USING MULLITE—CORUNDUM REFRACTORIES IN EQUIPMENT FOR REFINING AND VACUUM TREATMENT OF STEEL

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UDC 666.762.11:[621.746.329:
66.043.1]: 669.18.046.518

Using the ASEA-SKF equipment for out-of-furnace refining and vacuum treatment of steel with the "furnace—ladle" type, the long dwell time of the metal in the ladle (4-5 h, sometimes up to 8 h), electromagnetic mixing, and vacuum all create enhanced wear in the ladle lining, even in the metal zone. In the Soviet Union's first plant of this type, satisfactory resistance in this zone (8-10 heats/campaign) was shown by high-alumina articles grade MKO-72 with a weight proportion of Al_2O_3 of at least 72%, which have begun to be used instead of imported goods [1].

Operation of the plant showed that MKO-72 goods are rather deeply penetrated by metal (to 20-25 mm). As shown by calculations, the amount of metal absorbed by the lining of the ladle with such penetration reaches 800-900 kg. This adversely affects the out-of-furnace working of the steel; there is a reduction in the intensity of electromagnetic mixing; the metal penetrating the refractory is oxidized during cooling of the ladle between heats, and with subsequent treatment of the new melting is an additional source of oxygen.

In order to further increase the resistance of the working layer of the lining in the metal zone and reduce the depth of penetration, tests were made of high-alumina refractories grade MKT produced by the Semiluksk plant, having a higher Al_2O_3 content (83%) and lower porosity.

The batch of MKT articles amounting to 27 tons was prepared at the Semiluksk factory using the usual technology [2]. The articles were molded on the P-459 press and fired in a tunnel kiln at 1600°C with a soak of 6 h. The properties are shown in Table 1. The table also shows properties of MKO-72 goods with which we compared MKT articles tested in service conditions.

According to microstructural analysis, MKT (Fig. 1) is composed of filler and bond. The filler is chamotte grain (0.2-2.0 mm) mainly of corundum—mullite composition. The corundum—mullite chamotte grains consist of corundum (0.01-0.3 mm), of irregular isometric shape, arranged in poorly crystallized

TABLE 1. Properties of Mullite—Corundum Refractory

Property	Values for:	
	MKO-72	MKT
Open porosity, %	22,4	20,6
Compressive strength, MPa	80	54
Refractoriness under load of 0.2 MPa, °C	1500	1620
Thermal-shock resistance (1300°C — water), heat cycles	8	19
Gas permeability, μm^2	0,5	0,43
Thermal conductivity at 900°C, W/(m·K)	1,48	1,53
Weight of oxides, %		
SiO_2	22,1	12,4
Al_2O_3	73,5	84,3
Fe_2O_3	1,3	0,6
TiO_2	0,7	0,7
CaO	0,8	0,4
MgO	0,3	0,3

All-Union Institute of Refractories. Central Scientific-Research Institute of Engineering Technology. Planning Office of Izhorsk Factory. Semiluksk Refractories Factory. Translated from Ogneupory, No. 10, pp. 11-14, October, 1981.

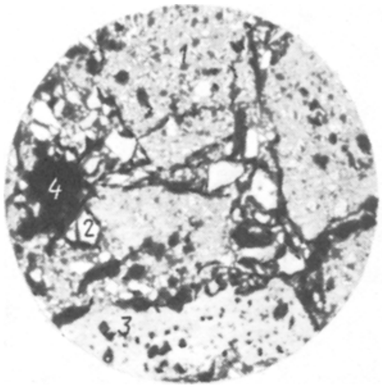

Fig. 1

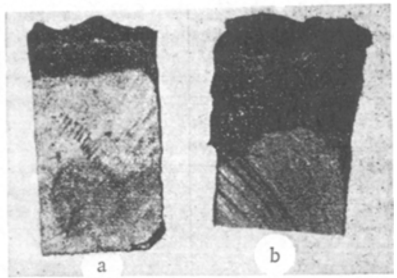

Fig. 2

Fig. 1. Microstructure of MKT: 1) corundum—mullite chamotte; 2) corundum; 3) glassy-mullite chamotte; 4) pores, ×63. Reflected light.

Fig. 2. Refractories MKT (a) and MKO-72 (b) after service in the lining of the ladle walls (16 heats).

glassy-mullite body. The bond consists of grains of corundum (0.01-0.1 mm) of irregular shape and small amounts of chamotte grain, of both corundum—mullite and glass—mullite composition.

Comparison of the microstructure of MKT refractories and those studied earlier (MKO-72) [1] shows that the feature of MKT is the higher corundum concentration and the lower amount of glassy-mullite phase; furthermore, in MKT the pores are generally fine (0.01-0.1 mm) and mainly isolated.

