Centrum Rzeczoznawstwa Budowlanego

Open Access Journal
Modern Engineering 3 (2020) 131-134
journal homepage: https://mengineering.eu/

MODERN ENGINEERING

Development of an energy-saving system for processing tin concentrates in a melt layer with phase inversion

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Abstract

An energy-saving scheme has been developed for a nonwaste processing system for refractory Sn-concentrates together with Zn-containing slags. The search for a new system was carried out in the following areas: the choice of a method for continuous, high-temperature and intensive processing of concentrates and the selection of high-performance melting equipment that implements this method; the formation of resource-saving technology; development of an energy-saving thermal scheme in the framework of which the selected melting equipment and non-waste technology will operate. In case of implementation of the proposed system, thermal efficiency will increase 1.42 times, and the total waste-free indicator will be 5.3 times higher than in existing fuming plants.

Keywords: energy efficiency, Sn refractory

1 Introduction

Syrymbet tin ore concentration concentrates contain 10-12% TiO_2, 32-36% Fe_{total} and, when melted, form refractory Fe-Ti compounds [6]. To obtain a melt that is acceptable in terms of fluidity and homogeneity of the melt, a process is required at a temperature above 1450^oC. A similar problem is present in the processing of dumped "poor" slags containing Zn in the form of zinc spinel, zinc ferrite and other refractory compounds, requiring 1400-1500^oC for their decomposition. In modern fuming furnaces using the traditional processing method — a melt bubbler layer and operating in a batch mode, the temperature in the melt bath does not exceed 1250–1300^oC [7]. The latter is associated with the design feature of the unit "fuming - furnace - boiler - utilizer", in which a temperature rise in the furnace bath above 1300^oC leads to unacceptable overheating of the pipe walls of the subsequent heat engineering elements (superheater, air heater). In addition to increasing the melting point of the slag, the presence of spinels also contributes to reducing the depth of distillation of tin, as in the Fe-Ti spinel slag before purging contains from 4 to 12% of tin. Due to the fact that the composition of spinels and their share in slags is extremely variable, it is difficult to quantify the tin fraction associated at the initial moment in the oxide; it can be only note that if such spinels cannot be destroyed during the recovery and sulfidation processes, then the final slag will be contain a residual amount of tin that does not correspond to the waste product. It does not contribute to the distillation of tin and its stay in slag SnO_2 in a form whose content reaches 2–3%, since the elasticity of tin dioxide vapor at fuming temperatures is small (0.03 mm Hg). In order to bring the tin content in slag to waste only due to reduction, a gas mixture with an oxidizer consumption coefficient is necessary α=0.55 . In this mode, a significant amount of iron will inevitably be restored simultaneously with tin, which leads to the formation of an alloy , which is undesirable due to settling in the form of crusts on the bottom of the furnace.

The search for an effective version of a new system for processing tin concentrates that meets modern requirements such as waste-free, energy-saving and environmental cleanliness was carried out in the following areas: the choice of a method for continuous, high-temperature and intensive processing of concentrates and the selection of melting equipment that implements this method; the formation of resource-saving technology, which corresponds to the lowest level of consumption of water, reagents, fluxes and a high degree of environmental protection; development of a thermal circuit in the framework of which the selected melting equipment and technology will operate in an energy-saving mode.

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Received 6 April 2020
Available online 15 September 2020
ISSN 2450-5501
Published by Centrum Rzeczoznawstwa Budowlanego

The experiments were carried out on dump "poor" slags (Zn≤3.5%) containing zinc spinels, zinc ferrite and other refractory compounds using a new method - a phase inversion melt layer implemented as a continuous phase inversion reactor – tube furnace aggregate (RIF-TP) and stably working with melt overheating in the temperature range 1300-1500^oC proved the effectiveness of this equipment in comparison with existing fuming furnaces [2].

For the formation of an effective technology, the most appropriate is the joint processing of Sn-concentrates and "poor" Zn-containing slags. According to [5], the zinc oxide contained in the melt prevents the accumulation of metallic iron and tin metal, contributing to the stripping of Sn and the conversion of Fe to slag by reactions:

$$[Sn]_{SPLAV} + (ZnO)_{SH} = SnO^G + Zn^G \quad (1)$$

$$[Fe]_{SPLAV} + (ZnO)_{SH} = (FeO)_{SH} + Zn^G \quad (2)$$

In this case, the limiting stage of the Sn stripping process will be the diffusion rate of ZnO to the reaction surface, which makes it possible to calculate the productivity and fuel consumption of the melting reactor using the technique presented in the work [4].

