CFD PREDICTIVE MODEL TO DETERMINE THE SEDIMENTATION AND COALESCENCE OF ENTRAINED COPPER DURING CONTROLLED COOLING PROCESS OF COPPER SMELTING SLAG

Copper Slag Processing: controlled cooling of copper slags prior to flotation treatment

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Introduction

Copper slag generated during the smelting stage of copper sulphide concentrate to produce matte, still contains considerable amounts of entrained copper (between 6-10 wt.% in Teniente converter technology) making necessary a subsequent treatment, in order to recover copper[1-3]. A new route that involves solidification/grinding/flotation of smelting slag is being widely applied[4]. Phenomena of sedimentation and coalescence of copper species, and crystallization and nucleation of matrix slag are relevant to understand the recovery of valuables.

During the controlled cooling process of copper smelting slag two principal phases are separated[5], a lower density phase located on the upper zone where a “slag matrix” is found together with few scattered copper species, and a higher density phase which is commonly named “copper matte button” located on the lower zone. The cooling rate of copper slag could clarify the optimal condition that allows to recover the valuable entrained copper.

Experimental

Industrial copper smelting slag from Teniente Converter technology was comminuted and homogenized, and then analyzed (main components are shown in Table 1. The slag was melted at 1350 °C under controlled atmosphere in a laboratory electric furnace, leaved it for different time inside the furnace after melting and then cooled at three different rates.

The results were incorporated into a CFD modelling developed using ANSYS Fluent software, allowing to performance simulations to clarify the behavior of entrained copper species during the controlled cooling of slag. The following kinetics, considering the phenomena of sedimentation and coalescence of copper species were experimentally performed and CFD simulated:

Set A: After melting at 1350 °C leaving the slag for 0, 2, 4, 8, 16 minutes inside the furnace and then abruptly quenched into water.

Set B: After melting at 1350 °C leaving the slag for 0, 2, 4, 8, 16 minutes inside the furnace and then cooled outside by natural convection into a N_2 atm.

Set C: After melting at 1350 °C cooling the slag until 1150 °C inside the furnace at controlled cooling rate of 10, 5, 3, 1 and 0.5 [°C/min].

CFD ANSYS simulations were carried out by using the "Mixture" model which applied to homogeneous flows with multiple phases[6].

Table1: Main components of copper slag determined by XRD, XRF and ICP analyses

Component	Cu_{Total}	$Cu_{Sol.}$	S	Fe	Fe_3O_4	SiO_2	Al_2O_3	CaO	Mg	Zn
(wt%)	12.5	4.2	3.5	37.9	23.7	22.1	2.6	1.0	0.7	3.8

Results

Experimental results show an increase in the concentration of two entrained phases (metallic copper and white metal) on the bottom zone of the crucible when the time after melting the slag inside the furnace was longer for the cases of quenching and natural convection cooling. The increase for the concentration of metallic copper phase was higher than that of white metal because of the lower density of the latter.

Controlled cooling rate simulations also show an increase in the concentration of both entrained phases toward the bottom of the crucible, but in this case it was widely affected by the control of temperature.

As is shown in Figure 1, it was possible to achieve in the bottom of the crucible, an increase from 4 to 90 wt% and from 10 to 84 wt% for metallic copper and white metal concentration, respectively, when the cooling rate was set at 0.5 °C/minute.

