

State and Prospects of Providing Mining and Smelting Plants of Ukraine with High-Quality Domestic Refractory Products

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Almost all refractory products and materials necessary for mining and smelting plants that correspond to the world analogues are made at plants of refractory industry of Ukraine.

Keywords: STATE, PROSPECTS, REFRACTORY PRODUCTS, RANGE, REFRACTORY PLANTS

Introduction

Refractory products are widely applied almost in all branches of industry, however metallurgy is still one of the primary refractory consumers (to 80 % from total production).

The primary refractory producers in Ukraine are integrated into association Ukrogneupor that includes JSC "Zaporozhogneupor", JSC "Chasovoyarsk Refractory Integrated Works", JSC "Velikoanadolsk Refractory Integrated Works", JSC "Krasnogorovsk Refractory Integrated Works", JSC "Krasnoarmeysk Dinas Plant", JSC "Panteleymonovsk Refractory Plant", JSC "Kondratevsk Refractory Plant", JSC "Khristogorovsk Refractory Block and Concrete Plant", JSC "Kalderis Ukraine". These plants make approximately 99 % of all refractory products in Ukraine. The association includes also JSC "Ukrainian Research Institute of Refractories named after A. S. Berezhnoy" and Donetsk State Institute of Scientific Research and Project Works and Engineering Services in Refractory Industry.

Refractory plants as well as the whole metallurgical and mining complex were operating under conditions of the world economic crisis in 2009. The volume of refractory output was 360.1 thousand tons in 2009 which was lower by 42.5 % in 2008.

Refractory plants of Ukraine produce almost the whole range of refractory materials necessary

for mining and smelting plants. Refractory products made in Ukraine are at the world analogues level. Import of refractory products has been fluctuating within 10-15 % from their total production for last years.

Traditional import of refractory products is periclase, periclase-chromite and periclase-carbonaceous goods mainly produced in China. Aluminosilicate and dinas refractories are imported in small amounts for last years. However, there are no objective reasons for refractory import. In this case, price policy, relationships between owners of iron & steel and refractory plants and other factors are important.

Data about domestic refractory production for the basic processes of metallurgical production are presented below.

Results and Discussion

Refractories for blast furnaces and hot-blast stoves

Aluminosilicate refractories are traditional for blast furnaces. They are produced by JSC "Zaporozhogneupor", JSC "Velikoanadolsk Refractory Integrated Works", JSC "Chasovoyarsk Refractory Integrated Works", JSC "Krasnogorovsk Refractory Plant" and JSC "Kondratevsk Refractory Plant" by State Standards of Ukraine 2345-94, 2344-94 and GOST 15635-70. The most crucial refractories applied in shafts,

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boshes, tuyere areas of blast furnaces are high-duty fireclay refractories of grades ШПД-39, 41 and 42 produced by JSC "Chasovoyarsk Refractory Integrated Works" and JSC "Krasnogorovsk Refractory Plant".

Aluminosilicate refractories for hot-blast stoves of blast furnaces (GOST 20901-75) are produced by JSC "Zaporozhneupor", JSC "Velikoanadolsk Refractory Integrated Works", JSC "Chasovoyarsk Refractory Integrated Works" and JSC "Krasnogorovsk Refractory Plant". The institute developed and adopted manufacture of mullite-corundum deformation-resistant refractories of grades MK-73, mullite-corundum refractory products of grade MK-80 and thermostable mullite-corundum refractory products of grade MKP-90 (Specifications of Ukraine 26.2-00190503-292:2006) for primary furnaces of hot-blast stoves [3].

Refractories for coke furnaces

Dinas and aluminosilicate refractories are used for coke furnaces. Silica refractories are produced by JSC "Krasnogorovsk Refractory Integrated Works" and JSC "Krasnoarmeysk Dinas Refractory Plant" under Specifications of Ukraine 322-7-00190503-125-97, aluminosilicate refractories for coke furnaces are produced by JSC "Velikoanadolsk Refractory Integrated Works", JSC "Krasnogorovsk Refractory Integrated Works" and JSC "Chasovoyarsk Refractory Integrated Works" under Specifications of Ukraine 322-7-00190503-082-97. High quality of refractories produced in Ukraine for coke furnaces is confirmed by long life of coke batteries in both CIS countries and abroad.

Refractories for steelmaking

Traditional aluminosilicate refractory products for steel teeming are produced by JSC "Zaporozhneupor", JSC "Velikoanadolsk Refractory Integrated Works", JSC "Chasovoyarsk Refractory Integrated Works", JSC "Krasnogorovsk Refractory Integrated Works" and JSC "Kondratevsk Refractory Plant".

