The intensification of the production processes associated with an increase in the working temperature and a reduction in the corrosive and erosive effects of the medium requires the development of new refractories with a different set of properties.

One method of obtaining such refractories is the application of high-quality coatings to the refractory. The gas-flame method of application can be used to manufacture the coatings made from virtually any refractory oxide, but it can be most usefully used to apply oxides which have a melting temperature of up to 2100°C.

The present report gives some results of a study of a few problems in the application of gas-flame coatings and demonstrates the properties of such coatings based on Al₂O₃ and SiO₂.

It should be pointed out that a particular feature of the application of coatings to refractories in order to improve their user properties includes the fact that the applied coating can be as thick as tens of millimeters. The application of the coatings was carried out in the flame of an oxygen-gas burner using 50 m³/h of natural gas,* 100 m³/h of oxygen, with a powder productivity of 50-60 kg/h.

In order to obtain good-quality coatings with a specified phase composition, it is necessary to know the basic principles of the behavior of atomized oxides in a two-phase stream. The task is somewhat complicated when, as in our case, the solid phase has two components: Al₂O₃ and SiO₂. We first studied the heating and interaction of the Al₂O₃ and SiO₂ particles in the flame of a gas-oxygen burner using α-Al₂O₃ and SiO₂ (α-quartz) in fractions less than 100 μm. The compositions of the powders covered 0-100% of the components† in steps of 10%. Preliminary mixing of the powders in a ball mill made it possible to obtain conglomerates of Al₂O₃ and SiO₂ particles. It was established that with a separated feed into the flame of particles of SiO₂ measuring less than 80 μm and of Al₂O₃ measuring less than 40 μm, the particles melted down and became spheroids (Fig. 1). The coarser particles were partially flashed off in the burner.

*These figures are given for normal conditions.
†Here and subsequently weight percentages are shown.

Fig. 1. Spheroidized quartz particles; × 120; reflected light.

All-Union Institute of Refractories. Translated from Ogneupory, No. 9, pp. 28-33, September 1982.

0034-3102/82/0910-0477$07.50 © 1983 Plenum Publishing Corporation
TABLE 1. Composition of Powdered Mixtures

<table>
<thead>
<tr>
<th>Comp. No.</th>
<th>quarts sand</th>
<th>aluminum oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>--</td>
<td>100</td>
</tr>
</tbody>
</table>

Fig. 2. Change in the intensity of the mullite line at $2\theta = 17°55'$ for mixtures of $\text{Al}_2\text{O}_3$ and $\text{SiO}_2$ powders passed through a gas-oxygen burner.

An x-ray phase analysis of the mixture of powder after being passed through the burner showed the presence of chemical interaction between $\text{Al}_2\text{O}_3$ and $\text{SiO}_2$ (Fig. 2), followed by the formation of mullite. In this case, no free crystalline silica was observed in the heat-treated mixtures with a concentration of $\alpha$-quartz of < 70%. This is because it partially takes part in the interaction with $\alpha$-$\text{Al}_2\text{O}_3$ forming mullite and partially changes to a vitreous silica. In the mixtures containing > 70% SiO$_2$, $\alpha$-quartz appears, as well as mullite.

The interaction in the burner of the components of the original powder enables us to also use this method for synthesizing powders of the required phase composition.

To study the properties of the coating, we chose compositions in the regions rich in $\text{Al}_2\text{O}_3$ and $\text{SiO}_2$ (Table 1).

As the starting material, we used $\alpha$-$\text{Al}_2\text{O}_3$ of fractions < 60 μm and quartz sand of fractions < 80 μm. Coatings were applied to a thickness of 20-40 mm on aluminosilicate brick.

The theoretical dependence of the duty factor $K_p$ of the multicomponent powder (ratio of mass of coating to mass of original powder), where there is no coagulation but an interaction between the components in the burner, and no significant difference in the melting temperature of the components, can be expressed by the formula

$$K_p = \sum_{i=1}^{i=n} m_i K_i,$$

where $K_i$ is the duty factor of the individual component and $m_i$ is the proportion of the individual component in the original powder.

Table 2 gives the calculated and experimental values of the duty factors of powder based on $\text{Al}_2\text{O}_3$ and $\text{SiO}_2$.

In the calculation of the duty factors of the powder, we determined the duty factors $\text{Al}_2\text{O}_3$ and $\text{SiO}_2$ experimentally as 0.50 and 0.80, respectively. The difference between the values of the calculated and experimental duty factors of the powders are associated with the interaction between particles in the burner which leads to the formation of conglomerates of the solid-melt type or to the coagulation of droplets. This phenomenon produces a reduction in the loss of the applied powder. To allow for this interaction, we introduce the idea of a coefficient $K_i$: