ENERGY AND MASS EXCHANGE PROCESSES
IN ELECTRIC ARC MELTING OF REFRACTORIES

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ABSTRACT

The results of arc investigations in the electric arc melting of refractories depending on the technological regimes: polarity of electrodes, current and the arc lengths are considered in the report.

1. EXPERIMENTAL

The present investigations were aimed at studying the energy and mass exchange processes in electric arc melting of refractories.

A method of spectral analysis of the electric arc burning between a graphitized electrode and a corundum refractory melt of the following chemical composition:
97% Al₂O₃; 2.9% SiO₂; 0.58% Fe₂O₃; 0.032% CaO; 0.01% MgO;
0.008% TiO₂; 0.001% MnO₂ was made use of.

Experiments were carried out at the set consisting in a graphite mould with the corundum burden, an electrode holder with an electrode, d.c. supply source and a spectograph. The mould is made up of graphite plates 50 mm thick and has the following geometric dimensions: 500 x 500 x 200 mm. The graphitized electrode is of the 510 type with a diameter of 50 mm.

The electric arc burned between an electrode and a corundum melt.

The measurements were taken at three areas of the electric arc: the electrode, the central and the melt ones.

The investigated regimes of the d.c. arc are given in Table I.

The spectrum was photographed on spectrum plates of type I by means of the VCI-30 spectrograph of average dispersion. An arc gap was reflected on the spectrograph slit by a single-lens condenser. Under these conditions the variations of the lines intensity correspond to the distribution of elements in the height by the arc length.
Arc parameters

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<th>Electrode polarity</th>
<th>Arc current, A</th>
<th>Arc length, mm</th>
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The spectra were identified by the chart of the flame, arc and spark spectra of elements /1/ and the tables of spectral lines of neutral and ionized atoms /2/.

2. RESULTS

The analysis of spectra showed that in the investigated arc aluminium and silicon are in an atomic state, calcium and manganese are present both in an atomic and ionized form, iron, magnesium and titanium are practically completely ionized. The spectrum of carbon is characterized by bright atomic lines as well as the lines of ions C$^+$ and C$^{2+}$. The ionization potentials of the elements studied and the potentials of exciting lines vary within wide limits (from $V_1 = 5.905$ eV for aluminium to $V_2 = 24.377$ eV for ionized carbon), but the correlation between the different elements ionization and the ionization potentials are not observed.

This testifies to the fact that the elements are in different temperature zones of the arc column diameter. The availability of ions C$^{2+}$ depends on the electrode polarity: when it is used as a cathode, the brightness of the entire spectrum increases and the lines CIII 2296.810 and CIII 2344.117 disappear. Brightness of the melt elements spectra is not dependent on polarity. The availability in plasma of particles both neutral and with a different degree of ionization testify to a considerable nonequilibrium in the excitation conditions in the arc at high currents.

In the spectrum the lines have a characteristic distribution by the height: the intensity, hence the number of the burden components near the melt surface is larger and decreases towards the electrode. The spectral lines of carbon are brighter in the electrode zone.

The quantitative measurement of the plasma components content was of interest. However, under the experimental conditions and at the nonstationary arc burning regime it was impossible to carry out the calibration against a basic standard. Therefore an attempt has been made to estimate the change of the quantity of elements in the various areas of the arc column by the absolute brightness or the width of their lines. The results of such estimation are given in the plot of Fig. 1. One can see that the character of change of the melt components quantity along the arc column does not
depend on the melt polarity for the elements of different ionization, apparently, it means that the entrance of elements into the arc is mainly due to the thermal evaporation. The carbon enters plasma with a larger quantity if the upper electrode is taken as a cathode. The character of the curves and their position are not dependent on the arc burning regime within the limits of the currents under study and the lengths of the arcs.

Character of change of the quantity of elements by the arc length

\[ \text{cathode} \quad \text{Fe}^+ \quad \text{Si} \quad \text{Ti}^+ \quad \text{Al} \quad \text{C} \]

\[ \text{arc} \]

\[ \text{melt} \quad \text{f (c), arb. unit} \]

\[ \text{electrode-cathode, melt-anode} \]

\[ \text{electrode-anode, melt-cathode} \]

Fig. 1

The investigations carried out made it possible to reveal some dependences of the energy-mass transfer through an electric arc melting a refractory material, to establish the association of these processes with a technological regime and to outline the ways of improving the technology of refractories of electric melting.

REFERENCES
