R & D of the JSC BRP for RUSAL's Projects for Reconstruction of Furnaces for the Production of Carbon Materials

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Abstract

JSC BKO develops and introduces new types of highly effective refractories, including for import substitution. When performing research on anode furnaces Sayanogorsk Aluminum Plant consistently solved for two objectives: primary – replaced supplies previously used for their repair services MLS-62, China's production of domestic products BorABF; promising to offer andalusite shared refractories with domestic-sitovich brand products HALBOR-46 ALS for the construction of new anode furnaces projected company RIEDHAMMER. In another innovative project for the reconstruction of the rotary kiln for coke calcination JSC "RUSAL Bratsk" were developed, manufactured and delivered innovative shaped and unshaped refractories JSC "BKO": andalusite bricks HALBOR-45 ALS and BOREX-65 ALS brand, refractory castable BORCAST-96W, refractory glue.

Key words: Anode furnace, coke baking furnace, shaped refractories, unshaped refractories.

1. Introduction

Sustainable development of JSC "BCO", as an industrial enterprise, in a highly competitive environment, is impossible without the diversification of production and associated with it, the development and implementation of high-performance refractories, improving the quality of shaped refractories. The policy of reconstruction and technical re-equipment of production is aimed at diversification.

The diversification of refractory production is expressed in the expansion of the list and the brand of shaped refractories and has the purpose:

- Extension of the scope of shaped refractories, including those previously not covered by the industry,
- Better satisfaction of the requirements of existing customers.

Currently, for some reasons, import substitution has become an additional driving force of diversification.

2. Innovative projects implemented by enterprises of UC «RUSAL»

It is known that UC "RUSAL" today provides its own production only part of the total needs of the burned anodes. Given that the need for burnt anodes will only increase, the company intends to increase its own production to fully meet its own needs in the foreseeable future.
During the development of refractory aluminosilicate shaped refractories for the laying of kilns of anodes, two tasks were consistently solved:

- Priority - to replace the previously used for the repair of anode furnaces Sayanogorsk aluminum plant shaped refractories MLS-62 production of China on domestic (import substitution),
- Promising - the offer of domestic shaped refractories for the construction of new anode furnaces for projects of leading European specialized design organizations, whose requirements for refractories are significantly higher than those applied in Russia and the CIS.

3. BorABF – high alumina shaped refractories For anode furnaces (project with RUSAL-ETC for Sayanogorsk aluminum smelter)

BorABF shaped refractories were proposed as a solution to the priority task for UC RUSAL: replacement of previously used for the repair of anode furnaces of Sayanogorsk Aluminum smelter of shaped refractories MLS-62 made in China for domestic (import substitution). It is a dense refractory shaped refractories composition (properties in table 1). Thanks to the interaction of the raw materials division of RUSAL, the production of the developed shaped refractories was applied to the Gayan bauxite, which provided a reduction in the cost and price of the shaped refractories offered to the required level.

Table 1. Physico-chemical properties of BorABF refractory bricks

Property	Values
1 Chemical composition, mass %:	
Al_2O_3, min	50
Fe_2O_3, max	1,7
2 Open porosity, %, min	15
3 C.C.S., N/mm^2, min	50
4 R.U.L., °C, min	1450
5 P.L.C. at 1400 °C, %, max	0,4
6 T.S.R. (1300 °C-water), cycles, min	4

Manufacturing and testing of a pilot batch of bricks were made in 2014. The monitoring of the service was carried out by RUSAL ETC. The dense structure of the bricks contributed to a decrease in the penetration rate of corrosion into the inner surface of the bricks, which provided increased resistance. After 6 months of operation of experienced partitions, it was decided to completely replace the Chinese bricks with the bricks of BRP JSC. Since 2015, JSC "BRP" has become the main supplier of refractory bricks for JSC RUSAL Sayanogorsk.

In 2016, JSC "BRP" in the All-Russian competition "100 best goods of Russia" presented mullite-silica refractory bricks for lining anode fired kilns, which were recognized as the winner of the Federal stage of the competition and received a laureate's diploma in the nomination "Production for technical purposes "Refractory mullite-silica bricks". The product was given the status "Novelty".

4. Andalusite shaped refractories for anode furnaces (project with RUSAL ETC and engineering company Riedhammer)

A joint project with UC RUSAL and the engineering company Riedhammer solves the long-term goal of offering domestic refractory bricks for the construction of new anode furnaces for projects of leading European specialized design organizations whose requirements for refractories are significantly higher than those used in Russia and CIS.

