DEVELOPMENT OF NEW REFRACTORY MATERIALS BY SHS-TECHNOLOGY BASED ON KAZAKHSTAN REPUBLIC RAW MATERIAL RESOURCES

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Studies are performed with the aim of developing scientific bases and creation of preparation methods based on local raw material resources for a new generation of SHS-refractory materials with high operating properties, making it possible to increase service life (resistance) of metallurgical heating unit linings, and also to improve the quality of metal obtained. A novelty of this research consists of development of scientifically based approaches for resolving this problem, which make it possible to reveal features of unmolded and molded refractory formation, required for effective control of complex physicochemical and production processes for preparing new grades of refractories.

Keywords: refractories, SHS-technology, self-sintering composition, self-sintering refractory mix, spinelids, thermal shock resistance, chromite ore, chamotte, exothermic reaction.

Stimulation of production processes and provision of innovative ways of developing metallurgical, chemical, oil processing industry, power generation, cement, and other products is unthinkable without creating new materials with improved operating properties, for example refractory objects for lining high-temperature units. A severe shortage of refractories in internal and external markets, and the steady growth in their requirement in metallurgical and cement industries, give rise to increasing interest for preparing high-quality refractory objects with prescribed properties. In this connection development and introduction of resource and energy saving, and ecologically clean technology, providing improvement in refractory material production based on raw material resources of Kazakhstan is important.

One of the leading research areas in the field of creating new refractories for metallurgical units is preparation of highly resistant materials related to multicomponent chromium-containing oxide systems. The high refractoriness and chemical inertness of chromium oxide has served as a basis for creating sintered chromium oxide refractories containing up to 95% Cr_2O_3 and having extremely high corrosion resistance; with respect to the same index chromium oxide refractories markedly surpass all known refractory materials used in practice.

We have proposed prescriptions for refractory compositions [1 – 16] for preparation of refractory materials by SHS-technology based on aluminum and chromium oxides. An advantage of the compositions developed is use of production waste, for example those of no ecological importance, such as dump slag from copper production, and cheap local natural raw material that considerably cheapen preparation of refractory object with good operating properties.

Composition 1 for preparation of refractory objects includes aluminum-chromium phosphate binder, sulfide-yeast mash, and magnesite chromite material. In order to prepare a self-sintering composition the existence of exothermic reactions is necessary:

$$Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr, \quad (1)$$

$$CaO + Al_2O_3 \rightarrow CaAl_2O_4, \quad (2)$$

$$MgO + Al_2O_3 \rightarrow MgAl_2O_4. \quad (3)$$

Active aluminum oxide reacts with calcium oxide of ferrochromium slag with formation of aluminum-calcium

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spinel. Simultaneously magnesium oxide of magnesite-chromite material reacts with aluminum oxide of ferrochromium slag and Al_2O_3 with preparation of aluminum-magnesia spinel.

Thus, as a result of chemical reaction of components of self-sintering composition there is formation of highly refractory crystalline phases: calcium aluminate (T_m 1960°C), and aluminum-magnesia spinel (T_m 2030 – 2050°C), which increase refractoriness of the proposed self-sintering composition and provides high strength. Refractory objects of the proposed composition have refractoriness of 1950 – 2000°C and ultimate strength in compression before self-sintering of 110 – 120 MPa, and after self-sintering 170 – 172 MPa, and at 1400°C 40 – 45 MPa. The content of filler in the form of magnesite-chromite material is controlled within the composition taking account of maintaining the optimum temperature of the process, and consequently occurrence of exothermic reactions leading to preparation of high quality refractory.

Composition 2 contains magnesium sulphate (16 – 18%), aluminum (10 – 15%), iron oxide (21 – 24%), chromite ore (35 – 39%), and water (10 – 13%), and it is recommended for preparing joints of refractory linings. In this case the SHS-process is caused by occurrence of reaction (1) and the following reactions:

$$2MgSO_4 + 4Al \rightarrow 2MgO{\cdot}Al_2O_3 + S_2, \quad (4)$$

$$3MgSO_4 + 2Al \rightarrow 3MgO + Al_2O_3 + 3SO_2, \quad (5)$$

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe, \quad (6)$$

$$3FeO + 2Al \rightarrow Al_2O_3 + 3Fe. \quad (7)$$

The content of magnesium sulphate proposed within the composition not only increases the amount of aluminum oxide in a refractory joint, but also provides the required initial porosity of a joint during composition solidification, which in turn has a favorable effect on the monolithic nature and refractoriness of a joint with a self-sintering composition. As x-ray structural and phase analyses have shown, the Al_2O_3 content in a refractory joint reaches 45%. An increase in Al_2O_3 content in a refractory joint will promote retention of favorable properties of the latter, and in particular refractoriness of a joint will increase and be 1840 – 1890°C.

