PRODUCTION OF DENSE REFRACTORIES FOR
BLAST FURNACE SHAFTS

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The Zaporozhe Refractories Plant together with the Ukraine Refractories Research Institute has
developed a technology for manufacturing dense kaolin chamotte products on the SM-143 toggle press. A
batch of products with a porosity of less than 15\% has been made for the shaft of a blast furnace. The poro-
sity of 92.5\% of the products was less than 13\%, and of 78.4\% not more than 12\% [1]. Porosity variations
were due to the variations in composition and grinding of the fine constituents, and variations in batching.

Measures were taken at the factory for accurate observation of the production cycle parameters in
order to obtain articles with a porosity of not more than 12\%. Gravimetric portion batchers (DPO-100 and
DPO-250 designed by the Kiev Dzerzhinskii Automatic Portioning Device Factory) were fitted to the tube
mill. They guaranteed a steady accuracy of ± 2\% for the batching process.

Component batching and feeding into the tube mill were completely automated. Feeding was done in
portions: 74 kg of chamotte made from Novoselitsk kaolin, and 26 kg of Chl clay.

Loading the mill can be controlled by changing the weight of the portions or the period between dis-
charging the scales. The automatic circuit controls all these operations. A sound signal is given when the
previous or parallel operations of batching the second component are not completed.*

The batching accuracy of the equipment on the centrifugal 115M runnermills of the DPO-250 gravi-
metric batchers was increased. Automating the operation of the mill and accurate batching of the com-
ponents before blending ensured a constant content in the batch of fractions finer than 0.088 mm with varia-
tions not exceeding ± 2\%.

The preparation cycles for the body were stabilized by completely automating the batching operations
for chamotte, finely milled mixture, and slip, successive feeding in runner mills, and reworking the body;
manual control was excluded.

The quality of the slip was improved. Two vanes with left screw and right screw arrangement of the
blades were installed in each slip mixer. Deflocculation of the particles of clay and removal of the air by
counter-streaming substantially reduced the viscosity of the slip and increased its fluidity without the use
of deflocculating additives for the same slip density of about 1.20 g/cm³.

TABLE 1

<table>
<thead>
<tr>
<th>No. of cut pieces</th>
<th>Temperature (°C) at positions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26</td>
</tr>
<tr>
<td>24</td>
<td>1500–1510</td>
</tr>
<tr>
<td>27</td>
<td>1510–1520</td>
</tr>
<tr>
<td>30</td>
<td>1510–1520</td>
</tr>
</tbody>
</table>

Elastic deformations of the press mold plates during pressing
were eliminated. We used molds with plates that had been carefully
adjusted and fitted with bolts. Grade K12F1 steel was used for mak-
ing the plates [2].

The articles were prepared with 5.5 pressings per minute.
The uniformity of firing the products and the accuracy of maintaining
the temperature at the required level (up to ± 10°C) was guaranteed
by using automatic methods and control systems for automatic cir-
cuits for the tunnel kilns [3] developed by the Central Planning Bu-
reau of the Ministry of Instrument Construction.

*This feeding method for the mill is suitable if the grinding capacity
of the starting raw material is stable. Otherwise an acoustic regula-
tor should be used for controlling the mill feed. (Editors.)

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lated from Ogneupory, No. 7, pp. 7-11, July, 1968.
The uniformity of preheating the setting was repeatedly checked by mass control of the porosity of the blast furnace products taken from various places in the setting. No differences were detected in the degree of firing.

With this degree of batching accuracy, it was possible to reduce the content of finely milled chamotte-clay mixture in the body to 42%, instead of 50-55% when pressing on friction presses [4] and 45% in manufacturing articles with a porosity of not more than 15% on toggle presses [1]. Accordingly, the content of fractions finer than 0.088 mm was 40 ± 20%. Reducing the content of dispersed component enables us to increase the density to 2.32-2.38 g/cm³, practically without loss due to overpressing cracks. Together with this, 42% of the finely ground mixture proved to be sufficient for thoroughly sintering the products. The water content of the body was 5%.

