper (equation 1 and 2).

$$2Cu_2S(l) + 3O_2(g) \leftrightarrow 2Cu_2O(l) + 2SO_2(g) \quad (1)$$

$$2Cu_2O(l) + Cu_2S(l) \leftrightarrow 6Cu(l) + SO_2(g) \quad (2)$$

While the white metal (Cu_2S) is still present in the bath, the purged gas will help to minimize the dead zone in the converter and increase the homogenization in the bath. At the end of the copper blowing, significant levels of copper oxides – and therefore, a copper oxide rich slag – will occur. During the second period, several effects can be seen as a result of using nitrogen as the purging gas:

1. The desulphurization is initiated earlier due to the decreased partial pressure of SO_2 in the bath.
2. The oxygen efficiency increases due to an improved agitation.
3. The surface area between the slag and blister copper increases.
4. The amount of copperoxidic slag decreases.

Copperoxidic slag tapping:
If the amount of copper rich slag is too high to retain all of it in the converter, the control of the individual plug flow rate will enable the slag to be tapped, as previously described.

Copper tapping:
To discharge a PS-Converter, with for example 300 tons of blister per cycle, takes at least one hour. However, with nitrogen as a purging gas, the converter can be used as a metallurgical reactor and the sulphur content can be reduced during the discharging period. If a stirring system is also installed in the anode furnace these two purging systems can work concurrently, and further optimize the process operation.

At Boliden, the most important goal is to reduce the amount of copperoxidic slag. However, because the blister copper at Boliden has to have a sulphur content less than 100 ppm it is necessary to over-blow the converter, which subsequently produces a high level of copperoxidic slag.

Investigations

In 2002, a COP KIN System was installed in one of the PS-Converters, at Boliden. In the first trial, only two porous plugs were used to determine if wear of the plugs in the converter would cause operational problems. After a normal operating period of 12 weeks, it was evident that no specific wear had occurred using the porous plugs. In the second trial, four plugs were installed and the operational safety and stability was evaluated. In the third trial, eight porous plugs were installed and this test was still ongoing at the time of writing this paper. The aim of the third and following subsequent tests is to determine if the use of porous plugs in a converter provides some metallurgical benefits to the process.

Results

The following results are from the preliminary investigations and whilst they give an indication of trends, further tests are required to expand and consolidate this data. The results presented are the average values for at least 50 blows.

A comparison of the process time for the last process step of Converter No. 1 (COP KIN System installed) and Converter No. 2 and 3 is detailed in Figure 1. Using Boliden´s process control system the time between nearly 100% blister copper and the final product (less than 100 ppm S) could be measured. During this process step the purged inert gas helped to initiate earlier desulphurization due to an increased bath agitation and a lower SO_2-partial pressure in the molten bath. These results revealed that on average a 5 minute reduction (nearly 20%) in the processing time was achieved in just the last process step. Converter No. 1 (COP KIN System installed) and Converter No. 3 are also compared in Figure 2 and 3. To ensure that any detected differences between the compared converters are due to the COP KIN System, figures from 2002, when no gas stirring system was installed in any of the converters, are also presented. During the test work some trends were observed including the fact that the amount of copper rich slag was decreased (Figure 2).

One reason for the slag reduction could be that the COP KIN System made the slag tapping easier and therefore, the amount of fayalitic slag remaining in the converter was reduced.

Figure 3 illustrates that whilst the amount of copperoxidic slag was decreased in Converter No. 1, the sulphur content was also decreased. Furthermore, the variation of the sulphur value present in the blister copper was much lower in Converter No. 1, than usually detected.

Summary

At Boliden´s copper plant in Rönnskär, Sweden, a COP KIN System was installed in a PS-Converter. Initial trials have indicated that the use of an additional bottom stirring system produces metallurgical benefits. Although further tests must be performed, the results were sufficiently encouraging that the installation of a second COP KIN System for Converter No. 3 is already in progress.

