The degree of complexity of the subsolidus structure of three-component systems MgO-Al$_2$O$_3$-FeO, MgO-Al$_2$O$_3$-TiO$_2$, MgO-TiO$_2$-FeO, Al$_2$O$_3$-TiO$_2$-FeO

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Abstract - The results of calculations of the subsolidus structure's complexity of three-component systems are presented. It has been found that for carrying out a research of the subsolidus structure of MgO-Al$_2$O$_3$-FeO system it is necessary to analyze 1 model solid-phase exchange reaction, for MgO-Al$_2$O$_3$-TiO$_2$ – 25, for MgO-TiO$_2$-FeO – 36 and for Al$_2$O$_3$-TiO$_2$-FeO – 25.

Keywords – the three-component system, subsolidus structure, connode, double compounds, phase composition.

Introduction

Three-component systems with different combinations of oxides form the physical and chemical basis of composite materials. The study of the structure of state diagrams of such systems gives technologists an opportunity to forecast the phase composition of materials based on them. However, the research on the state diagrams of three-component systems is the most knowledge-intensive task of materials science. To solve this problem, thermodynamic prognosis and modeling of all variants of solid-phase exchange reactions between compounds of the system are used. This is not difficult to achieve, when there are no triple compounds in the system and double compounds are in one or two subsystems. If double compounds are included in all subsystems and are not equally spread, as well as the presence of triple compounds, it makes this procedure much more difficult.

MgO-Al$_2$O$_3$-FeO, MgO-Al$_2$O$_3$-TiO$_2$, MgO-TiO$_2$-FeO, Al$_2$O$_3$-TiO$_2$-FeO systems are important for producing refractory materials, such as heat-resistant spinel-containing, modified magnesia, corundum-reinforced and others. They can also be contained in other more complex systems. In particular, they are part of the four-component MgO-Al$_2$O$_3$-FeO-TiO$_2$ system, which is the basis for production of periclase-spinel refractories for rotary furnaces of cement industry and mine furnaces of different purposes. The subsolidus structure of the considered three-component systems allows predicting not only the phase composition of the ready-made product, but also its behavior during exploitation. Thus, the estimation of the subsolidus structure's complexity of three-component systems, which in the future will be the basis for a more complex research of these systems' structures, is an innovative and relevant task.

Results and Discussion

The work considers the results of estimations of the complexity of MgO-Al$_2$O$_3$-FeO, MgO-Al$_2$O$_3$-TiO$_2$, MgO-TiO$_2$-FeO, Al$_2$O$_3$-TiO$_2$-FeO systems, which were carried out according to the methods of this work [1].

Subsolidus structure of MgO-Al$_2$O$_3$-FeO system is simpler, compared with other three-component systems, as in this system two compounds are stable: in subsystem MgO-Al$_2$O$_3$ [2] – 1, in subsystem Al$_2$O$_3$-FeO [3] – 1. The subsolidus structure of MgO-Al$_2$O$_3$-TiO$_2$, MgO-TiO$_2$-FeO, Al$_2$O$_3$-TiO$_2$-FeO systems is more complicated because of not only presence of three or more stable binary compounds, but also due to the increase of their number with rising the

temperature. In other words, the subsolidus structure of these systems becomes more complicated as the temperature goes up. Fig. 1 shows the analyzed systems above the temperature of 1537 K.
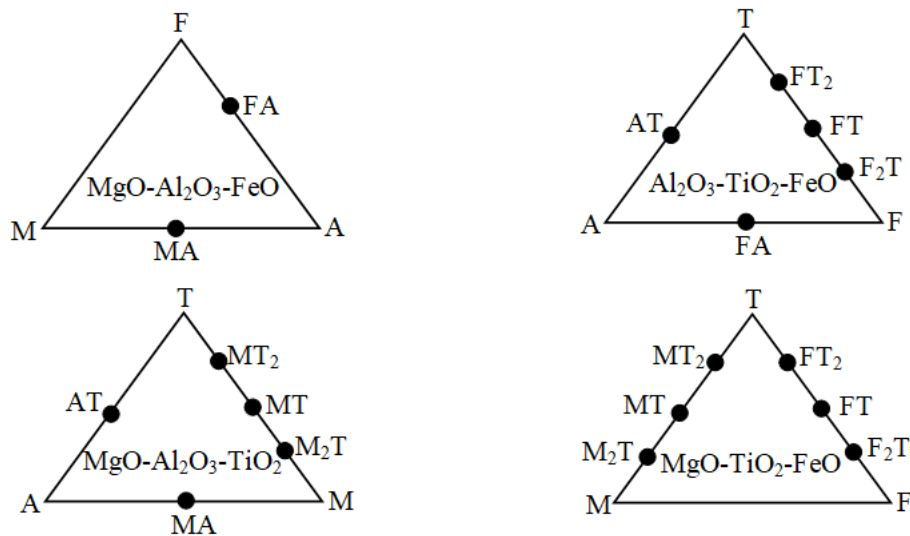

Fig.1. Composition points of binary compounds as initial information for establishing the subsolidus structure of systems above the temperature of 1537 K.

According to Fig. 1 in the $MgO-Al_2O_3-FeO$ system has two stable compounds, in Al_2O_3-TiO_2-FeO – five, in $MgO-Al_2O_3-TiO_2$ there are five, in $MgO-TiO_2-FeO$ – six. In the MgO-Al_2O_3-FeO ($V_1 = 1$, $V_2 = 1$) and $MgO-TiO_2-FeO$ ($V_1 = 3$, $V_2 = 3$) systems the compounds are equally divided into two subsystems. The $Al_2O_3-TiO_2-FeO$ ($V_1 = 1$, $V_2 = 1$, $V_3 = 3$) and MgO-$Al_2O_3-TiO_2$ ($V_1 = 1$, $V_2 = 1$, $V_3 = 3$) systems are almost similar – there are three compounds in one subsystem and one in two.

According to [1] for $MgO-Al_2O_3-FeO$ system we have determined: the number of compounds in the system $d = 2$, the number of possible connodes $k = 3$ and the number of intersection points of connodes $P = 1$; for $MgO-TiO_2-FeO$ – $d = 6$, $k = 15$ and $P = 36$; for Al_2O_3-TiO_2-FeO – $d = 5$, $k = 12$ and $P = 25$; for $MgO-Al_2O_3-TiO_2$ – $d = 5$, $k = 12$ and $P = 25$.

Conclusion

Therefore, the evaluation of the complexity of the systems boils down to the calculating the number of intersection points of all possible line segments between the points of compositions, this means that it allows defining all possible model solid-phase exchange reactions, and consequently the subsolidus structure of the systems.

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