PRESSURE-MOLDED HIGH-ALUMINA CERAMIC CASTABLES.  
2. COMPACTION AND PROPERTIES OF MATERIALS BASED ON PLASTICIZED BAUXITE HCBS, REACTIVE ALUMINA, AND THEIR BINARY MIXTURES

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The effect of compacting pressure (20 – 100 MPa) on the densification of refractory clay plasticized molding mixes based on bauxite HCBS containing 10% highly dispersed quartz glass, reactive STS-30 alumina, and their binary compositions has been studied. The properties of these materials subjected to heat treatment are discussed. Optimum compositions for binary systems are formulated that show promise as matrices for refractory materials and for preparation of engineering ceramics.

The matrix in ceramic castables of corundum of high-alumina composition may vary in Al2O3 content. For this reason, not only well-studied bauxite-based highly concentrated ceramic binding suspensions (HCBSs) with addition of highly dispersed quartz glass (HDQG) [1], but also HCBSs prepared from high-purity reactive alumina [2] or related binary systems, show promise for practical application.

In previous communication (Part I, [1]) an additional component, GEF-grade alumina, was introduced to increase the content of Al2O3 in bauxite HCBS. The GEF alumina had a lower degree of dispersion in comparison with the solid phase of base HCBS (specific surface \( S_{sp} = 0.16 \text{ m}^2/\text{g} \) against 1.62). In this study, we have tested an STS-30-grade reactive alumina (Alcoa) with 99.8% Al2O3, \( S_{sp} = 3.8 \text{ m}^2/\text{g} \), and median diameter \( d_m = 1.6 \text{ \mu m} \) [2 – 4]. The specific surface of the bauxite HCBS solid phase (1.2 m²/g) was somewhat less than that used in the previous work [1]. Thus, in the former case [1] the value of \( S_{sp} \) of the additional Al2O3 component was 10 times less, and in the latter case, 3 times greater as compared to the base HCBS (90% bauxite + 10% highly dispersed quartz glass).2 The integral grain-size distribution curves for the precursor systems (curves 1 and 2) and their binary mixture (curve 3) are shown in Fig. 1. As can be seen, in the STS-30-grade alumina the content of particles of size < 1 \text{ \mu m} is about 5 times less than in the base bauxite HCBS. The value of \( d_m \) in HCBS (6 \text{ \mu m}) is nearly 4 times the value of \( d_m \) in alumina. The maximum particle size \( d_{\text{max}} \) in bauxite HCBS reaches 100 \text{ \mu m}, whereas in alumina \( d_{\text{max}} \) is 12 \text{ \mu m}. The HCBS is rather low in ultrafine particles (0.1 – 0.3 \text{ \mu m}), whereas alumina lacks them altogether. The polydispersity index \( K_p \) for all the curves in Fig. 1 does not differ significantly and ranges from 5.5 to 7.0.

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2 In what follows, the initial mixes free of the additional alumina are denoted as bauxite HCBS (all of them contain 10% HDQG).

Fig. 1. Integral curves of particle size distribution for the solid phase in bauxite HCBS (1), reactive STS-30-grade alumina (2), and mixed HCBS with 20% STS-30 (3).
By analogy with [1], 3% refractory clay (as a plasticizer) and a deflocculating agent (0.1%) Castament (an organic addition based on polycarboxylate esters) were added to all the mixes. The binary mixes were prepared from bauxite HCBS and a deflocculated suspension of STS-30 alumina with a moisture content of 16%.

Our goal was to study the process of pressing and sintering of mixes based on bauxite HCBS and plasticized STS-30 alumina with a proportion of these components varied over a wide range. The press-powders [1] were prepared from precursor suspensions (both binary and mixed) dried to a moisture content of 6 – 7% and then granulated by passing through a 2 mm mesh sieve. The test specimens were rectangular prisms with dimensions of 5 × 5 × 45 mm or cylinders of diameter 10 (12) and height 10 – 12 mm; the specimens were pressed on a hydraulic press under a pressure of 20 to 100 MPa. Noteworthy is the fact that in cylinder specimens pressed under identical conditions (composition, moisture content, and pressure), the porosity was 3 – 5% less than in prismatic specimens. The heat treatment (sintering) of specimens was carried out using a laboratory electric furnace (100 – 1400°C) or an industrial tunnel-type furnace for sintering dinas components (with a furnace residence time of 40 h at 1400 – 1420°C).

The curves in Fig. 2 provide a general characterization of the behavior of pressed specimens of different composition during nonisothermal heating. In all specimens, the early stage of sintering manifested itself in the form of an appreciable shrinkage at 1050 – 1100°C. A departure in the course of the curves sets in at 1200°C to further increase at 1300 – 1400°C. In specimens based on HCBS or with 20% STS-30 (curves 1 and 2), as they reached a certain degree of shrinkage, growth was observed associated with mullitization [5]; by contrast, in specimens based on STS-30 alumina or containing 25% bauxite HCBS (curves 4 – 6), a regular shrinkage was observed. Curve 3 displayed an intermediate behavior. A comparison of curves 5 and 6 in Fig. 2 shows that the introduction of an amount of refractory clay resulted in an appreciable decrease in shrinkage in the temperature range of 1000 – 1400°C, which attests to the occurrence of mullitization (Fig. 2, curve 6).

The effect of pressure on open porosity $P_{op}$ or apparent density $\rho_{ap}$ in prismatic specimens is shown in Fig. 3. Considering that at 1000°C virtually no shrinkage or mullitization take place, the data on $P_{op}$ and $\rho_{ap}$ may by convention be regarded as typical for the precursor (dried) specimens. It follows from Fig. 3a that the parameters $P_{op}$ and $\rho_{ap}$ for precursor materials (based on HCBS and STS-30 alumina) show a different behavior with pressure $p$. With increase in $p$ from 20 to 100 MPa, the open porosity $P_{op}$ in the specimens based on bauxite HCBS decreases from 28.4 to 23.5%, and in those based on STS-30 alumina — from 32 to 29.5% (Fig. 3a, curves 1 and 2). The value of $P_{op}$ in bauxite HCBS-based (Fig. 3a, curve 1) at any $p$ is appreciably lower than in the corresponding specimens based on the reactive STS-30 alu-