At the same time, unmolded refractories are widely used for lining of steel-teeming and intermediate ladles in the world practice. JSC "Ukrainian Research Institute of Refractories named after A. S. Berezhnoy" is constantly developing new and improving current types of unmolded refractories for the purpose of their quality improvement. The institute has adopted production of a wide range of concrete mixes [4-7].

Periclase-carbonaceous refractories are applied for lining of slag-line area of steel-teeming ladles (Specifications of Ukraine 26.2-00190503-247-2003). Mixtures for opening steel-tapping holes in ladles were developed, tested at iron & steel plants and are produced under Specifications of Ukraine 26.2-00190503-272-2005 by JSC "Krasnogorovsk Refractory Plant" [8]. Cement-free calcinated corundum-spinel stoppers in ladles for steel blowing by argon were developed and produced by JSC "Ukrainian Research Institute of Refractories named after A. S. Berezhnoy" (Specifications of Ukraine 26.2-00190503-290:2006) [9]. JSC "Ukrainian Research Institute of Refractories named after A. S. Berezhnoy" produces zirconia metering nozzles for intermediate ladles (Specifications of Ukraine 26.2-00190503-264-2004) [10], and JSC "Krasnoarmeysk Dinas Refractory Plant" produces zirconia metering nozzles under Specifications of Ukraine 322-7-00190503-110-97.

A great range of magnesium articles are made for steelmaking in Ukraine. They are refractories for open-hearth furnace crowns - JSC "Zaporozhneupor" and JSC "Panteleymonovsk Refractory Plant", refractories for converters - JSC "Zaporozhneupor", steel-pouring nozzles - JSC "Zaporozhneupor" and JSC "Panteleymonovsk Refractory Plant", etc. (GOST 10888-94 (State Standard of Ukraine 2573-94).

A great range of heat-insulating refractories, in particular lightweight refractory products (GOST 5040-78) and fibrous materials (GOST 23619-79) are produced for iron & steel plants.

JSC "Ukrainian Research Institute of Refractories named after A. S. Berezhnoy" developed technology and adopted manufacture of new types of light refractories and concretes of anorthite, hexaaluminatecalcium and wollastonite compositions (Specifications of Ukraine 26.2-00190503-312:2008) [11]. They have thermal conductivity in 1.5-2.0 times smaller than usually produced light refractories due to their microporous structure.

The institute also developed manufacture of corundum light refractories differing by higher strength and low thermal conductivity in comparison with industrially-produced refractories. In Ukraine, a wide range of heat-insulating fibrous materials and aluminosilicate articles are produced by JSC "Sinelnikovsk Heat Insulation" [12] and JSC "Izosev". Produced fibrous materials and articles are effectively applied in various metallurgical aggregates. Properties of new refractories are presented in **Tables 1, 2**.

Table 1. Properties of new refractory products developed and produced by JSC “Ukrainian Research Institute of Refractories named after A. S. Berezhnoy”

Item name	Mass fraction, %						
	CaO	Al ₂ O ₃	MgO	Fe ₂ O ₃	SiC	N	Si _{free}
Mullite-corundum deformation-resistant MK-73	n/s	≥ 73.0	n/s	≤ 0.5	n/s	n/s	n/s
Mullite-corundum heat-resistant MKII-90	n/s	≥ 90.0	n/s	≤ 0.5	n/s	n/s	n/s
Mullite-corundum MK-80	n/s	≥ 80.0	n/s	≤ 0.5	n/s	n/s	n/s
Corundum-spinel ПКИИ	n/s	≥ 90.0	6	≤ 0.5	n/s	n/s	n/s
Zirconia metering nozzles ЦІК	3.5-5	≤ 3.0	n/s	≤ 0.5	ZrO ₂ ≥ 90.0	n/s	n/s
Mullite-corundum with silicon carbide МККК	n/s	≥ 80.0	n/s	≤ 1.6	≥ 7.0	n/s	n/s
Corundum-silicon-carbide ККСС	n/s	≥ 60.0	n/s	n/s	≥ 10.0	≥ 5	≤ 1
Silicon-carbide on silicon-nitride fines ККHKII and ККHKB	n/s	n/s	n/s	n/s	≥ 70.0	≥ 7	≤ 0.5
Silicon-carbide on alumina-containing fines ККГII	n/s	≤ 3.0	n/s	n/s	≥ 82.0	n/s	n/s
Corundum lightweight КJIA-1.3	n/s	≥ 95.0	n/s	≤ 0.03	n/s	n/s	n/s
Hexaaluminatecalcium lightweight ГAKJI-1.3	7-8	≥ 90.0	n/s	≤ 0.5	n/s	n/s	n/s
Anorthite lightweight AJI-0.8	14-18	≥ 36.0	n/s	≤ 1.0	n/s	n/s	n/s

