REFRACTORIES FOR THE CONSUMER

A DISCUSSION: PROBLEMS IN THE USE OF TORCH GUNITING FOR REPAIRING THE LINING OF HEATING EQUIPMENT AND PRODUCTION OF BLOCK REFRUCTORY PARTS. SELECTION OF COMPOUNDS FOR TORCH GUNITING OF OPEN-HEARTH ROOFS*

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An important measure making it possible to prolong the campaign of open hearths is hot repair of them, which may be done by torch guniting.

It is known that the operating time of an open hearth is determined by the service life of its roof and therefore selection of compounds providing the obtaining of a gunited coating reliably protecting the roof refractories must be considered a top priority problem.

At present there is experience in the torch guniting of open hearth roofs with periclase compounds [1, 2]. In [2] the insufficient heat resistance of a periclase coating and the necessity of improving the compositions of the compounds is shown.

Based on the properties of periclase-chromite refractories, which are well recommended in service in open hearth roofs, it is natural to assume that gunited coatings formed from periclase-chromite compounds must most fully answer the service requirements (high heat resistance and refractoriness, satisfactory porosity, etc.).

The question of the optimum ratio of periclase and chromite in the refractories formed was sufficiently fully studied in the 1950s and 1960s. It was established that the particle size distribution of the charge has a significant influence on this ratio and to obtain highly heat resistant refractories it is preferable to use coarse grained charges.

For torch guniting compounds with not less than 90 wt. % of the ≤ 0.09 mm fraction are used.

In [3, 4] the properties of periclase-chromite refractories the original charge of which consisted of finely ground powders of periclase and chromite with a grain size of ≤ 0.01 mm were investigated. However, the data presented in these works cannot be used in selection of the compounds for torch guniting not only because of the significant difference in the particle size distribution but also because of features of formation of the gunited coating including the almost complete absence of external pressure in application, the short high-temperature firing, and the presence of the low melting addition introduced by the fuel ash.

In conducting the present investigations charges with weight ratios of periclase and chromite (chrome ore and siftings of it) of 100:0, 90:10, 80:20, 70:30, 60:40, 30:70, and 0:100 were prepared and also charges based on scrap of used periclase-chromite roof brick (PKhS-scrap) with additions of periclase powder in the following weight ratios: 100:0; 90:10; 80:20; 70:30; 60:40. The chemical compositions of the investigated materials are given in Table 1.

Coal concentrate waste similar in composition to coke ash (the difference in oxide content did not exceed 1%) was added as the low-melting addition. The quantity of low-melting addition was calculated based on a weight ratio of refractory: fuel = 70:30 and an ash content of 15.8%. The share of the ≤ 0.09 mm fraction was 98 wt. %.

*For the start of the discussion see No. 11, 1986 and for the continuation No. 12, 1986 and Nos. 1-4, 1987.


TABLE 1. Chemical Analyses of the Original Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>MgO</th>
<th>Cr₂O₃</th>
<th>SiO₂</th>
<th>CaO</th>
<th>Fe₂O₃</th>
<th>FeO</th>
<th>Al₂O₃</th>
<th>MnO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periclase powder</td>
<td>89,20</td>
<td>2,22</td>
<td>5,48</td>
<td>3,10</td>
<td></td>
<td></td>
<td>1,13</td>
<td></td>
</tr>
<tr>
<td>Chrome ore of Kempirsk deposit</td>
<td>83,69</td>
<td>0,00</td>
<td>5,21</td>
<td>5,43</td>
<td>4,54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrome ore siftings</td>
<td>20,51</td>
<td>51,15</td>
<td>0,93</td>
<td>1,19</td>
<td>11,87</td>
<td>0,74</td>
<td>7,61</td>
<td></td>
</tr>
<tr>
<td>PKhS-scrap</td>
<td>19,35</td>
<td>47,91</td>
<td>9,64</td>
<td>1,40</td>
<td>12,76</td>
<td>0,60</td>
<td>8,26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29,71</td>
<td>39,49</td>
<td>13,75</td>
<td>1,55</td>
<td>9,52</td>
<td>0,88</td>
<td>6,90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26,30</td>
<td>37,02</td>
<td>16,08</td>
<td>1,71</td>
<td>10,49</td>
<td>0,78</td>
<td>7,62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>58,70</td>
<td>15,18</td>
<td>5,62</td>
<td>4,15</td>
<td>9,65</td>
<td>3,82</td>
<td>2,28</td>
<td>0,60</td>
</tr>
<tr>
<td></td>
<td>55,12</td>
<td>14,14</td>
<td>8,45</td>
<td>4,12</td>
<td>10,72</td>
<td>3,56</td>
<td>3,29</td>
<td>0,60</td>
</tr>
</tbody>
</table>

*The upper figure is the oxide content without taking into consideration the low-melting addition and the lower the oxide content taking the addition into consideration.

Since the formation of the gunited coating in torch guniting occurs primarily as the result of sintering pressing of the specimens was done with that specific pressure which has practically no influence on the properties of the fired refractories. According to the data presented in [5, 6] the properties of periclase-chromite refractories start to change significantly with a pressing pressure of not less than 10 N/mm².

The specimens were pressed under a pressure of 3 N/mm² and a 7% solution of polyvinyl alcohol was used as the binder. After drying they were fired in an induction furnace at 1800°C with a hold of 15 min. The average temperature differential across the thickness of the specimens in the last 3-5 min of firing was 200°C.*

In practice in torch guniting of an open hearth roof with shutting off of the open hearth flame the roof temperature may drop to 1300-1400°C while the temperature of the applied coating reaches 1800°C [2]. The temperature of the contact, calculated using the known equation [7], is 1550-1600°C. In this case the temperature differential across the thickness of the coating at the moment of its formation is 200-250°C.

The guniting time for a portion of the roof (2-3 min) is also comparable to the time of firing of the specimens with a temperature differential of 200°C (3-5 min).

A comparison of these temperature and time sintering parameters makes it possible to assume that the method of firing of the specimens is sufficiently close to the actual conditions of formation of the coating and makes it possible to obtain objective comparative characteristics of the sintered materials.

A confirmation of the correctness of the selected formation conditions is the open porosity Popen of the periclase specimens (24%), which completely agrees with the data obtained in determination of Popen of the periclase coating formed by torch guniting and taken from an open hearth roof (20-30%) [2].

Figure 1 shows the results of determination of Popen of specimens according to GOST 2409-80. Specimens with a weight ratio of periclase and chromite of 70:30 have the minimum values of Popen (11 and 15%). Obviously the initial reduction in Popen is related to the increase in content of low melting oxides introduced by the chromite and to the sufficient quantity of periclase, which promotes the occurrence of liquid- and solid-phase sintering reactions.

A further increase in chromite content in the charge leads to a decrease in the number of contacts between the periclase grains (with short firing the chromite grains are able to only partially dissolve in the periclase), which retards solid-phase sintering of the refractories and increases their porosity.

The addition of periclase to the PKhS-scrap causes an insignificant increase in Popen as the result of the increase in the refractoriness of the compositions.

*The temperature in the center of the control specimens was recorded with thermocouples pressed into them. After 10-12 min of firing the temperature in the center of the specimens was 1550°C and at the end of firing about 1650°C.