ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 6, Issue 1, January 2019

Physical and Chemical Transformations of Components of Fusion Mixture at Their Heating in Metallurgical Furnaces

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ABSTRACT: In article questions of physical and chemical transformations of starting materials at their heating in metallurgical furnaces are considered. It first of all moisture evaporation, dissociation of the difficult connections, oxidizing and recovery processes, formation of fusible eutectics. An attention to interaction of oxides and sulfides with formation of the new connections having smaller melting point than initial components. It is shown that these connections are the beginning of formation of melts and actually define thermodynamics and kinetics of all process. Transition of firm components of fusion mixture to flux has a great influence on technological indicators of smelting of metal. Considering it, the research on establishment was conducted began courses of these of reaction and a possibility of determination of this criterion without direct the made experiments.

KEYWORDS: solid fusion mixture, heating, physical and chemical transformations, moisture evaporation, dissociation of the difficult connections, simple components, chemical reactions, fusible eutectic, fusion, theoretical definition, beginning of chemical reactions.

I. INTRODUCTION

Process of receiving metals and alloys is set of a number of the self-contained, difficult phenomena taken in their interferences. To them, processes of restitution of oxides and the difficult connections, decomposition of hydrates and salts, burning of solid, liquid and gaseous fuel, solid-phase and heterogeneous chemical reactions, heat exchange, movements of firm, liquid and gaseous components, etc. belong.
Interference and simultaneity of course of these processes complicates the analysis of melting, complicates determination of the dependences characterizing the course of process [1].

II.RELETED WORK

Burdening materials always contain particular quantity physically or chemically the combined water. Content of the physical adsorbed or water-absorbing moisture in burdening materials depends on climate, season and is from 0,20 to 2,0% in coke, and in a concentrate sometimes of 5% and more. Temperature at the exit of gases is of the furnace 1200-1400^{0}C, it is much higher than boiling point of water. Therefore the translation of water-absorbing moisture in steam and its removal from fusion mixture begins on the top horizons of the furnace, right after heating of pieces of fusion mixture [2].
Evaporation of water-absorbing moisture and the additional heat consumption connected with it practically doesn't affect effectiveness of thermal operation of the metallurgical furnace and consequently, and on a fuel consumption as the amount of heat lost by the furnace with off-gases causes only some decrease.
When heating burdening materials in the furnace there is a dissociation of the difficult connections not simple making. So chalcopyrite, pyrite, carbonates and hydrates dissociate on reactions [3].

$$CuFeS_2 = CuS + FeS$$
$$FeS_2 = FeS + \frac{1}{2} S_2$$
$$CaCO_3 = CaO + CO_2$$
$$MgCO_3 = MgO + CO_2$$
$$FeCO_3 = FeO + CO_2 \text{ and others}$$

As a result of course of these reactions all burdening materials turn into mix of plain sulfides and oxides. Practically all pyrometallurgical processes of receiving metals consist of two stages (except subliming):
1. Fusion of all burdening materials.

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2. Selection of metal from a melt.
The dissociations of compound of metals received later have high temperature of melting. So SiO_2 melts at 1713 ^{0}C, Al_2O_3 2050 ^{0}C, CaO 2510^{0}C, FeO 2540 ^{0}C etc.
Such temperatures in metallurgical furnaces are almost not achievable as it is bound to stability of refractories at these temperatures. If chemical reactions between solid phases with formation of fusible eutectics didn't proceed, then receiving metals any metallurgical process would become very problematic [4].

III. OBJECTS AND METHODS OF RESEARCH

At intake of fusion mixture in the furnace and their heating solid-phase reactions between such substances as FeO, Fe_2O_3, Fe_3O_4, CaO, SiO_2, MgO, and others are of great importance. Metallurgical processes plays a special role in the main the interaction between CaO and Fe_2O_3 having significant effect on the course of receiving metals [5].
However the beginnings of this reaction, its speed given about temperature, the factors influencing reaction are very contradictory. It is in many respects bound to difficulties of monitoring of the course of interaction.
In the insisted work we applied to studying of the specified reaction, along with routine and widespread methods (petrographic, X-ray diffraction, differential and thermal) as well a conductometric method [6].
Earlier it was shown that electric characteristics of crude materials very reliably illustrate the processes happening at their heating, oxidation and restitution [7].
During the research applied the clear phases Fe_2O_3 and CaO of the brand "pure for analyze" To differentially thermal analysis used the FPK-59 device. The electrical conductivity was determined by the volt-ampere scheme on alternating current. Exemplars (the pressed cylinders with a diameter of 1 cm) heated in the controlled atmosphere with a small speed (5 hails/min.) that provides the uniform warming up on all section. Results of a thermal analysis are given in tab.1.