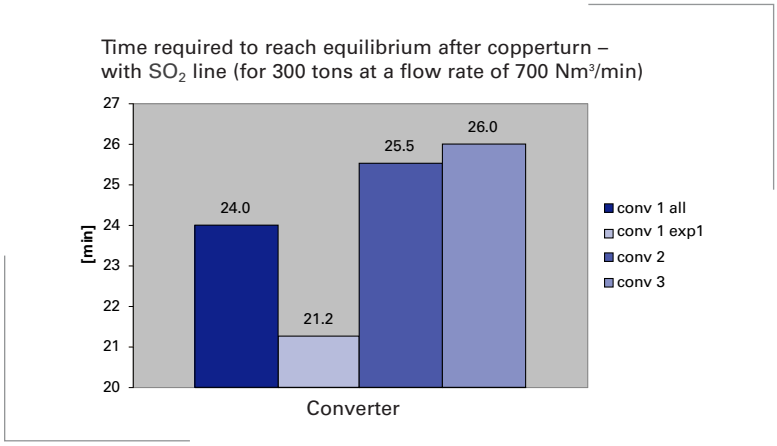

Figure 1. *Comparison of process time for converter No.1, 2 and 3.*

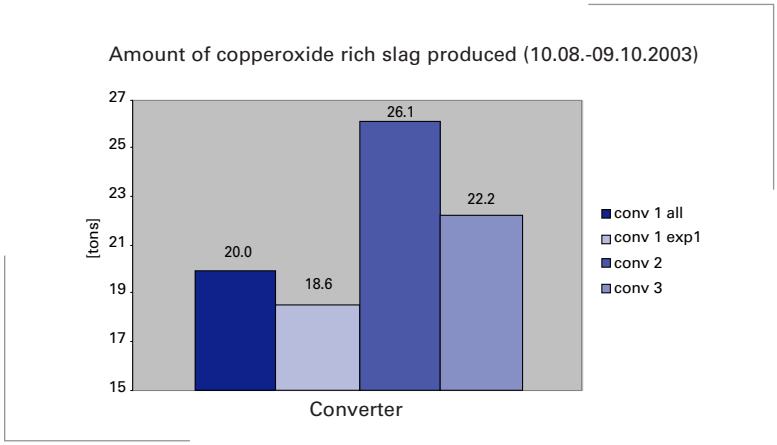

Figure 2. *Amount of copperoxidic slag in converter No. 1, 2 and 3.*

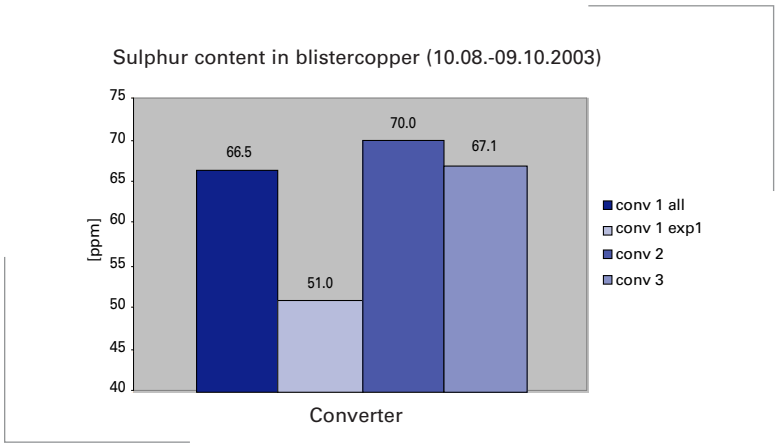

Figure 3. *Sulphur content in converter No. 1, 2 and 3.*

References

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[2] Rigby, J.; Filzwieser, A.; Wallner, S. and Caulfield, K.: The COP KIN System – Performance and benefits – a world wide overview, *Proceedings of Copper 2003/Cobre2003*, Santiago, Chile, 2003.

Authors

Andreas Filzwieser, RHI Refractories, Business Unit Non Ferrous Metals, Vienna, Austria.

Thomas Prietl, Christian Doppler Laboratory for Secondary Metallurgy of the Non Ferrous Metals, University of Leoben, Austria.

Per-Lennart Nystedt, Boliden Limited, Rönnskär, Sweden.

Peter Olsson, Boliden Limited, Rönnskär, Sweden.

Corresponding author: Andreas Filzwieser, andreas.filzwieser@rhi-ag.com