CHEMISTRY

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1957

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Abstract

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CHEMISTRY

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ACTIVITY OF ZINC OXIDE IN LEAD- AND COPPER-SMELTING SLAGS SUBJECTED TO FUMING

(Presented by Academician S. I. Vol' fkovich, June 22, 1956)

In the experimental study of the fuming of copper-smelting slags it was established that, in the course of fuming, a state close to equilibrium is attained in the liquid-gas interaction. From the experimental data, the activity coefficients of zinc oxide in the slag were calculated. For slags of the following composition (in %): SiO 22-26; Al O 5-7; Cu 1.2-2.5; CaO and MgO up to 1.0-1.5; Zn up to 5-6 (FeO—the remainder), it proved to be equal to 0.95-0.97.

For the sake of simplification, in all subsequent calculations the activity coefficient of zinc oxide was taken as equal to unity. The discrepancies between the calculated data and the results of observations for slags containing less than 10% zinc amounted to 5-10%. There is no doubt, however, that both for slags containing relatively small amounts of zinc and, especially, for slags containing more than 10% zinc, taking account of the activity coefficient of zinc oxide in slags is useful.

In the present work, determinations were made of the activity of zinc oxide in lead-smelting slags of the following composition (in %): Zn 16.9; Pb 3.6; SiO 19.3; CaO 7.4; MgO 6.3; Al O 5.1; S 1.5; FeO 39.4. For the calculations the following initial data were adopted: air consumption 450 m^3/min; coal consumption 90 kg/min; slag charge 55 t; process temperature 1150° at the beginning and 1225° at the end of the process. Composition of the coal (in %): fixed carbon 61.3; volatiles 20.9; ash 17.7; hydrogen about 4-5 (the remaining constituents were not taken into account for the sake of simplification). The rates of zinc fuming were determined every 20 min from the curve in Fig. 1 ([1]).

Fig. 1. Kinetics of zinc fuming from slag: *a* —air, *b* —air-oxygen (O content in the blast 24.8%)

To calculate the magnitude of the activity of zinc oxide in the slag, it is necessary to consider the interactions:
(ZnO) slag +CO (gas) = Zn (gas) +CO_2 (gas) (a),
(ZnO) slag +H_2 (gas) = Zn (gas) +H_2O (gas) (b),
and also the reaction: $H_2O + CO = H_2 + CO_2$ (c).

Of the three reactions indicated, any two are independent. Consequently, to calculate a_{ZnO} one more equation is needed. It is usually obtained by drawing up a material balance for one of the participating substances (in our case, for oxygen).

We shall use, as the best studied, reactions (a) and (c). The equilibrium constant of reaction (a) is expressed by the following equation, which shows satisfactory agreement with experimental data ([2]):

$$\lg K_{(a)} = -\frac{9680}{T} + 6.12. \quad (1)$$

Good agreement with the experimental data is also shown by the following equation, expressing the dependence of the equilibrium constant of reaction (b) on temperature:

Table 1

Change in the activity of zinc oxide during slag blowing

Time (min)	Zinc content (%)	Activity of zinc oxide	Activity coefficient of zinc oxide
0–20	16.8–14.3	0.141	0.88
20–40	14.3–12.1	0.122	0.91
40–60	12.1–10.0	0.103–0.108	0.90–0.94
60–80	10.0–7.9	0.093	0.95
80–100	7.9–6.0	0.078	1.0
100–120	6.0–4.3	0.055	1.0
120–140	4.3–3.3	0.0385	0.97

$$\lg K_{(b)} = \frac{1734}{T} - 1.583. \quad (2)$$

Let c, b, k, and a denote, respectively, the number of moles of carbon, hydrogen, oxygen, and nitrogen in the coal.

The gas mixture leaving the slag consists mainly of the following components: Zn, N_2, H_2, H_2O, CO, and CO_2. Their amounts at equilibrium will be: $|\mathrm{Zn}| = z$; $|\mathrm{N}_2| = a$; $|\mathrm{H}_2| = x$; $|\mathrm{H}_2\mathrm{O}| = b - x$; $|\mathrm{CO}| = y$; $|\mathrm{CO}_2| = c - y$, or in total

$$M = c + b + z + a.$$

From processes (a) and (b) we have:

$$a_{\mathrm{ZnO}} = \frac{(c-y)z}{K_{(a)}\, y(c+b+z+a)}; \tag{3}$$

$$K_{(b)} = \frac{(c-y)x}{y(b-x)}. \tag{4}$$

The oxygen balance gives:

$$x+y+z = 2(c-k) + \frac{1}{2}b. \tag{5}$$

The values of z were calculated from the curves in Fig. 1. The remaining unknowns and the values of a_{ZnO} were found by simultaneous solution of equations (3)–(4).

The results of calculating fuming with air blast, summarized in Table 1, show that in the case of lead slags, when the zinc content in the slag is less than 8%, the activity coefficient of zinc oxide is close to unity (0.95–0.97), while at a zinc content of 15% it decreases to 0.88–0.90.

In Fig. 2, for convenience of calculation, a curve is given for the dependence of the activity of zinc oxide on the zinc content in the slag. The agreement of the indicated dependences for slags of lead and copper smelting of the above compositions is noteworthy.

Fig. 2. Activity of zinc oxide in slag as zinc is distilled off: *a*—lead-smelting slag, air; —the same with an O_2 content in the blast of 24.8%; —copper-smelting slag.

The authors express their sincere gratitude to Academician S. I. Volfkovich for reviewing the manuscript and for valuable comments.

Ural Scientific-Research
and Design Institute of the Copper Industry

Received
22 VI 1956

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Note: Figure translations are in progress. See original paper for figures.