Composition 3. With reaction of aluminum with silicon and chromium oxide, within composition 3 in the form of additionally introduced refractory clay and chromite ore, there are exothermic self-sintering reactions, i.e., reaction (1) and the following:

$$3SiO_2 + 4Al \rightarrow 2Al_2O_3 + 3Si. \quad (8)$$

Simultaneously aluminum-chromium components of slag of ferrochromium and chromite ores react with magnesium oxide of ferrochrome with formation of highly refractory spinelids (T_m 2100°C) of the composition $Mg(AlCr)_2O_4$. presence of spinelids promotes a reduction in thermal stresses, arising in refractories at high temperature, and prevents loosening of the structure, thereby improving its refractory and strength properties. Refractoriness of the objects obtained is 1790 – 1800°C, and the ultimate strength in compression is 28 – 30 MPa. Self-sintering of refractory mix is recommended for manufacturing chromite aluminosilicate objects. Objects of this type are numerous, and this relates to magnesia spinelid refractories consisting of periclase and chromium spinelid $MgO{\cdot}Cr_2O_3$ (including spinel $MgO{\cdot}Al_2O_3$). Periclase-chromite refractories contain >60% MgO and 5 – 20% Cr_2O_3. For high quality periclase-chromite refractories MgO is used with purity of >96% and chromite concentrate. Magnesia spinelid refractories are also classified as chromite-periclase refractories manufactured from a mixture of periclase powder with chromite ore and containing 40 – 60% MgO and 15 – 35% Cr_2O_3; periclase-spinel (40% MgO and 5 – 55% Al_2O_3); spinel, consisting mainly of spinel $MgO{\cdot}Al_2O_3$ and chromite refractory (>30% Cr_2O_3 and,40% MgO).

Composition 4. The main condition for preparing self-sintering mix composition 4 is occurrence of exothermic reactions (1) and (4). In order to prepare final products in a solid form it is necessary to reduce the temperature of the exothermic reaction mixture (1000 – 1950°C), occurring with considerable heat liberation. For this purpose filler is introduced in the form of magnesite. Here within the self-sintering reaction there is chromium oxide phase with magnesium oxide of magnesite with formation of spinelid:

$$Cr_2O_3 + MgO \rightarrow MgCr_2O_4. \quad (9)$$

The content of components adopted in the proposed self-sintering refractory mix makes it possible to increase chemical resistance of the objects obtained from it at high temperature, since during self-sintering within a mix there is formation of the greatest amount of strong spinelids of compoound composition. Here within the spinelids formed there is an increase in strength and chemical resistance of components (in particular oxides of chromium and magnesium) within their combination compared with these properties of each component individually, which promotes a reduction in spalling, chemical corrosion, and erosion of refractory objects, and as result of this an increase in their ultimate strength in compression to 46 MPa. The ratio of ingredients in a self-sintering mix is determined by experiment and corresponds to preparation of high quality refractory objects.

Composition 5. In order to increase ultimate strength in compression and improve the number of thermal cycles, i.e., refractory service life, self-sintering composition 5 is proposed for lining or coating refractories, including aluminum, chromite ore, and witherite concentrate. CO_2 forming in the course of reaction interacts with SiO_2, which is within the filler:

$$CO_2 + SiO_2 \rightarrow SiC + 2O_2. \quad (10)$$

Within the composition proposed SiC forms in an exothermic mix during self-sintering at 850°C. Witherite concentrate of the following composition is used as barium carbonate, wt.%: $BaCO_3$ 90.5, Fe_2O_3 4.5, SiO_2 3.7, impurities the rest. Concentrate fineness is 0 – 20 μm.

Use of witherite concentrate makes it possible to prepare self-sintering refractory compositions from Kazakhstan raw material. The amount of witherite concentrate in the composition of 5 – 45% gives rise to its capacity to provide in an exothermic mix a self-sintering regime and prepare material with good final properties with respect to strength in compression and refractory service life. The filler is one of the traditionally used refractory oxides, but chromite ore of the following composition, wt.%: Cr_2O_3 54.5, Fe_2O_3 8.5, Al_2O_3 9, SiO_2 4.8, MgO 16, CaO 0.17; grain size composition 0 – 100 μm. Refractory composition, prepared in a self-sintering regime, exhibits ultimate strength in compression from 35 to 40 MPa, thermal shock resistance of 25 – 30 thermal cycles of 1300°C – water, refractoriness of 1850 – 1870°C, and is used in lining in the form of a joint or a coating applied to an object.

