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PHYSICAL AND CHEMICAL PROPERTIES OF FERRITE CALCIUM MELTS

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SYNOPSIS

The measure results of viscosity, density and surface tension of synthetic ferrite melts with various silica contents are presented in this article. The relevant polynomial equations were obtained. These equations reflect the influence of silica content on monocalcium and dicalcium ferrite melts. The type and level of polymerization of calcium ferrite anion and cation structures with silica content 0–15% were analyzed by infrared spectroscopy. The silica influence on the time of the lime dissolving in ferrite melts was studied.

Key words: monocalcium and dicalcium ferrite melts, viscosity, surface tension, density, infrared spectroscopy, silicate chains.

The ferrite calcium melts have a considerable influence on technological processes in many branches of steel industry. However, their physical and chemical properties are studied insufficiently, and the published data are often contradictory. This is caused by the fact that the instable iron oxide concentration in melt and the gas phase and the materials of crucible and fixtures dipped into the melt affect the obtained results. Taking into account the principal role of ferrite calcium melts in forming the structure of ultrabasic sinters and in process of primary slag forming in BOF process, an attempt was made to get more definite information about the physical and chemical nature of ferrite calcium melts.

To study the influence of silica on viscosity of ferrite melts a vibration viscometer with frequency 40 Hz has been used. At this frequency there are minimum "slippings" of the melt on the platinum plate surface. Ferrite slags have active corrosion properties, therefore the viscosity has been mainly measured in platinum crucibles. Surface tension and density were measured by the method of gas hole maximum pressure. The synthetic ferrite calcium compositions were produced of the mixture Fe_2O_3, CaO, SiO_2 in ceramic process. All measures have been carried out in oxiding atmosphere.

The wide range of viscosity values 0.002–1.0 Pa·c for $CaO{\cdot}Fe_2O_3$ and the smaller range 0.01–1.0 Pa·c for $2CaO{\cdot}Fe_2O_3$ is to be explained by the fact that at the measure temperatures 1300–1400°C and at the set time of composition holding after melting (15 minutes), the ferrite melts are structurized liquids where there are many undissociated complexes.

The results of analyzing the viscosity, density and surface tension of melts have been processed by a PC, UVM 8086 type, and the following regression equations were obtained:

$$\eta^{1300}_{CaOFe_2O_3} = 0.272 + 0.16\, SiO_2 - 0.09\, SiO_2^2 + 0.09\, SiO_2^3$$

$$\eta^{1400}_{CaOFe_2O_3} = -0.821 + 1.558\, SiO_2 - 0.361\, SiO_2^2 + 0.020\, SiO_2^3$$

$$\eta^{1300}_{2CaOFe_2O_3} = 4.444 - 1.512\ SiO_2 + 0.137\ SiO_2^2 + 0.001\ SiO_2^3$$

$$\eta^{1300}_{2CaOFe_2O_3} = 0.467 + 0.307\ SiO_2 - 0.093\ SiO_2^2 + 0.007\ SiO_2^3.$$

The following relations were obtained for density and surface tension of melts at 1400°C:

$$\rho_{CaOFe_2O_3} = 2.926 + 0.088\ SiO_2 - 0.029\ SiO_2^2 + 0.001\ SiO_2^3$$

$$\rho_{2CaOFe_2O_3} = 2.67 - 0.153\ SiO_2 + 0.022\ SiO_2^2 - 0.001\ SiO_2^3$$

$$\sigma_{CaOFe_2O_3} = 0.477 + 0.006\ SiO_2 - 0.003\ SiO_2^2 + 0.0001\ SiO_2^3$$

$$\sigma_{2CaOFe_2O_3} = 0.537 + 0.021\ SiO_2 - 0.003\ SiO_2^2 + 0.0001\ SiO_2^3$$

where: $\eta^{1300}_{CaOFe_2O_3}$, $\eta^{1300}_{2CaOFe_2O_3}$, $\eta^{1400}_{CaOFe_2O_3}$, $\eta^{1400}_{2CaOFe_2O_3}$ are viscosity of monocalcium and dicalcium ferrite melt at 1300°C and 1400°C,

$\rho_{CaOFe_2O_3}$, $\rho_{CaOFe_2O_3}$, $\sigma_{2CaOFe_2O_3}$, $\sigma_{2CaOFe_2O_3}$ are density and surface tension of ferrite melts at 1400°C,

SiO_2 is the weight content of silica in ferrite calcium melts.

The analysis of the relevant samples of ferrite calcium melts with silica content 0-15% by IR spectroscopy has shown that the number of chain structures of $|(SiO_3)_n|$ type of the ring metasilicates $(SiO_3)_n^{2n-}$ of Si_4O_{12} type in the melt is reduced at 6-9% SiO_2. This is obviously connected with silica transition into compound with CaO, i.e. into β-dicalcium silicate. When increasing SiO_2 over 12% in the melt, the chain and ring structures start again being formed in the ferrite structure.

It has been determined by X-ray analysis and petrography that there is no forming the calcium silicates at 6% SiO_2 when interacting the ferrite melts with silica within 2-10%. This enables to determine the limits of the rational silica content in iron and ore materials for producing the complex ferrite fluxes and the ironized lime.

