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PHENOMENON OF SINTER NETWORK FORMATION OF ZnO IN HIGH-TEMPERATURE ENVIRONMENTS

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Abstract

The process of sintering oxidation of zinc and lead sulfide concentrates is discussed. The process product is Zn–Pb sinter, the main metal-bearing ingredient for the ISP shaft furnace. Zn–Pb concentrates contain three principal metal sulfides: ZnS, PbS and FeS_2,of which ZnS plays the main role in forming the Zn–Pb sinter structure. It was decided to investigate the formation of ZnO crystallites.

Zn–Pb sinters obtained on a D-L sinter belt (operating temperature 1250–1350°C) were subjected to SEM observations with simultaneous micro-X-ray analysis of sites chosen in the field under observation; ZnO crystallites formed as a result of the oxidation of ZnS have a typical dendrite structure leading to the formation of 'sinter networks'; their structure is illustrated by SEM microphotographs.

Keywords: metallurgical process, non-ferrous metals, Zn–Pb sinter

Introduction

This paper relates to the process of roast sintering of zinc and lead sulfide concentrates. The sintering product is Zn–Pb sinter, which constitutes the main metal-bearing ingredient of the batch dosed into the ISP shaft furnace (Fig. 1).

This sinter is the initial raw material for making zinc and lead by the ISP method. Besides the required chemical composition, it should have appropriate physicochemical features and crystal structure, both of which influence the strength (resistance wear, squeezing) and 'sinter permeability', which are strictly related with the reduction process. Zn–Pb sinters contain three basic metal sulphides; ZnS, PbS and FeS_2; ZnS plays the most important role in constituting the Zn–Pb sinter structure [1–5]. It was decided to investigate the formation of ZnO crystallites.

Examinations and results

Zn–Pb sinters obtained during the roast sintering process on D-L sinter belts (processing temperature: 1250–1350°C) were subjected to SEM investigations

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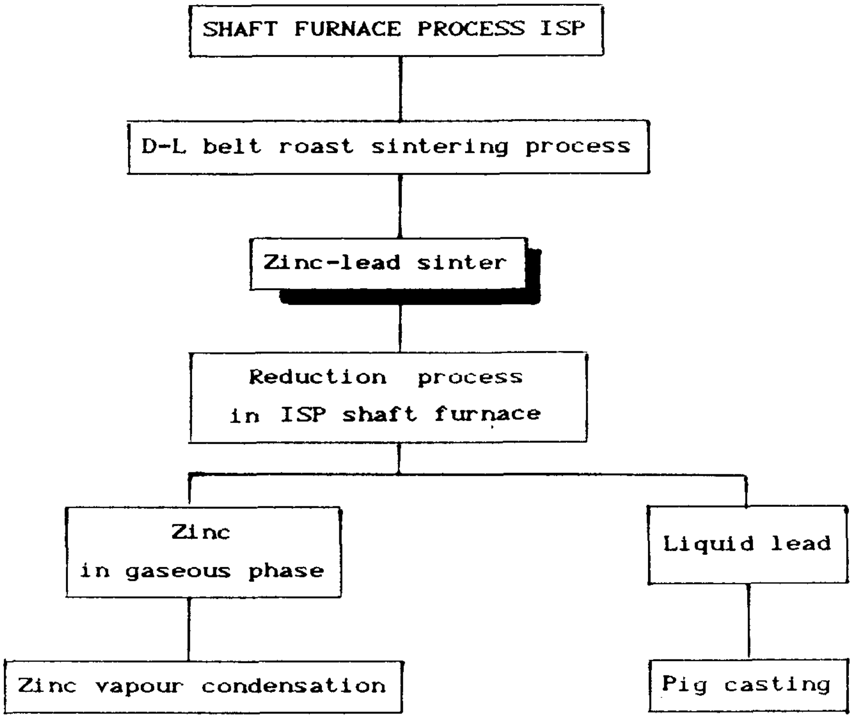

Fig. 1 A simplified scheme of producing zinc and lead in the ISP shaft furnace

with simultaneous micro-X-ray analysis of sites chosen within the field under observation; particular attention was paid to ZnO crystallites that appeared in the process of roast sintering in accordance with the reaction:

$$ZnS_{(s)} + 1.5O_2 \rightarrow ZnO_{(s)} + SO_2$$

The Zn–Pb sinters were investigated with a JEOL scanning electron microscope and an IXA-50A X-ray microanalyser with a KEVEX X-ray radiation dispersion spectrometer system. Fractures of Zn–Pb sinters were subjected to investigation. In parallel, qualitative analysis was carried out on the chemical composition in the micro-region under observation and at certain points. The observation results are presented as microphotographs in the following Figures.

