the granulator bowl right from the instance of initiation of granulation at regular intervals of 30 min and determined the increase in their diameter and the indices of their main physical and mechanical properties.

Figure 4 shows the appearance of the corundum granules. It was established that the growth rate of the granules before attaining a size of (20 ± 3) mm during granulation on the inoculator grains amounts to 0.14 mm/min, i.e., 1.4 times higher than that obtained during seedless granulation; furthermore, the period of granulation decreases from 240 up to 180 min and the yield of the final granules increases by 25-30%.

CONCLUSIONS

The improved technology for granulating particulate oxide materials using the grains of inoculator seeds makes it possible to reduce the period of granulation and to increase the yield of the final granules. The waste products obtained during production of flaky (plate-like) corundum can be used as the inoculator grains. In order to obtain granules having an ellipticity not exceeding 0.5-0.7 mm, the optimum size of the inoculator grains is 1-2 mm.

The inoculator grains obtained from the low-fired (undersintered) material has advantages over the densely sintered materials from the standpoint of improved internal structure of the granules. We established the optimum quantity of the inoculator grains for obtaining granules measuring (20 ± 3) mm in diameter using a granulator having a diameter of 1000 mm with minimum irretrievable waste products during the initial period of granulation.

We studied the growth kinetics during seedless granulation and during granulation with an inoculator. It was shown that densification of the granules occurs during granulation. We determined the main physical and mechanical properties of the granules obtained by granulating on the inoculator grains and by seedless granulation and established the optimum composition of the binding solution (binder) incorporating a phosphate-containing component as strengthening agent.

LITERATURE CITED

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SINTERED CHROMIUM-BEARING OXIDE SYSTEMS

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At the present time, chromium-bearing refractory materials are being widely used. Cast chromium-aluminum-zirconium oxide and chromium oxide-corundum products containing 20-45% chromium oxide have been developed for lining the glassmaking furnaces since their glass resistance is considerably superior to that of the electromelted Bakor refractories [1].

The specific features of the production technology of the fused cast refractories do not permit one to obtain intricate products that are often used as a constituent part of the refractory provisions of the glassmaking units and to increase the chromium oxide content in the products because of its high volatility under the conditions of electric arc melting.

Obtaining densely sintered refractories having a high chromium oxide content is difficult because of the low sinterability (inertness to densification) of Cr₂O₃, during high temperature firing and the necessity of carrying out firing in a controlled atmosphere [2].

This paper deals with a study of the phase transformations and the properties of the aluminum-chromium-zirconium oxide, chromium oxide-alumina, and the chromium oxide systems obtained by compacting the powders containing various mineralizing and binding (bonding) agents and subsequently sintering over a wide range of temperatures.

In the experimental aluminum-chromium-zirconium oxide systems (Table 1), we used the systems of sintered corundum-zirconia refractories [3] as the base. Besides aluminum and zirconium oxides, they contain silica and the oxides of the rare-earth elements. In the 1500-1700°C, sintering of such materials occurs due to the formation of a eutectic silicate melt that makes it possible to obtain highly dense refractories having an open porosity of 0-5%. The phase composition of the material is represented by corundum, monoclinic zirconium dioxide, and a glass phase.

Direct substitution of a part of zirconium dioxide with chromium oxide did not lead to a significant improvement in the mineralogical composition of the refractory (40% ZrO₂, 42% Al₂O₃, 10% Cr₂O₃, 5% SiO₂, 3% La₂O₃). The material (Fig. I) retains a significant quantity of residual glass under the same technological parameters. Synthesis of the solid solutions of chromium and aluminum oxides takes place at a lower temperature than that required for the formation of the eutectic melt, which decreases the quantity of aluminum oxide in the glass phase and, thereby, decreases its viscosity. Obtaining highly dense aluminum-chromium-zirconium oxide materials in this way is possible by maintaining the Cr₂O₃ content up to 15 wt.%; when the Cr₂O₃ content exceeds this value, the density of the material fired at 1700°C decreases abruptly.

Titanium dioxide activates the sintering process of chromium oxide most intensely. However, in this case, highly dense chromium oxide products can be obtained only when the pressure of oxygen in the furnace chamber is maintained at 10⁻⁴-10⁻⁵ MPa [4].

Sintering of the aluminum-chromium-zirconium oxide systems containing up to 40% Cr₂O₃ was achieved by replacing silica with titanium oxide. It was possible to increase the quantity of the crystalline phases in the material and to decrease the content of the glass phase by introducing a small quantity of tin dioxide [5] (Fig. 2).

Titanium dioxide improves the sintering process of the systems due mainly to the formation of a ternary solution; this was confirmed by the data of x-ray structural analysis that indicated a change in the lattice parameters and the lattice volume of the solid solution of aluminum and chromium oxides on increasing the titanium oxide content [6].

The comparative corrosion tests conducted on the corundum-zirconia and aluminum-chromium-zirconium oxide refractories in a silicate glass melt according to the dynamic method established that the refractory containing 30-40% Cr₂O₃ has a greater (by 1.5 times) corrosion resistance than the corundum-zirconia refractory containing 60% ZrO₂.

A study of the microstructure of the chromium-bearing refractory after the tests showed that the corrosion resistance of the Al₂O₃-Cr₂O₃ solid solution is comparable to that of the monoclinic ZrO₂. In the aluminum-chromium-zirconium oxide refractories having more than 50% Cr₂O₃ in the solid solution, zirconium dioxide loses its ability to act as the most chemically resistant phase of the refractory.

A study of the sintering process of the Al₂O₃-Cr₂O₃ systems was carried out on the materials containing 25-75% chromium oxide. Increasing the Cr₂O₃ content in the material decreases its ability to densify; in this case, the change in the porosity of the fired specimens is directly proportional to the chromium oxide content. At a firing temperature of 1700°C, dense specimens were obtained from the systems containing not more than 30% Cr₂O₃.

Highly dense chromium oxide-alumina refractories containing 40-75% Cr₂O₃ could be obtained using a complex additive consisting of titanium dioxide and metallic chromium [7]. During the oxidative (oxidizing) firing process, the metallic chromium additive forms a number of low-melting lower oxides of chromium which significantly intensify the densification process of the material and make it possible to decrease the firing temperature of the products.

Table 2 shows the composition and the properties of the chromium oxide-alumina systems.

The phase composition of the products is represented by a solid solution of aluminum and chromium oxides (Fig. 3). Microscopic studies carried out on the materials containing more than 5% TiO₂ showed the presence of a second phase (T) at the intergranular regions. X-ray fluorescence microanalysis (Fig. 4) established that there is a significant increase in titanium dioxide content in the new formation and that the quantity of aluminum oxide decreases at a virtually unaltered chromium oxide content. According to the data of Suvorov et al. [7], in the system of aluminum, chromium, and titanium oxides, binary and ternary compounds (solid

*Here and elsewhere, weight contents are given.