Table 1. Results of thermographical analysis of exemplars

Studied substance or mix	t_{ef}, ^oC	sign of effect	Transformation
CaO	515	-	$Ca(OH)_2 \rightarrow CaO + H_2O$
Fe_2O_3	-	Not effect	-
CaO +Fe_2O_3	315	+	-
	515	-	$Ca(OH)_2 \rightarrow CaO + H_2O$
	675	+	$CaO + Fe_2O_3 \rightarrow CaO \cdot Fe_2O_3$
	750	+	$2CaO + Fe_2O_3 \rightarrow 2CaO \cdot Fe_2O_3$
2CaO+Fe_2O_3	315	+	-
	520	-	$Ca(OH)_2 \rightarrow CaO + H_2O$
	675	+	$CaO + Fe_2O_3 \rightarrow CaO \cdot Fe_2O_3$
	800	+	$CaO \cdot Fe_2O_3 + CaO \rightarrow 2CaO \cdot Fe_2O_3$
2CaO+Fe_2O_3	310	+	-
	520	-	$Ca(OH)_2 \rightarrow CaO + H_2O$
	675	+	$CaO + Fe_2O_3 \rightarrow CaO \cdot Fe_2O_3$
	775	+	$CaO \cdot Fe_2O_3 + CaO \rightarrow 2CaO \cdot Fe_2O_3$

IV. RESULTS OF THE RESEARCH

It is known that irrespective of the quantitative ratio of reactants in a solid phase, primary resultant of reaction is one and too connections, in the case under consideration one-calcium ferrite [8].
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For receiving more reliable data, in a research studied reactions between CaO and Fe_2O_3 taken in different weight ratioes. The possible effect was deciphered both on a basis as literary data, and by means of the petrographic and X-ray diffraction analyses reporting data on availability of ferrite of calcium.

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Results of a research are shown in figure 1.

Apparently in figure 1. the electrical conductivity of exemplars changes with a temperature. The nature of dependences substantially falls into to semiconductors. Expression two sites is accurate: the low-temperature, caused by the impurity conductivity and it is high – temperature, corresponding self-admittance of oxide – the semiconductor.

