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THERMAL ANALYSIS OF CARBIDE SLAG SOLUTIONS

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Abstract

A model of slag refining processes and a method of determining the reduction capability of slag solutions are presented. Carbide slags were analysed by DTA methods.

Keywords: carbide slag, DTA

Introduction

The extraction of metallurgical slags can be intensified by the addition of carbides [1–3]. It is claimed [2] that ions of carbon and other elements of carbides readily reduce oxides, e.g.

$$Cu_2O + C \rightarrow 2Cu + CO, \quad \Delta G^{\circ}_{1500K} = -358 \text{ kJ}\cdot\text{mol}^{-1} \tag{1}$$

$$3Cu_2O + CaC_2 \rightarrow 6Cu + CaO + 2CO, \quad \Delta G^{\circ}_{1500K} = -665 \text{ kJ}\cdot\text{mol}^{-1} \tag{2}$$

The author [4, 5] has previously demonstrated possibilities for the estimation of carbides. The present paper discusses a way to analyse slag solutions.

Model scheme

A model scheme of the real processes of metallurgical slag refining (Fig. 1) is shown in Fig. 2. The symbols used in Figs 1 and 2 are explained as follows:

A gaseous substances from the atmosphere,
B gaseous substances from the slag solution,
MA melting atmosphere,
SS slag solution,
R elements of carbide reductor,
M molten metal.

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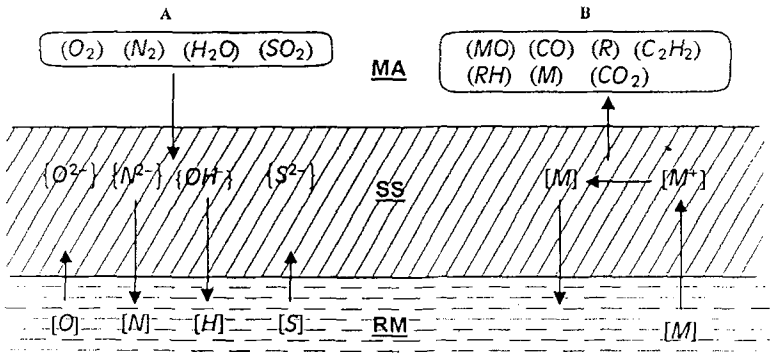

Fig. 1 Real processes of metallurgical slag refining

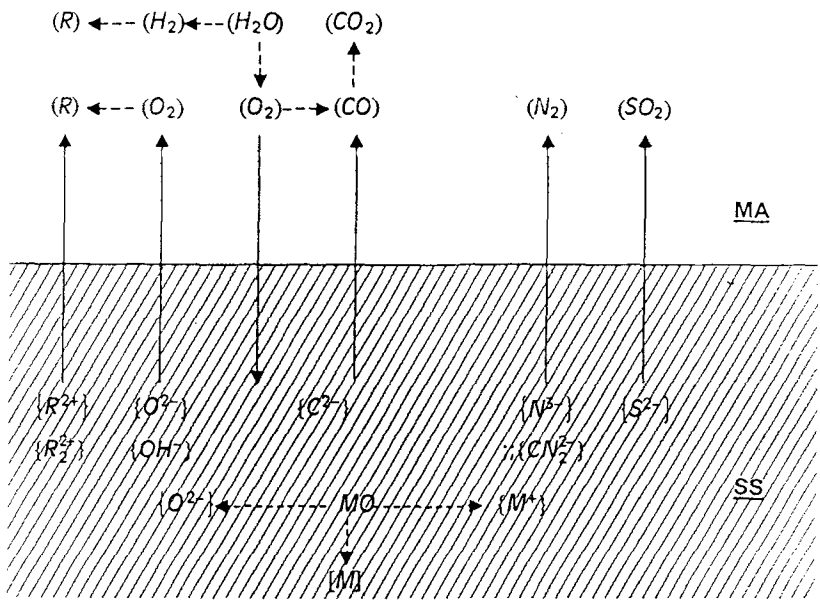

Fig. 2 The model scheme

Aim and method

The following analyses were performed:

I: carbide slag with 20% Cu_2O added, Al_2O_3 as standard;
II: carbides slag, Al_2O_3 as standard;
III: as in I, but with carbide slag as standard.

Table 1 Numerical data

Stages	T / K	Δm / %	E / kJ·mol^{-1}	r_s / %	a / %	y / %	x / %
	670	-1.0	+600				
	800	–	-10				
I	900	–	+15	32	22	20	43
	1180	-2.0	-120				
	1290	–	+140				
	500	–	-30				
	850	-2.0	+905				
II	940	–	-10	–	–	20	–
	1090	+1.5	+90				
	480	–	+80				
	590	–	-60				
	680	-1.0	+580				
III	870	-0.5	-95	40	22	20	45
	940	–	+90				
	1170	-2.5	-250				
	1240	–	-100				

The main components:

15% Al_2O_3, 35% SiO_2, 20% CaC_2, 5% CaO, 10% (Na, Na_2O, NaCl, Na_2CO_3), 4% MgO, 4% CaF_2, 6% C.

The investigation conditions: mass of sample, 800 mg, rate of temperature increase, 20 deg·min^{-1}, extra ceramic cover on ceramic crucible, and temperature range, 280–1330 K.

Results and conclusions

The activation energy (E) in Table 1 was determined by the Freeman-Carroll and Kissinger methods. The results of chemical analysis of the slags by DTA are also given (x=Cu_2O content in the total mass of the slags).

The results suggest that Cu_2O reduction through elements of CaC_2 decomposition such as C, Ca and $CaCN_3$ takes place mainly at 1170–1180 K.

Equation (2) can be generalized as follows:

$$\{RC\} + \{MO\} \rightarrow (RO)^* + (CO) + [M] \quad (3)$$

were () denotes gaseous substances, *denotes substances in the solid or gaseous state, [] denotes substances in the liquid state, and {} denotes substances dissolved in slag.

Equation (3) shows that, during the thermal analysis of refining processes, estimation of the reduction capability of carbide slag solution can be applied in two methods:

1. Comparison of the results (from DTA) on carbide slags with reduced oxides (measurement I) with the results on carbide slag solutions themselves (measurement II).

2. Recording of DTA results simultaneously on slags with oxides as a measurement probe and carbide slags as a standard probe.

To elaborate the results obtained in method 1, the following equation can be used:

$$r_s = \frac{\Delta m_o - \Delta m_1 y}{a} \tag{4}$$

where r_s=reduction capability, Δm_o=average mass decrease for slag–oxide scheme, Δm_1=slag mass decrease, a=amount of carbide reductor and oxygen according to stoichiometric calculations, y=part of carbide reductor for slag–oxide scheme.

For the results obtained according to method 2, the following approximation can be accepted:

$$\frac{\Delta m}{m} 100\% = r_s \tag{5}$$

The reduction capability of slag solutions calculated according to Eq. (4) is approximately equal to the value from Eq. (5), which confirms the assumptions.

Chemical analysis confirms that it is possible to estimate the reduction capability of carbide slags by using DTA methods.

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Zusammenfassung — Es wird ein Modell für Prozesse zur Schlackenverarbeitung und eine Methode zur Bestimmung der Reduktionskapazität von Schlackenlösungen dargelegt. Karbidschlacken wurden mittels DTA-Methoden analysiert.