LABORATORY STUDY OF THE RESISTANCE OF REFRACTORIES FOR SOAKING PIT HEARTHS

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The hearths of soaking pits are subjected to the abrasive and corrosive action of metal, slag, and scale.

The possible resistance of the refractories to abrasion is evaluated from the compressive and bending strengths at ordinary and high temperatures. Dynamic methods also exist for testing the abrasion resistance under the action of abrasive materials, in the form of a rotary wheel or jet of powder fed under pressure. However, these testing conditions inadequately reflect the actual conditions of service of the refractories.

The corrosive action in most soaking pits is due to the formation of scale, which occurs intensely at 800°C, and accelerates by a factor of 10 at 1250°C.

The scale in the soaking pits contains magnetite, hematite, and 66-89% wustite. The ratio of these minerals depends on the composition of the furnace gases, the section of the furnace, and the distance between the layer of scale and metal or refractory.

At hearth temperatures of 1200-1300°C the scale is softened, which accelerates the reaction with refractories, and hinders cleaning of the furnace [1].

The most complete combination of corrosive factors acting on the hearth of soaking pits is produced by testing on laboratory equipment of the dynamic type (see Fig. 1) [2]. An installation and the test method developed in France allows an evaluation of the combined influence of temperature, atmosphere, pressure, grade of steel, and type of refractory on its wear, and also the tendency to crust formation during prolonged abrasion.

Three specimens of refractory of the same type are fitted into supports across whose axis passes the pushing device. With its aid it is possible from the outside to regulate the installation of the specimens so that their surface is located on a single plane. The bottom of the refractory material can be rotated in an iron housing making from 2 to 12 rpm.

There is a burner in the split roof of the installation. By regulating the quantity of air and propane in the mixture the necessary temperature is developed, and also the test atmosphere. The content of CO₂ and CO + H₂ in the waste gases is automatically recorded by the Orsat instrument.

A platinum:rhodium-platinum thermocouple is fitted in the base of one of the refractory specimens. The readings are taken with a sliding contact or by rotating the bottom. The device for measuring the temperature can be regulated and temperatures are automatically recorded; it controls the quantity of air fed for combustion which in turn controls the feed or propane to the burner. Periodic checking of the thermocouple readings can be done through the apertures used for the pyrometric measurements.

The weight of the fixed discs rests on the specimen. The security of the disc is guaranteed by means of two pins fitted to the housing of the water jacket and engaging the gaps of the disc.

The friction force between the disc and the specimens is evaluated by periodic registration of the drive current.

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Fig. 1. Equipment for abrasion testing. 1) Water delivery and water removal connecting pipe; 2) discs; 3) refractory specimen; 4) thermocouple; 5) ramming; 6) holder; 7) pusher; 8) rotary hearth; 9) aperture for measuring the temperature with a pyrometer; 10) roof; 11) burner; 12) combustion chamber.

TABLE 1. Wear of Fusion Cast Corundum Refractories in the Laboratory Furnace

<table>
<thead>
<tr>
<th>Factors</th>
<th>Specimen No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Composition, %:</td>
<td></td>
</tr>
<tr>
<td>α-Al₂O₃</td>
<td>98,1</td>
</tr>
<tr>
<td>α-Al₂O₃</td>
<td>90-95</td>
</tr>
<tr>
<td>β-Al₂O₃</td>
<td>5-10</td>
</tr>
<tr>
<td>glass phase</td>
<td>0,0</td>
</tr>
<tr>
<td>Abrasion, mm</td>
<td>0,0</td>
</tr>
</tbody>
</table>

After completing the assembly the burner is inserted. Upon the attainment of the required temperature the disc is clamped to the specimens. After establishment of the necessary atmosphere the mechanism for rotating the hearth is switched on (usually making 5 rpm which corresponds to a peripheral velocity of the disc on the specimen of 270 cm/min). Every 15 min the direction of rotation is changed, and every 48 h the disc is changed.

The results of the experiment are evaluated with respect to the change in the height of the specimen of refractory with an accuracy of up to 0.04 mm. If slag or scale is sticking on the specimen, or if it has penetrated the refractory, microscopic study is carried out on the slides taken from typical zones. Thus, satisfactory comparative data on the resistance of the various refractories are obtained.

In Western Germany using equipment of this type tests were made of the abrasive capacity of various fusion cast corundum products. Experiments were done at 1300°C and a disc pressure of 1.5 kg/cm² in an atmosphere containing about 10% oxygen. After 20 h the abrasive distance (run) was 24,000 mm. The abrasive plate was made of open-hearth steel. The wear of the specimens was proportional to the content of β-Al₂O₃ in the refractory (Table 1) [3].

The same equipment was used to obtain comparative data of the wear of fusion cast mullite and corundum refractories. The results of laboratory and industrial tests were then compared.

Abrasion was applied to specimens cut from blocks delivered for construction, and from blocks of the same batch which had served in a furnace for 40 months. Then the rates of their corrosion in the laboratory furnace and in production conditions were compared (Table 2).

The mullite specimens in the laboratory conditions were worn out much more than the corundum specimens. In the industrial furnace the mullite refractory was located between the guide lines made of corundum, which at the end of the campaign has protruded by 5 mm, as a result of which after 40 months service the mullite had worn out only by 20–25 mm. Calculation of the possible wear of the mullite during this campaign on the basis of the velocity of abrasion in laboratory conditions gives a value of 800 mm. A discrepancy between the wear factors in the laboratory and in the factory is natural, since in industrial hearths the mullite blocks were in practice subjected only to corrosion, and not to the abrasive action of the scales.