REFRACTORIES AT THE USER

LINING OF THE SECTIONAL HEATING FURNACE
OF THE TPA 30-102 MILL


The operation of linings of sections of heating furnaces of old and new designs is considered. Specifications for periclase-chromite mortar produced by the Pervoural’sk New Pipe Plant are worked out. The behavior and structural transformation of the heated mortar are investigated.

Sectional furnaces of the TPA 30-102 mill for heating billets before rolling operate at a relatively low temperature (1200 - 1250°C) with short periods at 1300 - 1350°C.

The fuel is natural gas burned in burners with a coefficient of excess of air $\alpha = 1.1$, which ensures an oxidation nature for the gaseous medium in the working space of the furnace. The gaseous phase consists of 20% $\text{H}_2\text{O}$, 10% $\text{CO}_2$, < 5% $\text{CO}$, < 5% $\text{O}_2$, and 55% $\text{N}_2$. The expenditure of the fuel equivalent reaches 125 kg per one ton of heated metal.

Before modernization the furnace was designed as shown in Fig. 1. The lining was laid entirely of chamotte refractory material and a campaign lasted 3 - 4 months. In order to extend the campaign the lining of the working space of the module (the walls and the roof) was made of periclase-chromite parts of PKhSO grade produced by AO Magnezit. The forehearth and the second layer of the lining were laid of chamotte refractories of grade ShB. The periclase-chromite refractories were joined by periclase-chromite mortar.

The operation of sectional heating furnaces is characterized by an intense effect of scale on the lining surface and a large amplitude and frequency for temperature fluctuations in the working space due to the presence of water-cooled rolls. Every week on the day off and during planned repairs the furnaces are working in the no-load mode, when the temperature of the lining of the working space falls to 900 - 1000°C at a rate of 150°C per hour. The lining is also subjected to vibration from the rotating rolls, shaking, and impacts. The walls of the sections are mostly worn at the level of the moving billet. The average wear per campaign is 10 - 20 mm. When a pipe billet has direct contact with the lining the wear reaches 50 mm.

After use for one-half year service the periclase-chromite parts exhibit a low-wear zone, a transition zone, and a working zone. The mineral composition of the transition zone resembles that of the low-wear zone but has a greater porosity and more microcracks, i.e., it is looser than the low-wear zone.

The 5 - 6-mm thick working zone is denser, the periclase is partially recrystallized, and its grain size is greater than in the other zones. The periclase grains are highly saturated with iron oxides, whose concentration decreases with distance from the working surface. Visually, the amount of silicates in the working zone is less than in the other zones. The working zone is not fused and its refactoriness is 1750°C. After use for six months the ultimate compressive strength of the low-wear zone of the periclase-chromite refractory is 23 MPa. The phase composition of the parts after use is given in the Table 1.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Volume fraction of phases, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>periclase</td>
</tr>
<tr>
<td>Working</td>
<td>50</td>
</tr>
<tr>
<td>Low-wear</td>
<td>60</td>
</tr>
</tbody>
</table>

1 Ural State Engineering University, Ekaterinburg, Russia.
2 Pervouralski New Pipe Plant, Pervouralsk, Russia.
3 Composite Materials Scientific and Production Company, Ekaterinburg, Russia.
The main type of wear is associated with scouring of the working surface caused by cracks appearing due to thermal stresses and temperature fluctuations.

On the average a lining made of PKhSO parts is in use for six months. Depending on its wear it is subjected to a restorative or an overhaul.

During a restorative repair a 5 - 10-mm thick protective coating is applied to the working surface of the periclase - chromite lining after cleaning it of crust. The protective coating consists of 85% periclase - chromite mortar corresponding to TU 14-8-632 - 92 and 15% magnesium chromite. After mixing, the disperse powders are moistened by an aqueous solution of sodium polyphosphate with a density of 1.3 g/cm³. The principles of formation of protective coatings are described in [1, 2].

The periclase-chromite mortar is prepared from secondary refractories of PKhSO grade and Nizhne-Uvel'sk clay. The refractory scrap and the clay are dried and then ground in an SM-11B jaw crusher to lumps no larger than 30 mm, and then in an SM-1456 ball crusher. The ground powder is sieved through a 0.5 mm sieve, and the remainder is ground for a second time in the ball crusher. By the specifications of TU 14-8-632 - 92 the content of the 0.063 mm fraction in the ready mortar should be at least 40%. The weight fractions of the main components of the mortar are as follows: at least 65% MgO, at least 10% Cr₂O₃, at most 4% CaO, at most 5% SiO₂, and Δm,sol at most 0.5%. The mortar is produced at one of the shops of the Pervoural'sk New Pipe Plant.

The use of the protective coating increases the service life of the lining by one campaign.

In addition to the use of new refractories the wearability of the lining of the furnace sections can be improved by changing the design of the heating module.

The new configuration of the module and a diagram of its lining are shown in Fig. 2. More efficient jet-and-torch burners are used in the newly designed sections. The lining of the working space is made of carbide-silicon refractories in the roof and of periclase - chromite refractories in the walls and forehearth. The periclase-chromite parts are joined by mortar corresponding to TU 14-8-632 - 92 mortar and the carbide - silicon parts are joined by the carbide - silicon mortar.

The reliability and service life of a lining (especially of the roof) depend largely on the properties of the mortar and its behavior during long operating periods. The low temperature in the working space of the module results in poor sinterability of the mortar with the lining parts and in some cases (under strong vibration) leads to its issuance from the joints, which loosens the lining.

The behavior of the mortar developed by the authors was investigated for cubic specimens prepared from a mixture of normal consistency. The mixture was prepared from periclase - chromite mortar and an aqueous solution of sodium polyphosphate having a density of 1.3 g/cm³. After drying, the porosity of the cubes was 31 - 32% and the ultimate compressive and shear strengths were 6 and 1.5 MPa, respectively.

Differential and integral curves of change in the porous structure are shown in Fig. 3. Two pore classes can be seen in specimens treated at 800 and 1000°C. The total volume of the pores in the specimens is also close and amounts to 0.22 and 0.23 cm³/g for specimens treated at 800 and 1000°C, respectively. Pores with a radius between 0.1 and 6 μm occupy up to 90% their total volume. For both temperatures the