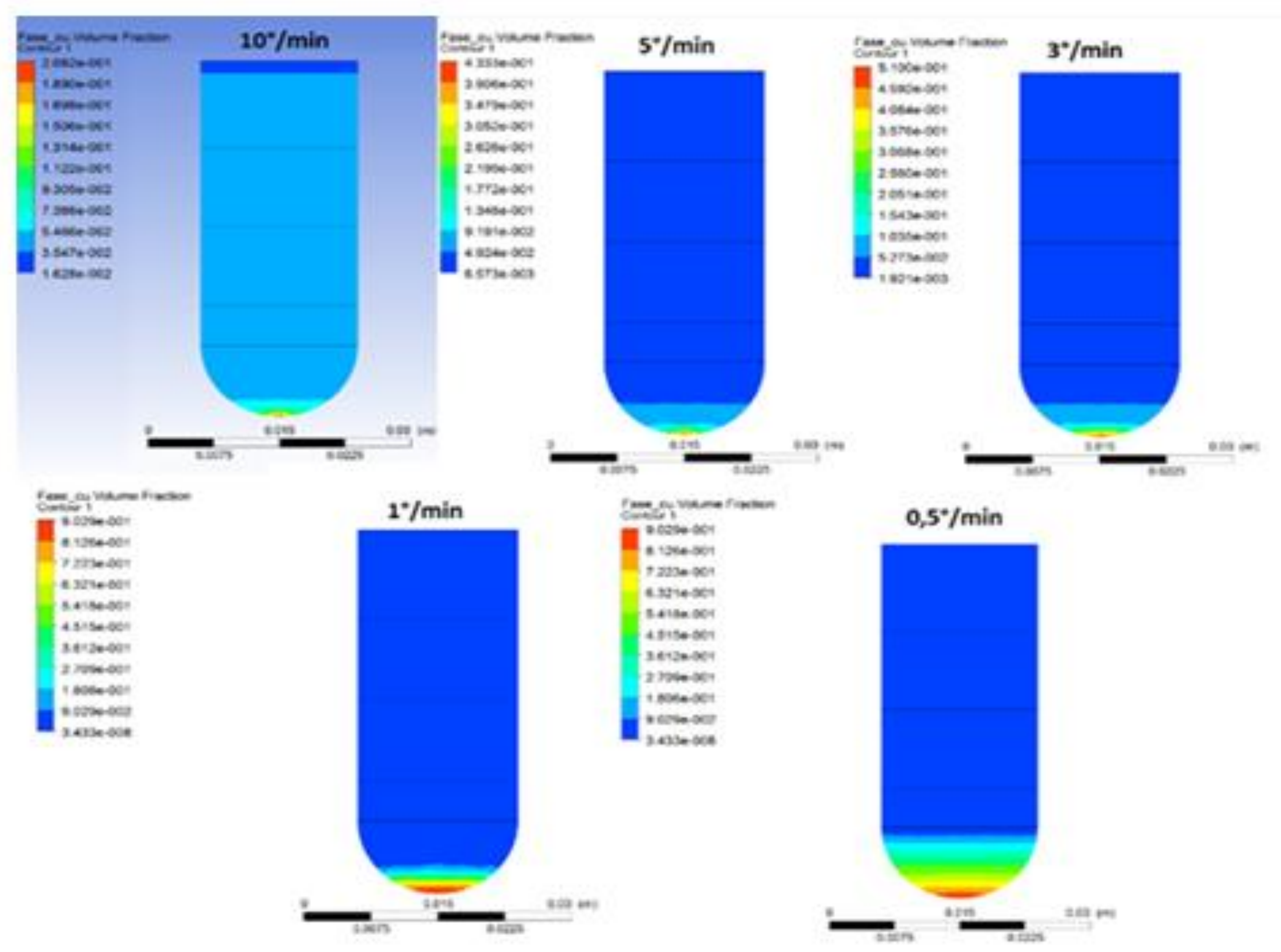

Figure 1: Distribution of copper species concentration inside the crucible for controlled cooling rate at 10, 5, 3, 1 and 0.5 °C/min

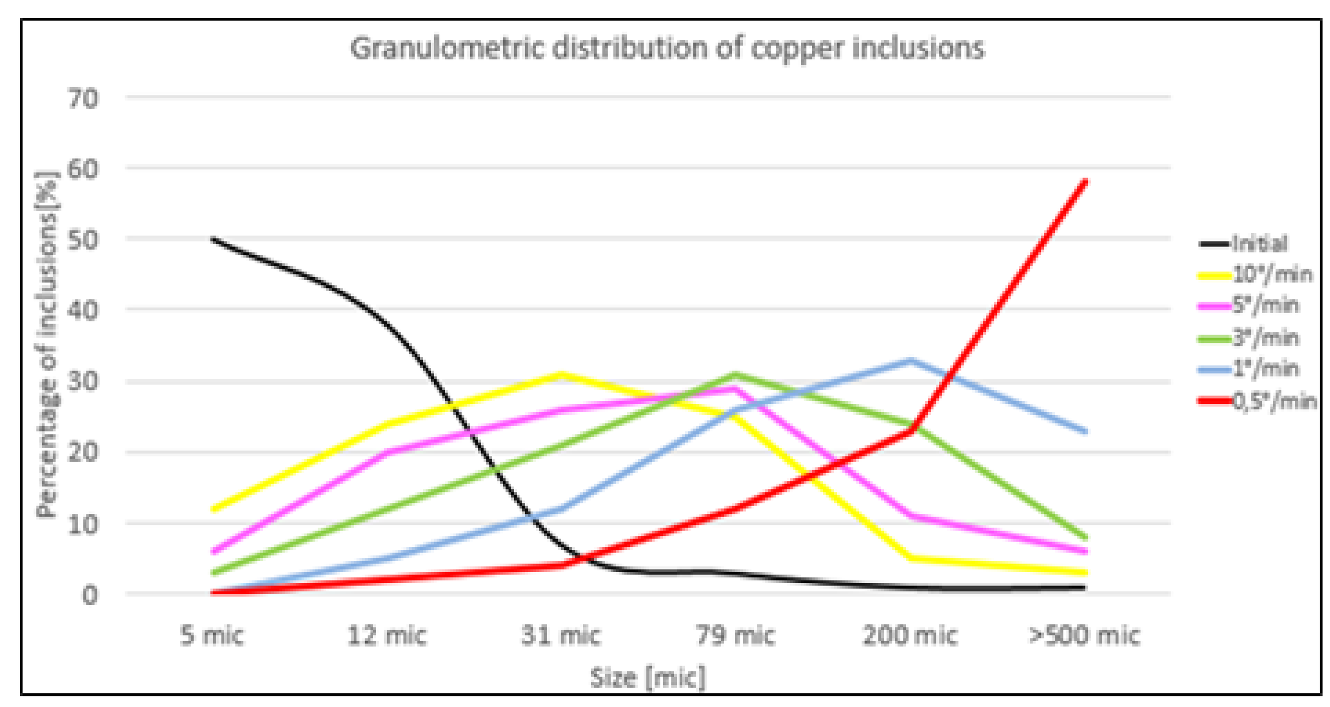

Figure 2: Metallic copper and white metal inclusions size distribution into the slag matrix toward the bottom of the crucible after controlled cooling of smelting slag

Conclusions

High recovery of entrained copper in the Teniente smelting slag could be achieved into the copper matte button because the improvement of sedimentation and coalescence phenomena. In this work, 38% of the entrained copper was distributed to the formed matte when the cooling rate was set at 0.5 °C/min (400 minutes of cooling) considering the corresponding experimental conditions.

The size of copper inclusion into the slag matrix toward the bottom of the crucible resulted to be larger for longer time of cooling because coalescence events.

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