A distinguishing feature of composition 5 refractory mix is simultaneous entry into reaction of aluminum during self-sintering both with $BaSO_4$ and with one of the dolomite components, which is the silica phase. Reaction with alumina proceeds by Eq. (8). Here introduction of $BaSO_4$, having a high melting temperature, readily available and comparatively cheap, in combination with aluminum and dolomite makes it possible to increase in addition the strength of material due to forming the compounds $BaAl_2O_3$, which by exhibiting high melting temperature makes it possible to retain high mix refractoriness. As a result of tests it has been established that the ultimate strength in shear of an object is 3.5 – 3.9 MPa, the number of thermal cycles is 17 – 19 (in the range 900 – 925°C) during operation of high-temperature units.

Composition 6. Self-sintering mix of composition 6 is prepared as a result of exothermic reaction between an oxidizing agent in the form of barite concentrate and dolomite, and a reducing agent that is aluminum:

$$MgCO_3{\cdot}CaCO_3 + 2Al \rightarrow MgO{\cdot}CaO{\cdot}Al_2O_3 + 2CO_2. \quad (11)$$

The main distinguishing feature of composition 6 is presence with the refractory mix of a compound of the type $(BaO{\cdot}MgO{\cdot}CaO){\cdot}Al_2O_3$, which increases lining resistance, prolonging an oxygen converter campaign to 585 – 590 melts, and here refractory objects retain strength during storage for 53 – 55 days from the instant of preparation (self-sintering) before use in a lining.

Composition 7 for lining or coating refractory objects includes magnesium sulphate, aluminum, and magnesite. A self-sintering refractory composition is prepared as a result of exothermic reaction (4). During self-sintering aluminum simultaneously also enters into reaction with one of the components of a mortar NSh-39, which is a silica phase, and reaction with aluminum proceeds by scheme (8). The same mortar gives composition plasticity, easily and uniformly applied to the surface of a lining and after sintering a joint it exhibits good adhesion with objects. As a result of testing the refractory composition it has been established that the ultimate strength in shear is 3.2 – 3.5 MPa. The ratio of components in the self-sintering composition is determined by experiment, and deviation of it leads to worsening of lining or refractory object coating quality. The particle size is, μm: magnesium sulphate ≤100, aluminum ≤100, mortar MSh-39 ≤100, magnesite ≤20 μm.

Composition 8 is a coating for refractory objects, including magnesium sulphate, aluminum, iron oxide, chromite concentrate, refractory clay, water, and broken chromite or chromite-periclase refractory objects. A self-sintering composition for coating refractory objects is prepared with exothermic reaction of aluminum with magnesium sulphate, iron oxide, and silica, which are within the refractory clay composition, by reactions (4), (6), and (8). The Si forming during reaction enters into reaction with CO_2, separating during thermal decomposition of dextrin $(C_6H_{10}O_5)_n$:

$$Si + CO_2 \rightarrow SiC + O_2, \quad (12)$$

whose presence in the composition proposed sharply increases ultimate strength in compression and refractoriness due to the high melting temperature (>2000°C). In addition, high-temperature compounds (spinel and oxides) forming in the course of reaction, also promote an increase in refractoriness and lining mechanical strength. Chromite or chromite-periclase broken material makes it possible not only to vary the self-sintering composition temperature, but also to provide a granular structure in the refractory obtained and thereby increase its refractoriness and ultimate strength in shear. Refractory clay, contained within the composition, is cheap, and a readily accessible component, and also provides strength in shear for coatings of a lining. The refractoriness of a coating, manufactured from the composition provided, is 1730 – 1780°C, and ultimate strength in shear 23 – 30 MPa. The ratio of component in the self-sintering refractory composition has been determined by experiment.