The MKT articles were tested in the working layer of the lining of the bottom and walls of the ladles in the metal zone.

In the working layer of the lining of the walls we tested MKT for two campaigns. In one ladle after 13 heats (the total duration of the heat was 67 h 45 min) the residual thickness of the articles was 95-110 mm (original thickness 150 mm), i.e., the wear was equal to 27-37%. The average rate of wear in the refractory was 0.7 mm/h during the hot time. In the second ladle after 16 heats (total process time 73 h 53 min) the residual thickness of the articles was 100-110 mm, the average rate of wear 0.6 mm per hot hour. In one of these ladles the three upper courses of the lining in the metal zone was built of MKO-72 articles. Comparison showed that in identical conditions of service the average rate of wear for MKO-72 was twice as high, and equaled 1.2 mm per hot hour. Furthermore, the working zone of MKT was impregnated with metal to a depth of not more than 10 mm, while in MKO-72 products the depth of penetration reached 20 mm (Fig. 2).

The MKT brick was tested in the working layer of the lining bottom for three campaigns. In two ladles the bottom was completely lined with MKT. In the first ladle the bottom failed in service after 8 heats

Fig. 3. Microstructure of MKT after service: a) transition zone, b) reaction zone, c) slag skin; 1) corundum, 2) glassy-mullite phase, 3) pores, 4) β-alumina, 5) metal, 6) spinel, a, b) ×100, c) ×200. Reflected light.

(working time 36 h 20 min), and in the second after 6 heats (process time 23 h). The residual thickness of the articles was, respectively, 90-95 and 95-100 mm, with an original thickness in the lining of 150 mm. The main cause of the wear was the formation of cracks and scaling.

In the third ladle, for comparison, half of the lining of the bottom was built of MKO-72 brick. In comparative testing we established that the MKO-72 articles have much less wear than MKT. After nine heats (process time 41 h 40 min) the bottom lining of the ladle failed as a result of wear in MKT brick on account of scaling. The residual thickness of the MKO-72 was 115 mm, MKT 80-90 mm, the rate of wear was equal, respectively, to 0.84 and 1.5 mm during the hot hour.

The MKT after service in the metal zone was subjected to detailed microstructural analysis. The specimen exhibited three clear zones: transition, reaction, and slag-skin. The transition zone (Fig. 3a) is 25-27 mm thick and is distinguished in structure from the original specimens (see Fig. 1) due to the absence of a clear boundary between the grains of filler and the bond. We note an edging of crystals of corundum; in the chamotte grains they acquire mainly a prismatic form (length 0.02-0.05 mm); in the bond, crystallization is worse, and in the main is preserved as irregular forms. Toward the boundary with the reaction zone we note an improvement in the crystallinity of the mullite and corundum. The pores in the transition zone are mainly isolated, isometric (0.01-0.1 mm). In the middle of this zone (20-22 mm from the working surface) we note metal buttons (0.1-0.5 mm).

The reaction zone 5-8 mm thick (Fig. 3b) is characterized by fusion of the filler and the bond, even more so than in the transition zone, by crystallization of the corundum and mullite, and by a large amount of inclusions of metal of rounded and irregular form (0.01-1.0 mm) and also by a significant amount of glass in which we observe locally numerous extended dendritic inclusions of magnetite. We also note a subzone 1-2 mm thick consisting of radiant growths of prismatic (length 0.1-0.3 mm) crystals of the well-known β-alumina. The porosity of the reaction zone is less than the transition zone, the pores are mainly isolated (0.01-0.03 mm).

The slag skin 1-2 mm thick (Fig. 3c) consists of mullite, glass, and numerous well-crystallized grains of colorless spinel (0.01-0.05 mm, sometimes up to 0.1 mm). The pores are isolated, comparatively large (0.1-0.4 mm), and irregular in shape.

Thus, as a result of testing MKT refractories in the metal zone of the ladles for ASEA-SKF equipment, we found that in the lining of the walls these bricks are worn out only half as much as MKO-72 brick. The lining of the walls of the ladle made of MKT after 13 and 16 heats was prematurely scrapped due to causes not depending on the wear of the bricks, and in this case, their residual thickness was two-thirds of the original. It should be expected that the resistance of the wall made of MKT can reach 20 heats with a permitted wear of 50%.

In the lining of the ladle bottom for MKT brick, we demonstrated a worse resistance than the articles MKO-72. The study of the service of refractories MKT in the bottom needs to be continued to explain the causes of the lower resistance compared with MKO-72 brick.

The MKT articles have been accepted for introduction for lining the walls of ladles used with ASEA-ASF in the metal zone. Their use will significantly increase the economic factors for the operation of the installation on account of the reduction in the consumption of refractories and an increase in the metal quality.

LITERATURE CITED

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