Forsterite Refractories Made with Olivinite

Research has shown that olivinite from the Khabozerskiy deposit is a promising raw material for manufacturing forsterite refractories [1 - 3].

This article describes the results of research and industrial tests on a representative sample of Khabozerskiy olivinite. The sample consisted of a mixture of lumps of rock with a crystal structure of 3 different types: 10 - 12% dark gray to black, up to 65% brown and 23 - 25% greenish.

The composition of the different varieties of olivinite was as follows, in %: 37.00 - 38.60 SiO₂; 0.48 - 0.97 Al₂O₃; 0.15 - 0.60 TiO₂; 0.10 - 0.36 Cr₂O₃; 0.76 - 4.10 Fe₂O₃; 11.52 - 12.28 FeO; 0.85 - 2.00 CaO; 41.00 - 46.34 MgO; 0.32 - 3.35 MnO; 0.51 - 0.55 NiO; and 0.16 - 0.50 other impurities. The refactoriness of the olivinite is 1580 - 1690 °C, apparent porosity 0.66 - 2.05%, bulk density 3.23 - 3.35 g/cm³, specific gravity 3.22 - 3.36, and compressive strength 378 - 790 kg/cm².

Microscopic investigation [2] of sections of different types shows that they consist of 80% olivine, 10 - 12% serpentine and 5 - 7% titamagnetite and carbonates.

Of all the types of raw material used to make forsterite refractories, olivinite contains the greatest amount of iron oxides and this may reduce the refactoriness and refractoriness-under-load. Hence when making these refractories it is very important to add the right amount of magnesite.

We tried out the addition of 5, 10, 15, 20, 25 and 30% magnesite powder under laboratory conditions. We added magnesite powder finer than 0.088 mm and olivinite from which 15 and 25% magnesite powder had been added. The mixtures were prepared in a mill: first the olivinite was ground into a 3 - 0 mm fraction, and then the magnesite powder was added. The mixtures were pressed at 800 and 1000 kg/cm² and fired at 1600 °C.

When 0 - 15% magnesite was added, the porosity varied between 15.2 and 17% and the refractoriness-under-load of 2 kg/cm² ranged from 1640 to 1690 °C. The refractoriness of the specimens with 15% magnesite was 1650 °C. When the magnesite content in the powder was increased from 15 to 30%, the porosity varied less - 17 to 17.5%, and the refractoriness-under-load then ranged from 1690 to 1720 °C.

These figures show that at least 15% magnesite powder has to be added to the divinite when making forsterite refractories.

The presence of the brown variety containing up to 16% Fe₂O₃, FeO and 2% CaO may reduce the refactoriness of the parts, hence it is advisable to add more magnesite powder.

Specimens were also prepared from the different types of olivinite with the addition of 25% magnesite powder. The specimens made from the dark gray variety, containing the greatest amount of MgO and the least amount of iron oxide and calcium showed the least porosity - 17.7 - 14.0%; specimens of the green variety showed 18.3 - 18.5% and those made with the brown type 16.1 - 16.5%. The porosity of the specimens was 17.8 - 18.4%.

Experimental bricks 230 X 115 X 65 mm in size were manufactured at the UNIO experimental plant from olivinite to which 15 and 25% magnesite powder had been added. The olivinite was added in the form of a 3 - 0 mm fraction, and the magnesite powder in a fraction less than 0.088 mm. The mixtures were prepared in a mill; first the olivinite was loaded, and moistened with sulfite-cellulose liquor (% of the dry weight), and then the magnesite powder was added. The mixing lasted 10 to 12 minutes. The bricks were pressed on a hydraulic press at 800 and 1000 kg/cm² and on a 180-ton friction press with different numbers of pressings.

An increase in pressure from 800 to 1000 kg/cm² and a greater number of pressings on the friction press had little effect on the density of the parts. When the mixture contained 25% magnesite powder the bricks manufactured on the hydraulic press at 500 kg/cm² showed a porosity of 14.8 - 16.1%, and when pressed at 1000 kg/cm² - 15.0 to 15.6%. Bricks made with the same mixture on a friction press with 4 pressings showed a porosity 14.9 - 16.4%, and after 10 pressings 14.5 - 16.3%.

The bricks were fired in a batch kiln with oil firing at 1600 °C for 6 hours. The firing lasted 77 hours.

Two industrial batches of forsterite brick 370 X 150 X 75 mm in size were manufactured for open-hearth furnace regenerator checkers from olivinite at the Panteleymonovo Plant [2].

LITERATURE

REFRACTORIES IN SERVICE

FORSTERITE REFRACTORIES MADE WITH OLIVINITE FROM KHAHOZERSKIY DEPOSIT AND THEIR SERVICE IN OPEN-HEARTH FURNACE REGENERATOR CHECKERS

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The first batch weighing 95 tons was made from olivinite with maximum grain size 2 mm by the plant's standard procedure for forsterite refractories from dunite. The second batch weighing 345 tons was made with olivinite with a maximum grain size 3 mm. The magnesite powder added was finer than 0.088 mm.

