Vibrational mixing of highly dispersed powders makes it possible to improve the homogeneity of the mixtures up to 99% and, at the same time, intensifies the mixing process significantly.

LITERATURE CITED


IMPROVING THE STRUCTURE AND PROPERTIES OF AN ALUMINUM OXIDE CERAMIC

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Ceramic materials containing 75-100% $\text{Al}_2\text{O}_3$ are widely used in technology. They include the aluminum oxide materials containing 94-95% $\text{Al}_2\text{O}_3$ that are used for obtaining vacuum-tight joints (seals) with metals [1]. The VK 95-1 ceramic forms an example of such materials.

Aluminum oxide materials contain a glass phase that is necessary for decreasing the sintering temperature and obtaining strong joints with metals. It forms due to the presence of some additives such as natural minerals, pure chemical substances, compounds synthesized in advance, and a specially prepared glass. The composition of the glass-forming system and the method of introducing the substances facilitating its formation have a significant effect on the structure and the properties of the aluminum oxide ceramics and the quality of the metal-ceramic joints obtained using them.

Initially, when producing the VK 95-1 aluminum oxide ceramic, natural minerals, viz., talc (3%) and kaolin (2%) were introduced into the charge besides commercial-grade alumina (95%) for developing the glass phase. However, the studies carried out under the conditions of batch production showed that in this case, adequate uniformity of structure is not ensured in the ceramic (in particular, with regard to the volumetric distribution, the composition, and the properties of the glass phase). The compositional variations of the glass phase are due to the nonuniform distribution of the oxide additives introduced with the natural minerals. All these factors lead to significant changes in the properties of the ceramic under the conditions of batch production and to the absence of stable quality of the metal-ceramic joints.

In order to improve the strength and the operational reliability of the metal-ceramic joints, we developed a technological route involving the following steps: synthesis from the oxides of aluminamagnesia spinel $\text{MgAl}_2\text{O}_4$ at 1340-1360°C after introducing 0.4% $\text{B}_2\text{O}_3$ as a mineralizer; mixing the charge consisting of (%): 93.4 $\alpha$-$\text{Al}_2\text{O}_3$, 3.6 spinel, and 3 $\text{SiO}_2$; and obtaining a slip from this mixture for hot coating of ceramic products.

$\text{Here and elsewhere, weight contents are given.}$

This production technology made it possible to improve the strength of the metal-ceramic joints. However, the aforementioned method of introducing the glass-forming components has certain shortcomings which were recognized during batch production.

When producing intricate insulators, the number of defective products (rejections) increased because of crack formation. Microstructural analysis showed that the sites of crack formation contain a large quantity of the glass phase. Layering (stratification of the slip (in particular, nonuniform distribution of SiO₂ because of the significant difference in the densities of α-Al₂O₃ and SiO₂) is the most probable reason underlying defect formation. In view of this, we studied the effect of introducing a presynthesized glass into the VK 95-1 ceramic.

The glass phase formed in the aluminum oxide ceramic obtained by introducing spinel and SiO₂ into the charge contains (%): 41 Al₂O₃, 44.5 SiO₂, and 14.5 MgO. In order to reveal the effect of the percentage of the oxides on the interaction between the glass phase and corundum during the sintering process of the ceramic, we studied the systems having low and high Al₂O₃ contents (Table 1).

In the MgO–Al₂O₃–SiO₂ phase diagram, the STK-I–STK-III systems are located in the region of primary crystallization of mullite and the STK-IV system is located in the region of primary crystallization of cordierite in that its composition is close to the eutectic composition having a melting point of 1345°C.

X-ray phase analysis (XPA) carried out on a DRON-2,0 apparatus using a copper anode and maintaining an accelerating voltage of 40 kV and an anode current of 20 mA showed that the experimental systems synthesized in the 1280-1340°C range contain cordierite (d = 3.027; 3.138; 3.379; 1.688 nm) and spinel (d = 2.085; 2.008 nm).

The near-eutectic STK-I system was found to melt at 1320-1340°C. At this temperature, sintering of the metallized layer on the ceramic occurs which is necessary for obtaining a vacuum-tight joint (seal). In this case, formation of a liquid phase leads to the loss of tightness of the joints. In view of this, further studies were not carried out on the STK-I system.

XPA of the samples fired at 1450-1500°C established that cordierite is virtually absent in the STK-II and STK-III systems. In the STK-I system, cordierite was recorded at 1450°C. The STK-I system, cordierite was recorded at 1450°C. The STK-I system was found to melt at 1500°C.

We studied the interaction of these systems with Al₂O₃. Mixtures containing the experimental materials (50%) and Al₂O₃ (50%) were prepared. XPA of the mixtures fired at 1340 and