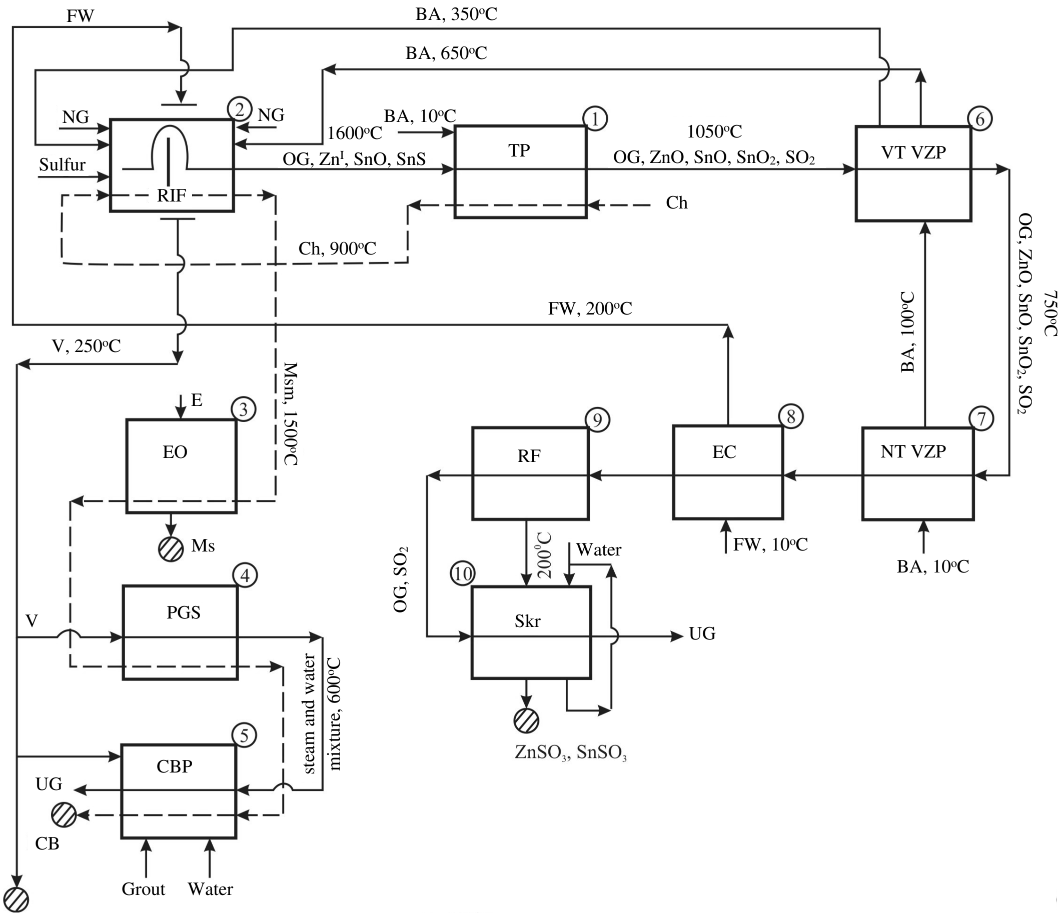

Figure 1. The thermal scheme of the joint processing of tin concentrates with zinc slag

Based on the calculated characteristics of the RIF-TP unit, a variant of the heat scheme of the joint processing system for Syrymbet concentrates and dump zinc-containing slag of the former Chimkent Lead Plant ($ChLP$) was developed (Fig. 1). Based on the experimental data [1], calculation of material and heat fluxes, the thermal and temperature graphs of the proposed system are constructed (Fig. 2).

Legend: 1 – tube furnace (TP), 2-2^x - chamber phase inversion reactor (RIF), 3 – electric sedimentation tank (EO), 4 – steam slag granulation (PGS), 5 – cinder block production (CBP), 6 – high-temperature air heater (VT VZP) 7-low-temperature VZP (NT VZP), 8 – economizer (EC), 9 – bag filters (RF), 10 – scrubber (Skr), Ch - charge, Ms - matte slag, Msm - melt slag matte, CB - cinder blocks, NG - natural gas, E - electricity, BA - blast air, FW - feed water, V - steam, OG, UG - exhaust gas, η_{heat} - fraction of heat used in the heat balance of the element, η_{lost} - fraction of heat loss to the environment environment from the total heat entering the system element, η_{vap} is the fraction of heat for steam generation in the caissons of the reactor, η_{OG} is the fraction of heat with exhaust gases [3].

2 The principle of the system

The process is continuous. The mixture, consisting of zinc-poor slag and pellets of tin concentrate, is loaded into a tube furnace (1), where, after heating the mixture with counter-high-temperature RIF gases (2), it enters the first section of the reactor.

