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CONTINUOUS COPPER SMELTING INVESTIGATIONS FOR DIRECT PRODUCTION COPPER FROM SULFIDE CONCENTRATES

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ABSTRACT

Blister copper as a primary product in one single vessel is one attractive approach and has always been the dream of all copper metallurgists [1]. This work investigations used for the new one continuous technological concept contain gas-stream separated process of smelting, slag cleaning and converting with continuous of melt in single vessel unit. Besides, it is needed additional preheating of melt with graphite electrodes in the slag finishing part of unit (0.6 % Cu). Finally, it is suggest high mate grade convert to blister simultaneous with calcium-ferrite slag formation (Cu_2O-Fe_3O_4-CaO).

Keywords: continuous copper smelting, calcium ferrite slag

1. PROCESS DESCRIBE

In pyrometallurgical processes for direct copper production from copper concentrate, the formation of discard slag with less then 0.5 % dissolved copper requires an oxygen partial pressure less than 10^{-3} Pa, while the formation of blister copper requires and oxygen partial pressure in excess of $10^{-1.5}$ Pa, and no single oxygen partial pressure can satisfy both of these requirements [2]. This was one of the main reasons for separation of the technological process in the multi-furnace system. With the multi-furnace system, it was then necessary to find a suitable converting furnace slag under a high oxygen partial pressure and the means to transfer continuously various kinds of melts, slag, matte and blister copper.

There is a trend to produce a higher copper matte in smelting by doing more oxidation in it. These smelting processes entail the need to recover metal values from slag in a separate operation, using electric furnace for reduction of slag, under conditions in which furnace volume contain low level of oxygen/SO_2.

Processing matte to blister copper needs increasing oxygen potential for cc one hundred times (from $10^{-3.5}$ up to 10^{-1} Pa, Figure 1). It is evident increasing content of magnetite, Fe_3O_4, in the melt during oxidation process, especially in the final part oxidation of FeS. Increase of magnetite in the melt results the increasing copper losses in the slag. High temperature in the smelting unit prevents copper losses in the slag.

2. THE CONTINUOUS SMELTING MODEL

Investigation in this area results the modern technological model for continuous smelting, without problem of magnetite, shown in the Figure 2. This technological concept made for Bor mine standard pyrite-chalcopyrite concentrates assay as follows: 20.3 % Cu, 28.7 % Fe, 33.8 % S and 10.2 % SiO_2.

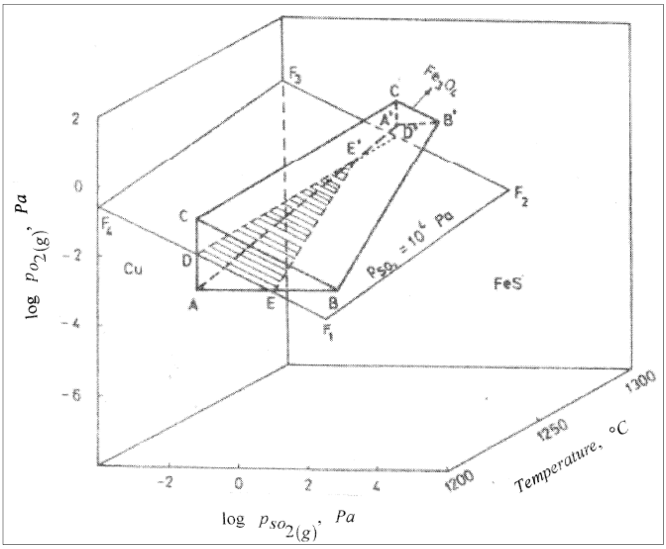

Figure 1. S-O-T potential diagram of Cu-Fe-S-O-SiO_2 system with Fe_3O_4 polyhedron in detail in F_{1-4} process plane.

