The results of our experiments showed that the application of the resol (bakelite)-type phenolic resins makes it possible to obtain unfired periclase materials having better property levels than those obtained using WCTB. From the standpoint of technological suitability, it is preferable to use the S-II resin having lower viscosity.

The highest indices of density, strength, and thermal shock resistance are obtained in the materials incorporating phenolic resins after drying at 100-150°C. In this case, their property levels are higher than those of the fired materials. However, with increasing heat treatment temperature, the quality of these materials deteriorates and the important properties like strength and thermal shock resistance of these materials become inferior to those of the fired materials. In this context, it may be assumed that the periclase systems (compositions) containing phenolic resins can find limited applications. Besides this, addition of carbonaceous and oxygen-free components to the systems leads to a significant improvement of thermal shock resistance and to the commonly known improvement in the resistance to slag and metal induced corrosion.

Based on the results of laboratory studies, we prepared experimental products based on periclase, graphite, and the phenolic resin S-II; when tested in a high-capacity steel making electric arc furnace, these products showed less wear rate than the PKhS refractories (more than 20% improvement was observed).

Thus, we confirmed the promising performance of the periclase–carbonaceous systems incorporating phenolic resins in the linings of walls and slag ladles of metallurgical units, in particular, steel making electric arc furnaces.

LITERATURE CITED


EFFECT OF ZIRCON AND ALUMINUM OXIDE ADDITIONS ON THE SINTERING AND PROPERTIES OF BADDELEYITE REFRACTORIES

A. G. Karaulov and N. M. Mikhal'chuk

UDC 666.762.5.022.69.046.4

Solid phase sintering of the granular bodies consisting of zirconium dioxide solid solutions does not permit one to obtain dense products by firing at 1750–1850°C [1]. Addition of aluminum oxide facilitates liquid phase sintering at this firing temperature owing to the formation of the Al₂O₃–ZrO₂ eutectic at 1710°C [2]. Liquid phase sintering makes it possible to obtain dense (porosity 10–15%) baddeleyite products from the granular bodies containing approximately 3% * Al₂O₃ [3, 4]. Increasing the amount of Al₂O₃ in the baddeleyite granular powders resulted in swelling.

We studied the effect of the combined addition of Al₂O₃ and zircon. It is known that zircon dissociates into ZrO₂ and SiO₂ during the firing process. The isolated SiO₂ is expected to facilitate liquid phase sintering because the eutectic of the ZrO₂–Al₂O₃–SiO₂ system forms at 1550°C itself [5].

The following raw materials were used in the present study: commercial purity G-0 grade alumina (99.59% Al₂O₃), KTsP grade zircon (64.39% ZrO₂ + HfO₂, 31.72% SiO₂, 0.76% Fe₂O₃, 2.09% Al₂O₃), PB-1 grade baddeleyite (98.8% ZrO₂ + HfO₂, 0.14% Fe₂O₃), and chalk obtained from the Belgorodsk deposit (55.0% CaO, 0.22% Fe₂O₃, 2.56% SiO₂, 41.86% ΔmCaO).

*Here and elsewhere, weight contents are given.

Ukrainian Scientific-Research Institute of Refractories. Translated from Ogneupory, No. 10, pp. 11-13, October, 1986.
Fig. 1. Properties of the specimens made from baddeleyite of natural granularity with addition of 1 and 3% $\text{Al}_2\text{O}_3$ as a function of the $\text{ZrSiO}_4$ content. The specimens were fired in a tunnel furnace at 1580°C (a) and in a kiln at 1750°C (b) and 1580°C (c). The numbers on the curves correspond to the $\text{Al}_2\text{O}_3$ content.

Fig. 2. Effect of $\text{ZrSiO}_4$ addition on the properties of the specimens made from baddeleyite of natural granularity and containing 3% $\text{Al}_2\text{O}_3$: 1) firing in the kiln at 1580°C; 2) firing in the tunnel furnace at 1580°C; 3) firing in the kiln at 1750°C; $\Delta l_d$) radial shrinkage; $\Delta l_h$) axial shrinkage.

Specimens measuring 30 mm in diameter and 40 mm in height were prepared from baddeleyite of natural granularity with the addition of the stabilizing agent CaZrO$_3$ [6] to the charge and from the previously stabilized (using 6% CaO) electromelted material having a limiting grain size of 2 mm.

The sintering agents $\text{Al}_2\text{O}_3$ and $\text{ZrSiO}_4$ were milled up to a grain (particle) size <63 μm and were introduced through the finely dispersed constituent of the body.

Calcium zirconate was synthesized from baddeleyite and chalk by firing the briquette at 1580°C and subsequently milling up to a grain size <63 μm and was introduced in the same way.

Specimens were compacted at a pressure of 50 MPa from the bodies based on the baddeleyite of natural granularity and at 100 MPa from the bodies based on the electromelted material. Firing was carried out in a semiindustrial furnace (kiln) at 1580 and 1750°C with a 6-h dwell at the final temperature and at 1580°C in a tunnel furnace.

Figure 1 shows that in the specimens made from baddeleyite of natural granularity with additions of 1 and 3% $\text{Al}_2\text{O}_3$ and fired at 1580°C (independent of the type of the furnace), increasing the $\text{ZrSiO}_4$ content up to 5% leads to a reduction in the open porosity $P_{opn}$ from 20–22 up to 15%. However, subsequent increase in the $\text{ZrSiO}_4$ content is not effective. After firing at 1750°C, only the specimens containing 1% $\text{Al}_2\text{O}_3$ exhibit this regularity, i.e., the maximum reduction in the porosity occurs at 5% $\text{ZrSiO}_4$. The porosity of the specimens containing 3% $\text{Al}_2\text{O}_3$ decreases proportionately with increasing $\text{ZrSiO}_4$ content. This phenomenon can be attributed to the fact that at 1750°C, there is a significant increase in the amount of the melt (liquid phase) that covers zirconium dioxide grains and fills up the intergranular space. At the same time, the ultimate compressive strength $\sigma_{cm}$ of the specimens containing 3% $\text{Al}_2\text{O}_3$ attains its maximum value at 3% $\text{ZrSiO}_4$ and $\sigma_{cm}$ of the specimens containing 1% $\text{Al}_2\text{O}_3$ attains its maximum at 5% $\text{ZrSiO}_4$; in this case, the strength of the specimens is approximately the same (see Fig. 1). Evidently, $\sigma_{cm}$ is determined by the strength of the alumina–zircon binder.