The charge consisted of 75% olivinite and 25% magnesite powder. The mixture was processed in a mill and moistened with an aqueous solution of sulfite-cellulose base 1,25 - 1.26 g/cm³ in density. The moisture content of the mixtures was about 3%. The grain composition is given in Table 1.

<table>
<thead>
<tr>
<th>Batch</th>
<th>Grain content, mm, %</th>
<th>(&lt;0.5)</th>
<th>(&lt;0.5)</th>
<th>(&lt;0.5)</th>
<th>(&lt;0.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>7.6</td>
<td>32.4</td>
<td>59.0</td>
<td>39.5</td>
<td>35.2</td>
</tr>
<tr>
<td>Second</td>
<td>1.3</td>
<td>9.3</td>
<td>38.6</td>
<td>34.1</td>
<td>35.2</td>
</tr>
</tbody>
</table>

The bricks were tested at the "Zaporozhstal" Plant in open-hearth furnaces A and B with medium capacity.

The open-hearth furnaces were operated by the scrap-ore system with the addition of 70 - 75% liquid pig. The furnaces were fired with a mixture of coke and flue gases and the air used was enriched to 23% oxygen. During the tests, 53.2% of the melts in furnace B were made with an increased oxygen usc~ was enriched to 23~; oxygen. During the tests, 53.2% of the melts in furnace B were made with an increased oxygen

The approximate chemical composition of the bricks, after service, in %, is as follows: 28.60 SiO₂, 2.00 Al₂O₃, 1.10 Cr₂O₃, 9.24 Fe₂O₃, 0.87 FeO, 3.30 CaO, 49.4 MgO, 0.40 MnO, 0.44 alkalies, and 0.18 ignition losses. The refractoriness of the brick is 1600°, porosity 14.4%. The chemical composition of the dust deposits on the horizontal surface is: 5.26 SiO₂, 3.85 Al₂O₃, 0.02 Cr₂O₃, 62.6 Fe₂O₃, 2.80 FeO, 6.90 CaO, 15.28 MgO, 1.70 MnO, 0.52 alkalies, and 0.08 ignition losses. The refractoriness of the deposits was 1600°

The photograph shows the appearance of spent bricks from the first row.

The loosened layer in the bricks from the second row was greatly saturated with iron and calcium oxides.

In outward appearance and the amount of dust deposit the regenerator checker made of brick F 2 was not different from the checkers made with brick F 1, but the F 2 bricks were looser. The thickness of the zone saturated with melts in the first row was 2 - 25 mm, and up to 6 mm in the third row.

The dust deposits were not firmly welded to the forsterite brick made of olivinite. The impregnation of the surface layer of the bricks with low-melting melt dust components led to densification of the altered zone (reduction in porosity to 14.4%) and to a reduction in refractoriness to 1600°. When the saturation was extensive, as was noticed in the first rows, the brick cracked completely.

Outward examination of the checkers after completion of the second run showed that loosening with respect to the height of the checker was less in the case of F1 than in F2. On account

<table>
<thead>
<tr>
<th>Manufacturing plant</th>
<th>Batch</th>
<th>Content of magnetic charge, %</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Cr₂O₃</th>
<th>Fe₂O₃</th>
<th>FeO</th>
<th>CaO</th>
<th>MgO</th>
<th>MnO</th>
<th>Alkalis</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIO experimental plant</td>
<td>First</td>
<td>15</td>
<td>32.28</td>
<td>1.15</td>
<td>0.18</td>
<td>11.64</td>
<td>2.78</td>
<td>1.15</td>
<td>49.90</td>
<td>0.34</td>
<td>0.51</td>
</tr>
<tr>
<td>Second</td>
<td>25</td>
<td>27.92</td>
<td>0.84</td>
<td>0.18</td>
<td>10.80</td>
<td>2.18</td>
<td>2.00</td>
<td>55.35</td>
<td>0.34</td>
<td>0.40</td>
<td>0.18</td>
</tr>
<tr>
<td>Panteleymov-ov plant</td>
<td>First</td>
<td>25</td>
<td>24.50</td>
<td>1.96</td>
<td>1.42</td>
<td>10.22</td>
<td>2.16</td>
<td>2.00</td>
<td>56.90</td>
<td>-</td>
<td>0.36</td>
</tr>
<tr>
<td>Second</td>
<td>25 - 30</td>
<td>26.80</td>
<td>1.45</td>
<td>0.43</td>
<td>9.44</td>
<td>2.60</td>
<td>2.00</td>
<td>57.11</td>
<td>0.38</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: Commas represent decimal points.