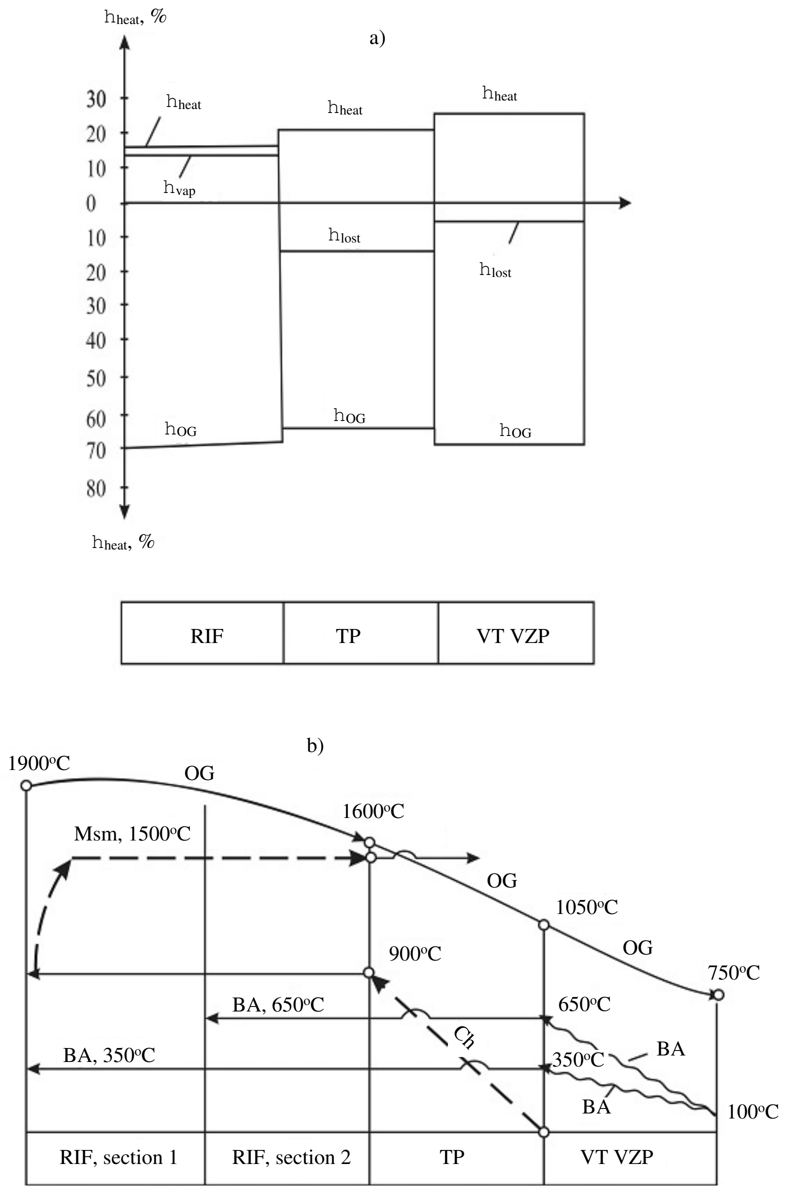

Figure 2. Estimated thermal a) and temperature b) graphs of the main elements of the tin concentrate processing system

In the first RIF section, elemental sulfur is blown into the melt and, in regime s, $\alpha \sim 1$, the mixture is melted and the melt is overheated to a temperature of 1500^oC. In the second chamber, in the reduction-sulphiding mode, s $\alpha \leq 0,7$, sublimation of tin is carried out in the form SnS, SnO , and zinc - Zn^G. The slag melt, which is depleted of sublimated components, is sent to the electric sump (3), where copper-containing matte is separated from the slag.

Next, the melt enters the steam granulation chamber of slag (4) and then into production (5) for the manufacture of slag block products. Part of the matte, after cooling and crushing, is sent to a tubular furnace (1), as a circulating sulfidizer in the RIF. In a tube furnace (1), together with the exhaust gases, atmospheric air is supplied for afterburning of the combustible gas components, tin sulfides and oxidation of lead and zinc vapors. Afterburning products are sent to a high-temperature air heater (VT VZP). The exhaust gases of a VT VZP containing sulfur dioxide, zinc and tin sublimates are fed for cooling to a low-temperature NT VZP (7), then to an economizer (8), and then to purge from sublimates into bag filters (9). Gases after the Russian Federation (9) containing compounds of sulfur, arsenic and other elements are washed in a scrubber (10) with an aqueous suspension of sublimates. Zinc and tin sulfites isolated in a scrubber (9) are sent to hydrometallurgical processing. The steam obtained as a result of heating feed water in the economizer (8) and in the evaporative cooling caissons of the reactor (2) is used in cinder block production (4), (5) and for covering own needs.

The proposed system (PS) with a charge capacity of 4 t/h has the following forecast characteristics:

- thermal efficiency of PS is $\eta_t^{Sn} = 65.5\%$;
- utilization rate of thermal waste of the phase inversion reactor $\eta_{T.O}^{ISP} = 51.5\%$;
- the total indicator of the target extraction of useful components of the feedstock and materials (non-waste indicator) Ψ =58%.

3 Summary

Article shows, that if this solution is implemented, the thermal efficiency of the substation will be 1.42 times higher than in the slag-distillation plant (46%), the RIF heat waste utilization factor is 3.68 times higher than in the fuming furnace (14%), the total non-waste indicator will be 5.3 times higher than in the slag-distillation plant, (11%) [1], and the profit from sales ~100 million tons/year gives payback period 1.8 years.

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