ZnO crystallites have a dendritic structure (Fig. 2). In turn, the Zn–Pb sinter contains visible ZnO crystallites forming a 'sinter bridge' (Fig. 3). A typical fragment of ZnO crystallites formed as a 'sinter bridge' is presented in Fig. 4. Further, Figs 5 and 6 demonstrate the interesting formation of ZnO crystallites on a Zn–Pb sinter fracture, while Figs 7, 8 and 9 present ZnO crystallites appearing in the Zn–Pb sinters.

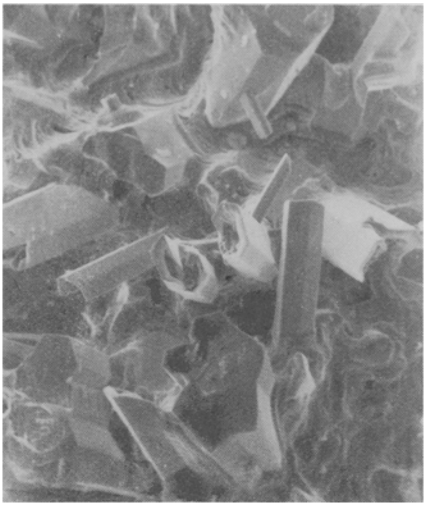

Fig. 2 Fracture of Zn–Pb sinter specimen. Visible ZnO dendrites. SEM, 2000×

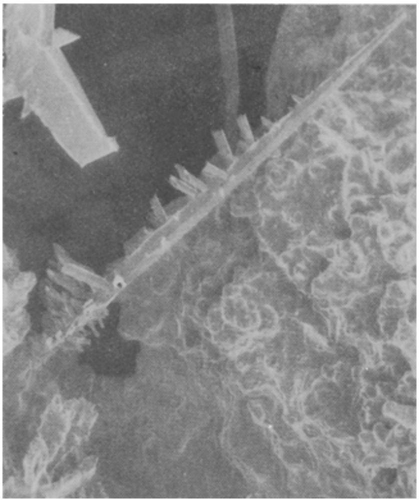

Fig. 3 Fracture of Zn–Pb sinter specimen. ZnO dendrite visible in the field of vision. SEM, 1000×

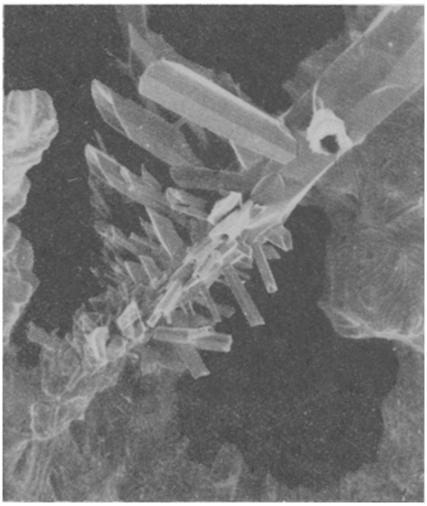

Fig. 4 ZnO dendrites in Zn–Pb sinter. SEM, 2000×

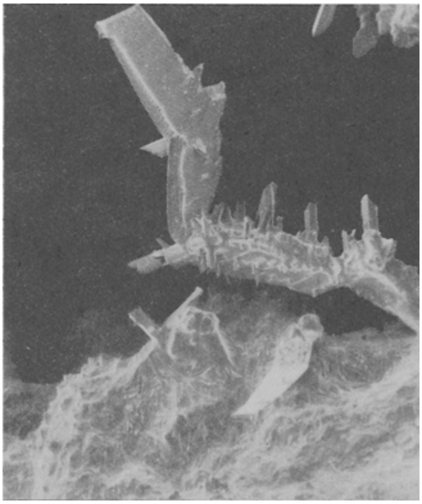

Fig. 5 ZnO dendrites forming a sinter bridge. SEM, 1000×

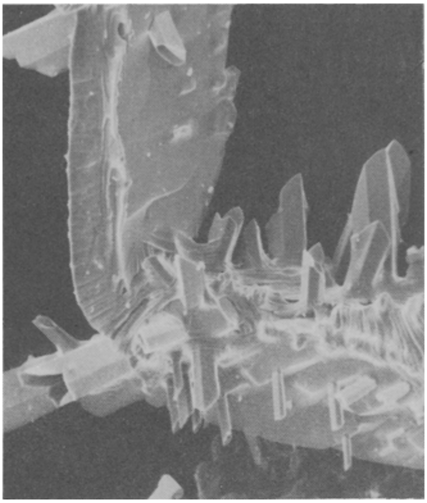

Fig. 6 ZnO dendrite in Zn–Pb sinter. The dendrites form a sinter bridge. SEM, 2000×