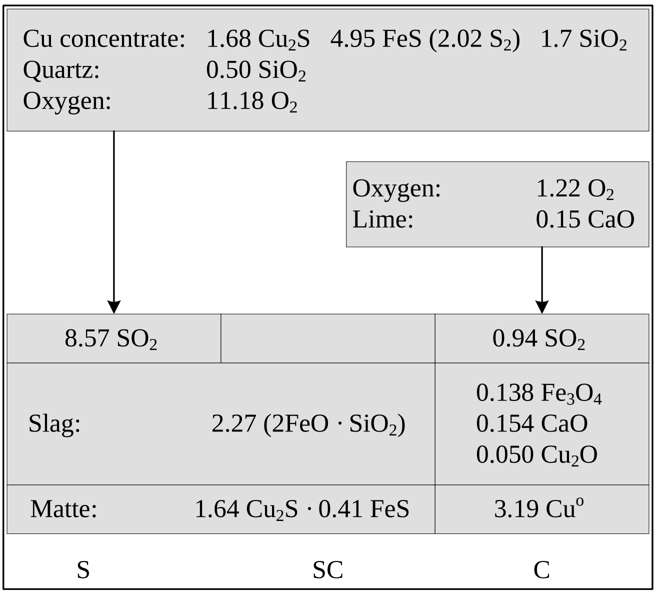

Figure 2. Continuous smelting technological model for standard concentrates in Bor smelting plant:

S melting
SC slag cleaning
C converting

With such a new type of slag, the oxidation reaction mechanism would differ from that in conventional copper blow operation. In conventional converters, the main reaction involved when white metal and blister copper coexist with each other is direct oxidation of Cu_2O with oxygen, as follow:

$$Cu_2S + O_2 = 2Cu + SO_2 \quad (1)$$

On the other hand, in the converting furnace, where the matte inlet is located with some distance from the tuyeres blow area, a considerable portion of matte entering the furnace immediately reacts with the slag to produce blister copper according to the following reactions:

$$Cu_2S + 2Cu_2O = 6Cu + SO_2 \quad (2)$$

$$3FeS + 10Cu_2O = 20Cu + Fe_3O_4 + 3SO_2 \quad (3)$$

The Cu_2O content in the slag is utilized for control of the sulfur content in the blister copper and the fluidity of the slag is sensitive to the changes of Cu_2O and CaO content in the slag. Therefore, the Cu content in the slag is the most important factor for the converting furnace operation control. The operation is stable when the Cu content is higher then 15 %, but the optimum range is 12 - 15 %, Figure 3.

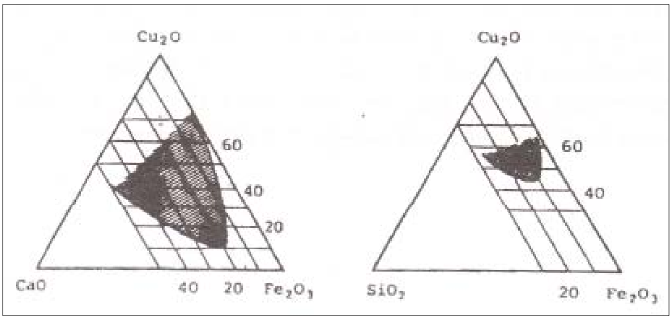

Figure 3. Low viscosity area Cu_2O-O-Fe_2O_3-CaO and Cu_2O-Fe_2O_3-SiO_2 slag on temperature 1250 ^oC.

Because of similar features, Fe_2O_3 is used instead of Fe_3O_4, in experiments [3]. As shown in Figure 3, the Cu_2O-Fe_2O_3-CaO slag has a wider low-melting temperature range than the Cu_2O-Fe_2O_3-SiO_2 slag and contains a less amount of Cu_2O [4, 5]. Because of this features, it was judged that the CaO slag would be more suitable in the actual operation. Within the low-melting temperature range shown in the figure before, the higher content of Cu_2O would improve the fluidity while the higher content of Fe_3O_4 would increase the viscosity. For practical purposes, it was found that sufficient fluidity would be obtained with 10 - 20 % Cu_2O and 15 - 35 % CaO.

3. CONCLUSION

The basic technological concept of continuous smelting Bor Mine sulfide concentrates is given in the paper. For realization this model in practice contain gas-stream separated process of smelting, slag cleaning and converting, so to keep low level partial pressure of SO_2 in the process smelting and converting. Besides, it is needed additional preheating of melt with graphite electrodes in the slag finishing part of the unit. Finally, it is suggest high matte grade convert to blister copper simultaneous with calcium-ferrite slag formation.

4. REFERENCES

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