At firing temperatures of above 1500°C the articles fused, so they were scattered with quartz sand with at least 96% SiO₂ in it during setting. We used Novoselov and Avdeev sands and also quartz waste from enrichment plant at the Verkhnedneprov Mining Metallurgical Combine. The kaolin articles scattered with sand did not fuse at a firing temperature of 1550°C. Tests were done with loads of 0.5 kg/cm², which is double the maximum possible load in the setting.

The firing cycles for the articles made for blast furnaces are given in Table 1.

There was no deformation during firing.

The properties of the industrial batch articles (1100 tons) made for the blast furnace shafts of the Krivoi Rog Metallurgical Factory are listed in Table 2. For comparison we also give the properties of the articles in the previously prepared batched [1, 4].

Since low porosity is one of the basic requirements of these products we checked this factor regularly during the industrial batch production.

A sample of nine bricks was taken from each kiln car at previously determined sites on the setting: six from the lower row of the setting from the middle and the end of the car, and three from the top row of the setting from the middle of the car. Samples of 27 articles were taken from some cars for more detailed testing. The test results are given in Table 3.

One batch of D-2 products measuring 345 × 150 × 75 mm was checked using the statistical quality control method developed by the East Institute of Refractories (GOST project entitled "Rules for Collecting, Storing and Transferring Refractory Products," instead of GOST 8179-56). We selected 40 articles from the batch which had no external defects according to our examination. From the 40 samples we selected 12 for the dimensions inspection and for checking curvature and apparent density. Deviations over the length were noted in two bricks +1 and +2 mm, while the permitted deviations according to the East Institute of Refractories project may occur in three bricks. Of the 12 samples, three specimens with the lowest apparent density, determined from the dimensions, were sent to the laboratory for determining the quality factors. The following results were obtained:

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### Table 2

<table>
<thead>
<tr>
<th>Factors</th>
<th>Articles made on presses</th>
<th>1967</th>
<th>1966</th>
<th>1964</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SM-143</td>
<td>friction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content Al₂O₃ + TiO₂, %</td>
<td>42,26±45,54</td>
<td>42,00—44,65</td>
<td>42,00—44,32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>43,53</td>
<td>43,40</td>
<td>43,1</td>
<td></td>
</tr>
<tr>
<td>Fe₂O₃, %</td>
<td>1,00—1,50</td>
<td>0,84—1,56</td>
<td>1,38—1,60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,24</td>
<td>1,29</td>
<td>1,26</td>
<td></td>
</tr>
<tr>
<td>Refractoriness, °C</td>
<td>1750—1770</td>
<td>1750—1770</td>
<td>1750—1770</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1760</td>
<td>1760</td>
<td>1760</td>
<td></td>
</tr>
<tr>
<td>Refractoriness under load, 2 kg/cm², °C</td>
<td>1510—1560</td>
<td>1520—1570</td>
<td>1530—1570</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1540</td>
<td>1550</td>
<td>1540</td>
<td></td>
</tr>
<tr>
<td>After-contraction at 1450°C, %</td>
<td>0,00—0,20</td>
<td>0,00—0,24</td>
<td>0,00—0,10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0,10</td>
<td>0,10</td>
<td>0,05</td>
<td></td>
</tr>
<tr>
<td>Apparent porosity, %</td>
<td>7,7—12,0</td>
<td>6,1—15,0</td>
<td>7,9—12,0</td>
<td></td>
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<tr>
<td></td>
<td>10,4</td>
<td>11,2</td>
<td>9,5</td>
<td></td>
</tr>
<tr>
<td>Compressive strength, kg/cm²²</td>
<td>725—1135</td>
<td>605—1118</td>
<td>637—1165</td>
<td></td>
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<tr>
<td></td>
<td>882</td>
<td>810</td>
<td>840</td>
<td></td>
</tr>
</tbody>
</table>

* The limiting values are shown in the numerator, and the averages in the denominator.