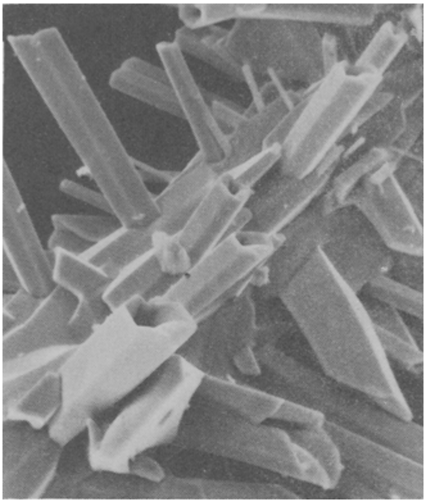

Fig. 7 ZnO crystallites forming a sinter bridge. SEM, 2000×

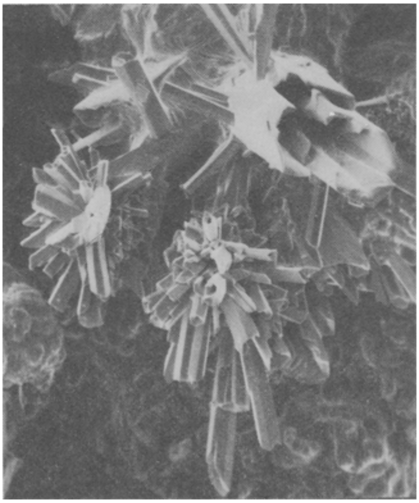

Fig. 8 ZnO crystallites in Zn–Pb sinter. SEM, 1000×

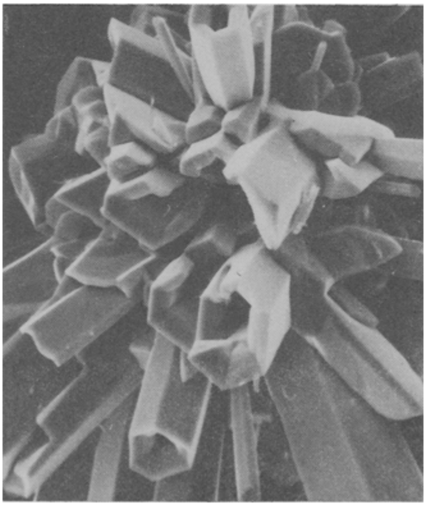

Fig. 9 ZnO crystallites from sinter bridge in Zn–Pb sinter. SEM, 2000×

The shape of the ZnO crystallites corresponds to the ZnO model developed by Benard [6].

Conclusions

As concerns the ISP shaft process, the physical properties and the structure of the Zn–Pb sinters appreciably influence the course of the reduction process, the reoxidation of Zn vapour and the slag-forming process (Zn and Pb slag contents) in the shaft furnace. The 'sinter bridges' made of ZnO that are uniformly distributed in the solid space of the sinter constitute a frame leading to an increase in the strength properties of the sinter. During the reduction process in the upper zone of the shaft furnace, lead compounds are reduced and in parallel the relative surface and the porosity of Zn–Pb sinters develop. Due to the 'sinter bridges', these regions preserve their shape and systematically develop their specific surface. Subsequently, the reduction of ZnO and zinc ferrites occurs in the nozzle zone as follows:

$$2ZnO+C \rightarrow 2Zn+CO_2 \qquad (1)$$

$$ZnO+CO \rightarrow Zn+CO_2 \qquad (2)$$

The courses of these reactions are in strict relation with the mentioned properties of the Zn–Pb sinter.

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Zusammenfassung — Es wird der Vorgang der Sinteroxidation von Zink- und Bleisulfidkonzentraten diskutiert. Das Produkt dieses Vorganges ist ein Zn–Pb sinter, der wichtigste metallhaltige Zusatz für ISP Schachtöfen. Zn–Pb-Konzentrate erhalten drei grundsätzliche Metallsulfide: ZnS, PbS und FeS_2 spielen die Hauptrolle bei der Bildung der Zn–Pb–Sinterstruktur. Man beschloß die Untersuchung der Bildung von ZnO-Kristalliten.

Zn–Pb-Sinter von einem D-L-Sinterband (mit einer Betriebstemperatur von 1250–1350°C) waren das Objekt von SEM-Beobachtungen mit simultaner Mikro-Röntgenanalyse von Stellen des beobachteten Bereiches; die im Ergebnis der Oxidation von ZnS gebildeten ZnO Kristallite besitzen eine typische Dendritstruktur, die zur Bildung von 'Sinternetzen' führt; deren Struktur wird anhand von SEM-Mikrofotografien illustriert.