Andalusite bricks have been used for several decades for the construction and repair of anode furnaces abroad. Due to the unique properties of andalusite, the bricks with its use are highly resistant to unfavorable factors affecting the lining: high mechanical load due to the large size of the base elements of the furnace design - heated piers, high temperature in the firing chamber (about 1300 ° C), cyclic thermal loads , in combination with the temperature drop across the wall thickness, the action of the reducing medium (carbon backfill and its oxidation bricks) and sodium fluoride vapor from cryolite contains in the anode mixture, which is part of the anode mass in an amount from 5 to 20%.

Requirements for refractory bricks are installed by specialized engineering companies (SEC) for the design and construction of furnaces for roasting anodes of aluminum electrolysis cells, such as the French Aluminum Pechiney Technology and the German company Riedhammer. The latter won a tender for the provision of a project and technical support for the construction of new and reconstruction of the existing anode baking furnaces at RUSAL.

The requirements for the bricks of both companies practically coincide, they are given in Table 2. The results of certification tests of the bricks of JSC "BRP" in independent laboratories ICAR (France) and DIFK (Germany) are also given there.

The positive results of the certification tests together with the positive conclusion of the audit of the engineering company specialists make it possible to obtain the certificate and qualification of the approved supplier. JSC "BRP" fulfilled the necessary conditions, which makes it possible to supply bricks under SEC projects not only in Russia, but also abroad.

Table 2. PhySECal and chemical properties of andalusite refractory bricks

Property	Requirements of SEC	Values for bricks JSC "BRP"	Requirements of SEC	Values for bricks JSC "BRP"	Requirements of SEC	Values for bricks JSC "BRP"
Trade marks	0	BOREX-62 ALS	1	HALBOR-46 ALS	2	ALBOR 500
Elements of furnace construction	End wall		The heating walls		The bottom of the firing chambers	
R.U.L., $T_{0.5}$, °C (ISO 1893)	min 1600	1660	min 1480	1555	min 1420	1461
Bulk density, g/cm^3	max 2,45	2,65	max 2,30	2,35	max 2,25	2,32
Open porosity, %	max 17,0	14,9	max 17,0	17,0	max 16,0	15,4
C.C.S., N/mm^2	min 50	106,7	min 45	75,1	Max 50	54,7
T.S.R., cycles (DIN 51068)	max 25	>30	max 15	23	-	20
Thermal expansion at 20°C – 1000°C	max 0,7	0,50	max0,7	0,56	min 0,7	0,67
Creep at 1280°C (0.2 MPa, 0-25h). Deformation Z_{25}, %	max 0,3	0,08	max 0,3	0,05	-	-
Creep velocity V_{15-25}, % per hour	max 0,005	0,003	max 0,005	0,0002	-	-
Resistance at CO(200 ч)	A	A	A or B	B	-	-
Chemistry, mass. %						
Al_2O_3	min 55	65,73	min 46	52,89	min 42	48,58
Fe_2O_3	max 1,0	0,71	max 1,5	0,86	max 2,0	1,12
CaO + MgO	max 0,6	0,12	max 0,6	0,42	-	0,36
$Na_2O + K_2O$	max 0,6	0,37	max 0,6	0,60	-	0,64
H.M.O.R., N/mm^2 at 1300°C	min 6,0	At 1350°C 6,7	min 6,0	7,52	-	-

5. The lining of furnaces for the calcination of coke

JSC "BRP" participated in the innovative project of RUSAL ETC on the reconstruction of rotary kiln No. 2 for calcination of coke of JSC "RUSAL Bratsk" (branch in the Shelekhov).

For lining of the furnace JSC "BRP" were specially designed, manufactured and delivered the following innovative refractory bricks and unformed materials JSC " BRP»:

- Andalusite bricks of HALBOR-45 ALS format VDZ in the lining of the heating zone,
- BOREX-65 ALS ANDALUSITE bricks in VDZ format in the firing zone lining,
- Refractory concrete BORCAST-96W for the manufacture of pipes of the supply of tertiary air,
- Refractory adhesives mortars MCRB-52 and MMK-72 and phosphate binder.

Installation of furnace lining, manufacture of tuyere lining of refractory concrete and the output of the furnace mode was carried out under the supervision of specialists of JSC "BRP".

After 1 month of operation, the lining of all tuyeres were destroyed by cracking. According to the results of the inspection of the furnace and detailed analysis of operating conditions of JSC "BRP" deviations from the project were identified and a number of measures were proposed to prevent cracking of the lining of pipes, which were not fully performed during the repair, which led to its re-destruction.

The refractory brick lining of the rotary kiln has been in operation since July 2017.

During the scheduled stop of the furnace for repair, it will be necessary to return to the completeness of the proposed activities and to assess the wear of the brick lining.

6. Conclusion

JSC "BCO", following the trends in the development of the refractory industry and applied science, based on the results of its own research in the field of materials science, develops projects to create new types of refractory materials at the level of international analogues, than contributes to the implementation of the national program of import substitution. The above projects have already been implemented to confirm this.