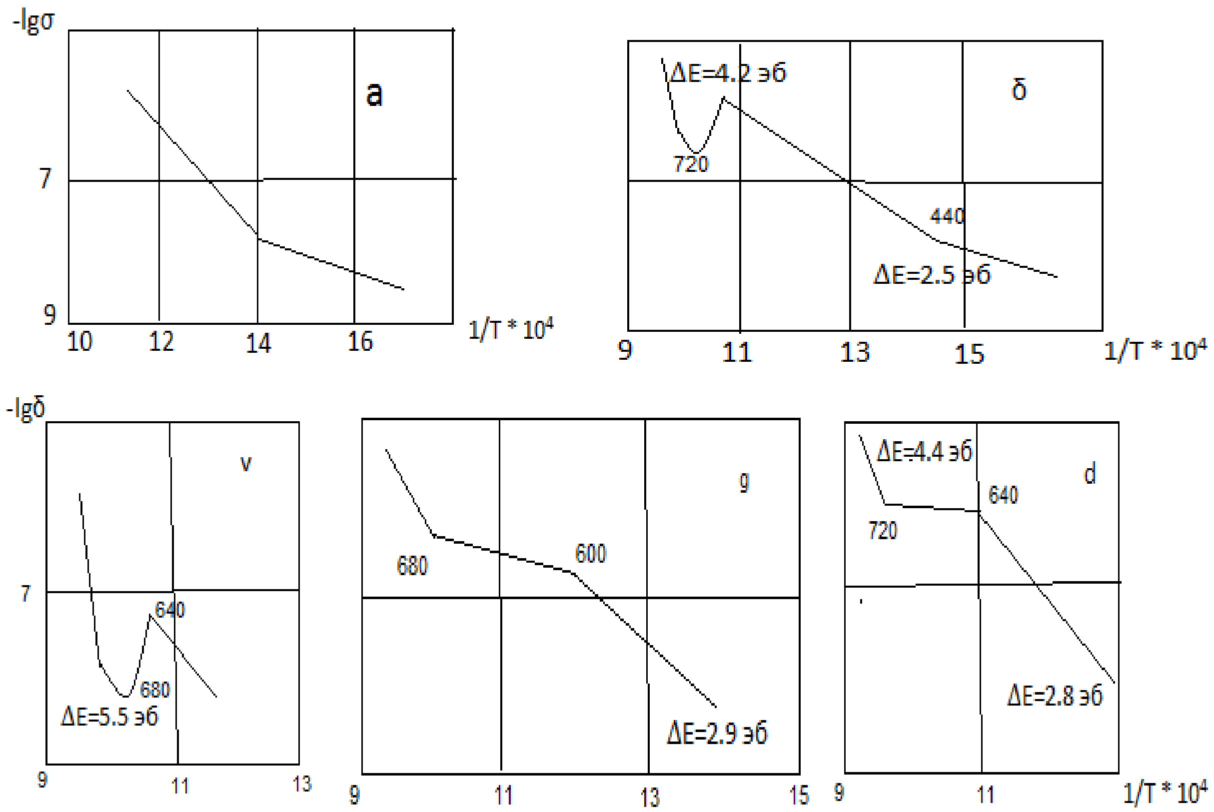

Fig. 1. Temperature effect on an electrical conductivity of exemplars from FeO (a), CaO (b), CaO $2Fe_2O_3$ (v), 2CaO + Fe_2O_3 (g), CaO + Fe_2O_3

The break during dependences is caused by exhaustion of the impurity levels and transition to area of self-admittance. For Fe_2O_3 this transition is expressed less obviously though the break in slant lines is revealed and corresponds 440^{0}C. The fact of coincidence of temperature of the beginning of interaction between SAO and Fe_2O_3 with a temperature band of the transitional area of an electrical conductivity (tab. 2) pays an attention. This experimentally established fact can't be considered unexpected as both phenomena (the chemical act and an electrical conductivity) eventually come down to the electronic mechanism.

Table 2. Temperatures of the beginning of interaction in the Fe_2O_3 SAO system

The studied substance	**t,°C Before interactions of definition on a method**		**Temperature an interval of the transitional area**	
	thermodynamic	**microstructural**	**began**	**the end**
CaO	-	-	640	680
Fe_2O_3	-	-	440	-
CaO+2 Fe_2O_3	675	670	640	720
CaO+ Fe_2O_3	675	670	640	720
2CaO+ Fe_2O_3	675	670	600	680

In this regard, the concept "temperature of the beginning of chemical interaction" gains particular sense for oxides semiconductors. Probably, the ability to the chemical act at these connections appears at such value of energy to its crystal lattice when the electron concentration in the free zone of the semiconductor sharply raises that corresponds to transition from applied to characteristic. Temperature which answers this state depends, mainly, by nature oxide, i.e. on energy of its crystal lattice [10].

On the basis of the experimental dates which are carried out above and their value and their processing it is possible to draw a conclusion that the ability to chemical interaction of oxides of semiconductors is allowed only on at such state when transition from the impurity conductivity to characteristic is observed. This has important practical value as allows receiving data on temperature of the beginning of interaction of oxides of semiconductors only on measurement of an electrical conductivity of the last when immediate monitoring is complicated in other ways. If the oxides reacting among themselves - semiconductors have different junction temperature from the impurities to self-admittance, then chemical interaction is possible only at achievement of temperature in which transition for the semiconductor having more high temperature of transition is carried out. The beginning of reaction of SAO Fe_2O_3 is limited, for example by temperature of change of conduction for SAO (670 ^{0}C).

V.CONCLUSION

1. Using thermographic, X-ray diffraction and petrographic methods of the analysis determined temperature the beginning of interaction between SAO and Fe2O3 (670 ^{0}C).
2. It is established that interaction of oxides semiconductors corresponds to transition from the impurities to own producible.
3. It is shown that using data on type carried out and their change when heating, methods can determine temperature of their chemical interaction without their definition by the experimental

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