HEARTHS OF 30-TON ELECTRIC FURNACES WITHOUT A RAMMED LAYER

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For a long time the hearths of the electric furnaces at our Combine were manufactured of magnesite brick and a rammed layer of magnesite powder on a coal-tar base. The thickness of the rammed layer reached 200-250 mm. The order of the lining of the hearth was as follows: after laying out an insulating layer of asbestos, fireclay powder, and foam fireclay, we began laying the magnesite brick on edge. Bricking was done dry, joints with a thickness greater than 0.8 mm were not permitted. After laying out the lining of the entire furnace we installed the roof and heated the furnace with firewood to a temperature of about 120°C.

After cooling the furnace down to 60-70°C we began ramming the hearth with magnesite powder on a binder of dehydrated coal tar and pitch with a moisture content less than 0.4%. For ramming we used powder sifted through a screen with a mesh size of 0.5, 2, 5, and 7 mm. Fractions less than 0.5 and more than 7 mm were not used. The dehydrated tar (75-80%) and pitch (20-25%) was used at a rate of 8-10% of the powder weight. The magnesite powder and tar were heated to 80-100°C. The trash-free hearth was coated with the tar, then rammed. After this the hearth was heated with coke according to the established schedule.

The first heats had a small charge. After 10-15 heats a desirable monolithic layer was not obtained, and the working part of the hearth was formed by fettling with fine magnesite powder. The endeavor to obtain a dense rammed layer led only to prolongation of the repair period. Destruction of the rammed layer usually occurred after 5-10 heats.

During lining repair analyses were made over the height of the hearth brickwork. They showed that to a depth of 200-250 mm the hearth was markedly saturated with the oxides of silicon, calcium, aluminum, and iron. These oxides migrate into the hearth. Figure 1 shows the change of the chemical composition of the hearth with depth. The porosity of the surface reaction zone is almost one-half that at a depth of 100-150 mm. The silicates were represented mainly by monticellite (CaO·MgO·SiO₂), cuspidine (3CaO·CaF₂·2SiO₂), and dicalcium silicate (2CaO·SiO₂). Attempts to use the iron scale when ramming the upper layer did not lead to the desired result. The hearth manufactured in this manner is, so to speak, low-grade iron ore, which under favorable temperature and physicochemical conditions is comparatively easily reduced by the carbon of the metal. This phenomenon is observed also when ramming the hearths of open-hearth furnaces.

An important role is played by the column of metal on the furnace hearth. When ordinary magnesite powder is used, compaction of the upper layer of the hearths of open-hearth furnaces occurs at a metal load of 2-5 tons/m². The maximum size of the pore into which the metal cannot penetrate is determined by the expression

\[ z = \frac{2\gamma \cdot \cos \theta}{P}, \]

where \( z \) is the radius of the pore, \( \gamma \) is surface tension; \( \theta \) is the wetting angle of the refractory by the metal; \( P \) is the pressure of the liquid-metal column.

If for carbon steel we take a surface tension of 1500 dyn/cm², angle \( \theta = 120^\circ \), and pressure of the liquid metal at a bath depth of about 650 mm of 0.4 atm, or 4.6 \times 10^5 dyn/cm², then the maximum radius of the pore will be 3 \times 10^{-2} cm, or 0.3 mm. It is not possible to obtain this density under shop conditions when ramming the hearth. Therefore we did away with the rammed layer altogether.

In this case an additional course of magnesite brick is laid in place of the rammed layer. The joints between the bricks (not more than 0.8 mm) were carefully filled with fine magnesite powder. After completing the brickwork of the furnace the hearth was carefully cleaned free of trash and heated with firewood. When a temperature of 60-80°C was reached we began applying a protective layer with a thickness of 30 mm, consisting of magnesite powder sealed with waterglass. At the same time the ledges of the batters were smoothed out for the ramming.
The protective layer was prepared on the working platform, the weight of one batch was about 150-200 kg. After applying the mass on the batters and hearth the mass was slightly compacted, dried with coke-oven gas for 1.5-2.0 h, the furnace was heated for 3 h by firewood and coke, and then the coke remains were removed and changing began.

All heats were of full weight. The first three were medium-carbon steel without oxidation, the fourth and fifth were tool steel, steel ShKh15 (intermediate product) was produced from the 6-10th heats, beginning from the 10th heat all grades of steel with oxidation were produced, and from the 20th heat those with oxygen blowing, including stainless steel. After the first heats the protective layer is very compact, however, there are small cracks, therefore, the hearth is easily fettled with magnesite powder of the 0.8 mm fraction and the electrodes are lowered for 20 min.

The service life of the hearth fabricated in this manner is very long (1800-2000 heats). The hearths are usually replaced owing to deterioration in the quality of the slags. On the old hearths the layer is more intensely eroded as a consequence of the high content of silica and calcium oxide in the upper layers, which leads to an increase of the magnesium content in the slag during refining and to a deterioration of metal quality.

The protective layer during the first heat is readily impregnated by a ferruginous melt. The formation of the protective layer of the hearth in many respects depends on the porosity of the powder. In this case the dispersed part of the powder is quickly dissolved in the silicate-iron melt with the formation of a magnesite-iron mixture. The concentration of iron oxides in the melt decreases as a result of their migration from the melt to the large powder grains. Penetration of a small quantity of the iron oxides into the large powder fragments completes the process of the change of the melt into a refractory solution. Monticellite and forsterite form on the surface of the brick as a result of the silica, waterglass, and magnesite. Magnesioferrite is formed appreciably more rarely. Migration of the oxides into the brick occurs simultaneously.

The protective layer is strongly bound with the hearth and then acts as a whole. The high content of magnesium oxide in the powder raises the melting point of the magnesium-iron binder and the refractoriness of the working layer of the hearth. The strength of the upper layer after the first heats is very high and it was impossible.