Item name	Open porosity, %	Compressive resistance, N/mm ²	Heat conduction, W/m·K, at t _{av} 650 °C	Deformation temperature under loading 0.2 MPa, °C, not lower
Mullite-corundum deformation-resistant MK-73	≤ 20	≥ 50	-	≥ 1750
Mullite-corundum heat-resistant MKII-90	≤ 22	≥ 55	-	≥ 1630
Mullite-corundum MK-80	16-22	≥ 40	-	-
Corundum-spinel ПКИИ	≤ 18	≥ 70	-	-
Zirconia metering nozzles ЦІК	≤ 18	-	-	-
Mullite-corundum with silicon carbide МККК	≤ 18	≥ 80	-	≥ 1700
Corundum-silicon-carbide ККСС	≤ 18	≥ 120	-	≥ 1700
Silicon-carbide on silicon-nitride fines ККHKII and ККHKB	≤ 18	≥ 140	-	≥ 1700
Silicon-carbide on alumina-containing fines ККГII	≤ 18	≥ 70	-	≥ 1550
Corundum lightweight КJIA-1.3	Total porosity > 67	≥ 4.5	≤ 0.55	n/s
Hexaaluminatecalcium lightweight ГAKJI-1.3	Total porosity > 67	≥ 3.5	≤ 0.40	n/s
Anorthite lightweight AJI-0.8	Total porosity > 70	≥ 3	≤ 0.23	n/s

*Note: n/s - no standard

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Table 2. Properties of new refractory concretes developed and produced by JSC “Ukrainian Research Institute of Refractories named after A. S. Berezhnoy”

Concrete type	Mass fraction, %					Compressive resistance, MPa, not less, form mixture after air solidification of samples and their heat treatment, °C			Heat conduction at $t_{av} 350 \pm 25$ °C, W/(m·K)	Grain size, mm
	Al ₂ O ₃	CaO	Fe ₂ O ₃	MgO	SiC	110	1350	1450		
Corundum СКпл-50-94	≥ 94.0	≥ 3.0	≤ 0.5	n/s	n/s	≥ 45	n/s	n/s	n/s	0–6
Mullite-corundum vibrational ССМКНЦБ	> 72.0	≤ 2.5	≤ 1.0	n/s	n/s	> 35	n/s	≥ 100	n/s	0–6
Mullite-corundum self-leveling СМКНЦБС-1	≥ 94.0	1.0–2.5	≤ 0.5	n/s	n/s	≥ 20	n/s	≥ 100	n/s	0–3
Mullite ССМЛНЦБ	> 62.0	≤ 2.5	≤ 1.0	n/s	n/s	≥ 25	≥ 70	n/s	n/s	0–6
Multisiliceous ССМКРНЦБ	≥ 55.0	≤ 2.5	≤ 1.5	n/s	n/s	≥ 25	≥ 65	n/s	n/s	0–6
Aluminous spinel vibrational СГШНЦОБ	≥ 90.0	1.0–2.5	≤ 0.5	5.0–7.0	n/s	≥ 25	n/s	≥ 85	n/s	0–6
Aluminous spinel for gunning СКШНЦОБРТ	≥ 90.0	2.5–3.5	≤ 0.5	3.0–6.0	n/s	≥ 15	n/s	≥ 50	n/s	0–3
Mullite-corundum (grade МКБС)	≥ 72.0	4.0–6.0	≤ 1.0	n/s	n/s	≥ 47 (20 °C)	≥ 35 (1100 °C)	n/s	n/s	0–3
Corundum-carbide-silicon КККБС	≥ 77.0	≥ 1.2	≤ 0.8	n/s	≥ 9.0	≥ 10 (20 °C)	n/s	10	n/s	0–3
Anorthite САНБТ-0.8	≥ 38.0	18.0–20.0	≤ 1.5	n/s	SiO ₂ ≤ 40.0	≥ 1.5	≥ 1.0 (800 °C)	n/s	≤ 0.18	0–5
Hexaaluminatecalcium СГАКБТ-1.5	≥ 82.0	10.0–14.0	≤ 0.3	n/s	SiO ₂ ≤ 0.5	≥ 5.5	≥ 4.0 (1000 °C)	n/s	≤ 0.55	0–5

*Note: n/s - no standard

Conclusions

Refractory plants of Ukraine produce almost the whole range of refractory products and materials necessary for mining and smelting plants. All made refractory products correspond to the world analogues.

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*Published in Russian

Received January 26, 2010

**Состояние и перспективы обеспечения
высококачественными отечественными
огнеупорами предприятий ГМК
Украины**

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