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PREDICTION OF ZINC AND LEAD BEHAVIOR DURING STEEL ELECTRIC SMELTING

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The balance of zinc and lead is calculated during steel smelting in an electric arc furnace (EAF). It is shown that the main proportion of zinc and lead is removed from metal during charge melting in an EAF, and the remaining amount evaporates during steel degassing. With an increase in the proportion of galvanized steel in a charge, dust formation and zinc and lead contents in EAF discharges increase considerably. In order to determine a strategy for treating zinc-containing dust, it is necessary to monitor its content in all production stages.
Keywords: *zinc, lead, steel smelting, electric arc furnace, steel degassing, dust formation.*

It is well known that there is zinc and lead together with a charge in an electric arc furnace (EAF). Normally, these elements evaporate in the charge melting period [1, 2], but since there is no separate collection of zinc-containing dust in domestic practice, an averaged dust composition is collected in bag filters for all smelting periods. Normally, the zinc and lead content in a charge is uncontrolled, and therefore their content in dust varies over wide limits; according to data in [3–5] from several percent to 45%. If it is assumed that a whole charge consists of galvanized steel containing 3% Zn, dust formed during EAF melting the zinc content is about 30 kg/ton of steel (this is usual 50% or more), and the specific formation of dust is doubled. In view of this in producing steel in an EAF monitoring zinc and lead content with the aim of predicting possible dust composition and developing methods for processing it is an important task.

As a rule, charge materials are not analyzed for zinc and lead content since it is assumed that these metals evaporate entirely on heating and melting a charge in an EAF. Approximate evaluation of the amount of them in a charge is made on the basis of indirect data, i.e., some data for steel 20 records in an OMK Stal EAF-190/160. Missing data are determined by experiment or calculation.

Calculations [6] by a procedure in [7] take account of blowing intensity of a bath with oxygen show that during melting 156.1 tons of metal in an EAF there is formation of 4.79 tons of dust or 30.7 kg/ton of steel. Then the metal is degassed, during which there is also dust formation. Elemental analysis of dust samples has shown presence of zinc and lead not only in EAF dust (16.3 and 1.3%, respectively), but also in degasser dust (4.61 and 1.61%, respectively), and the zinc content within it appeared to be higher than in EAF dust.

On the basis of these data, the amount of zinc and lead was evaluated entrained together with dust from an EAF. With dust formation in an amount of 4.79 tons, the zinc content within it is $(4.79 \cdot 16.3)/100 = 0.781$ ton or 781 kg, and for lead it is $(4.79 \cdot 1.3)/100 = 0.062$ ton or 62 kg.

According to the melting record, liquid metal after total charge melting in an EAF contains 0.0023% Zn and 0.0010% Pb or $(156.1 \cdot 0.0023)/100 = 3.6$ kg Zn and $(156.1 \cdot 0.001)/100 = 1.56$ kg Pb.

The zinc and lead content in a charge (172.7 tons) including the amount of that evaporated and remaining and is $781 + 3.6 = 784.6$ kg Zn (0.45%) and 63.56 kg Pb (0,04%). These are not very high values proceeding from the fact that for galvanized steel the average zinc content is about 3.5% (lead content an order of magnitude lower).

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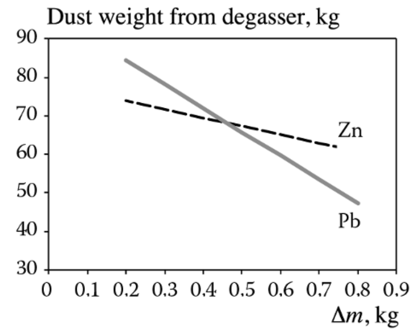

Fig. 1. Determination of dust weight formed during steel degassing.

TABLE 1. Sample Balance of Zn and Pb during Melting Steel 20 in an EAF Followed by Degassing

Source	Zn	Pb
	kg / %	kg / %
Charge (calculation)	784.6 / 0.45	63.56 / 0.04
EAF dust (chemical analysis)	781 / 16.3	62 / 1.3
Melt (melting certificate)	3.6 / 0.0023	1.56 / 0.001
Degasser dust (chemical analysis)	3.14 / 4.61	1.1 / 1.61
Steel after degassing (calculated)	0.46 / 0.0003	0.46 / 0.0003
Degree of extraction in EAF	– / 99.54	– / 97.5
Degree of extraction during degassing	– / 86.9	– / 70.2

Metal enters a degasser containing zinc 0.0023% (3.6 kg) and lead 0.0010% (1.56 kg). The amount remaining after degassing Δm_{Zn} equals the difference in the amount entering m_{Zn} equals 3.6 kg, and removed together with dust: $\%Zn \cdot X_{dust}$, where X_{dust} is amount of dust formed in a degasser (missing data) that requires evaluation: $\Delta m_{Zn} = m_{Zn} - X_{dust} \cdot \%Zn/100 = 3.6 - X_{dust} \cdot 4.61/100$. Similarly for lead $\Delta m_{Pb} = m_{Pb} - X_{dust} \cdot \%Pb/100 = 1.56 - X_{dust} \cdot 1.61/100$.

We compose a set of equations with three unknowns:

$$X_{dust} = (3.6 - \Delta m_{Zn}) \cdot 21.7,$$

$$X_{dust} = (1.56 - \Delta m_{Pb}) \cdot 62.1.$$

This system may be resolved graphically proceeding from the dependence of X_{dust} on Δm_{Zn} and Δm_{Pb} (see Fig. 1). The point of intersection of the curves obtained shows the amount of dust formed: X_{dust} = 68 kg or 0.44 kg/ton of steel. According to the results obtained, the degree of zinc removal from melt during degassing is 86.9%, and for lead it is 70.2%.

The balance of zinc and lead during electric melting is provided in Table 1. According to calculation after degassing the zinc and lead content in metal will be low (0.0003% each).

Conclusion. The concentration of zinc and lead in electric steel melting dust with their content in a charge of 0.45 and 0.04% is 16.3 and 4.61%, respectively. The degree of their extraction from metal in an EAF comprises 99.5 and 97.5%, and in a degasser 87 and 70%, respectively. With an increase in the proportion of galvanized steel in scrap, the zinc concentration in EAF dust may increase for example by a factor of two to three. Dust formation increases sharply, especially in the melting period, and therefore it is necessary to monitor the content (in particular zinc) in all production stages with the aim of correct organization of the production process, collection systems, and gas cleaning in different melting periods, and also during transportation and process of the dust collected.

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