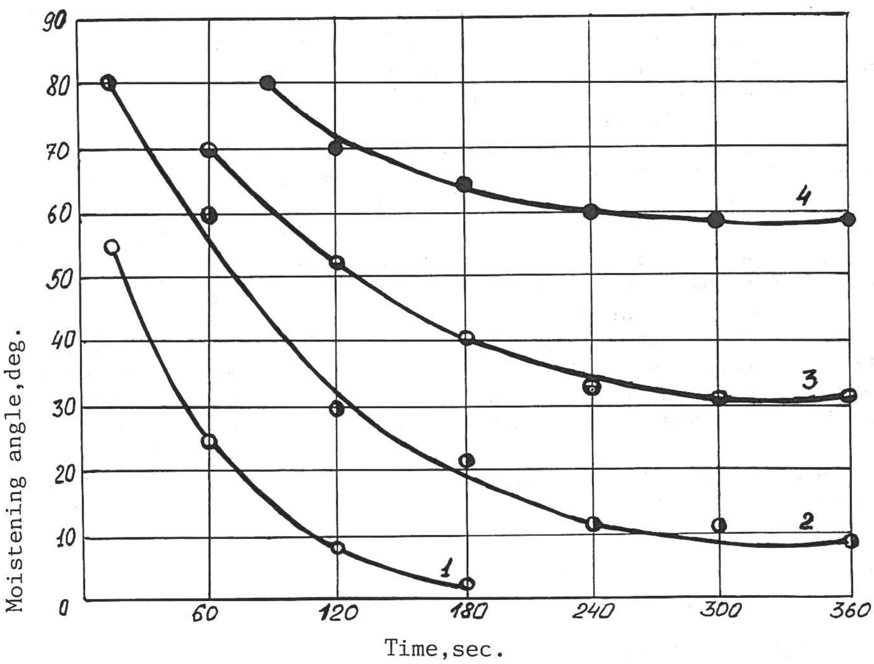


Fig.1 Lime moistening by ferrite calcium melts
SiO_2 content in the melt: 1 - 4%, 2 - 2%, 3 - 0%, 4 - 6%

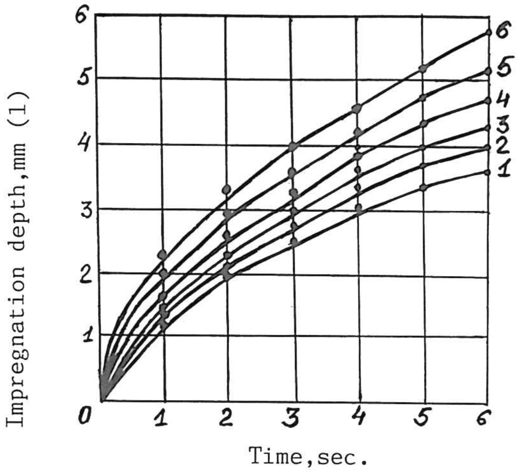
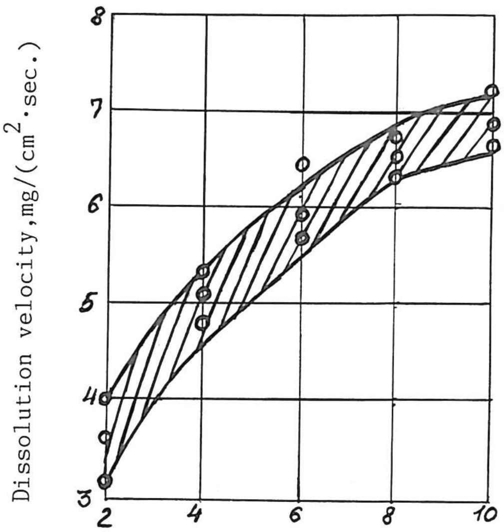


Fig.2 Kinetics of lime impregnation by monocalcium ferrite melts at 1400°C

SiO_2 content: 1 - 0%,2 - 2%,3 - 4%, 4 - 6%,5 - 8%,6 - 10%



SiO_2 content in melt,%

Fig.3 Kinetics of lime dissolution by ferrite calcium melts

The analysis of results of studying the moistening processes as well as the lime impregnation and dissolution in monocalcium ferrite with silica content 0-10% (Figures 1,2,3) enables the following conclusions:

- calcium ferrite melts with4%SiO_2 are the easiest fusible and moisten the lime in the best way,
- when increasing the silica up to 10%,there is no forming the refractory shell $2CaO{\cdot}SiO_2$ on the surface of the lime impregnated by ferrite melts,
- studying the lime moistening,impregnation and dissolution kinetics in the melts being analyzed have confirmed the potential possibility of slag forming intensification when using the synthetic fluxes on ferrite basis.

Conclusions: Analysis of physical and chemical properties of ferrite melts with 0-15% silica allows to recommend a rational composition of iron containing materials for production of ultra-basic complex flux and ironized lime for BOF process.

The silica content in iron and ore charge should not exceed 2-4% in order to provide high process values in production of complex ferrite fluxes and ironized lime.