Composition 9 for preparing refractory objects includes magnesium sulphate, magnesite, aluminum, dolomite, and water as a binder. The reducing agent is aluminum (powder grade PA-4 with particle fineness 0 – 100 μm), which has high reducing capacity during occurrence of an exothermic reaction, and consequently affects object quality. Magnesium sulphate $MgSO_4{\cdot}7H_2O$ (particle size 0 – 20 μm) is used in the exothermic mix during self-sintering as an oxidizing agent. The magnesium sulphate content within the mix is less than 7 wt.% and gives stable self-sintering of the exothermic mix, and possibly diminution. With a magnesium sulphate content of more than 10% the mixture burns, the mix is softened and deformed, which also has an unfavorable effect on object quality. The dolimite used is unfired magnesite-lime containing objects with a content of the main components, wt.%: magnesium carbonate 45 – 50, calcium carbonate 45 – 50, alumina 2 – 5; fineness 0 – 20 μm. filler within the mix composition is magnesite of the following composition, wt.%: MgO 85 – 92, CaO 0,2 – 2,5, Al_2O_3 1 – 3, SiO_2 2 – 5, Fe_2O_3 1 – 4; fineness 0 – 20 μm. the mix is recommended for use in manufacture of refractory objects. Objects prepared in a self-sintering regime are uniform with respect to composition, and exhibit high refractoriness of 1950 – 2000°C.

Composition 10. In order to increase adhesive strength in shear of composition 10 for laying or coating a lining, including magnesium sulphate, aluminum, iron oxide, and water, it additionally contains aluminochromium phosphate binder and chromite concentrate. During reaction of magnesium sulphate and iron oxide with aluminum there is exothermic reaction of self-sintering by Eqs. (4) and (6).

High-temperature oxides Al_2O_3, $AlPO_4$ and $CrPO_4$, that are products of exothermic reaction, form a monolithic refractory that the aluminochromium phosphate binder gives an initial strength before sintering due to occurrence of reaction of aluminum with free orthophosphoric acid, present within the binder, with formation of mono- and disubstituted aluminum phosphates. The refractory in the from of a joint or coating has an ultimate strength in shear of 5 – 7 MPa. Self-sintering mix of composition 10 is recommended for use as a refractory object lining.

Composition 11 of refractory mix of magnesium sulphate, aluminum, magnesite, chromite, and binder (sulfite-yeast mash) is an exothermic mix capable of sintering during heat treatment up to 1000°C, which leads to accomplishment of self-sintering technology for forming the structure of a refractory object with improved engineering indices. Within the mix composition there is magnesite for increasing object mechanical properties. In particular, an increase in lining strength occurs due to an oxidation-reduction reaction. The aluminum oxide formed reacts with magnesium oxide and magnesite by reaction (3) with formation of highly refractory crystalline phase in the form of a finely-bonded structure of aluminum-magnesia spinel, which promotes a reduction in the intensity of penetration of melt reagents into a lining, for example molten slag, and increases object thermal shock resistance. Thus, presence within the proposed self-sintering composition of refractory mix of high-temperature oxide and finely porous high-temperature compound promotes an increase in refractory strength and thermal shock resistance. The thermal shock resistance (1300°C – water) is 9 – 10 thermal cycles. The composition of magnesite used in the refractory is, wt.%: MgO 85 – 92, CaO 0.2 – 2.5, Al_2O_3 1 – 3, SiO_2 2 – 6, Fe_2O_4 1 – 4; fineness 0 – 20 μm. the filler used is chromite ore of the following composition, wt.%: Cr_2O_3 54, Fe_2O_3 5, FeO 8.5, Al_2O_3 9, SiO_2 4.8, MgO 16, CaO 0.17, particle fineness 0 – 100 μm.

Composition 12. In order to increase ultimate strength in compression and increase the density of self-sintering refractory of composition 12 for manufacturing refractory objects, including magnesium sulphate, an argillaceous component, chamotte, and water, it contains in addition aluminum, iron (II) oxide, and chromite concentrate, and bentonite as the argillaceous component. During reaction of magnesium sulphate and iron oxide with aluminum there is exothermic self-sintering reaction (5) and (7).

Simultaneously active oxides Al_2O_3, SiO_2, and bentonite within the composition by entering into reaction with MgO, promote formation of crystalline phases of forsterite and aluminum-magnesia spinel, which stabilizes strength over the whole temperature range, and makes it possible to obtain good sintered, dense objects without cracks. The effect of bentonite as a plastifier also appears in a capacity to increase filler particle mobility (chromite concentrate and chamotte), creating conditions for their dense packing, and this reduces object porosity. With an increase temperature the maximum SiO_2 content gives rise to the maximum amount of forsterite binder between particles of filler, which is characterized by stability at elevated temperature, and this also improves object refractory properties, the ultimate strength in compression is 35 – 40 MPa with an apparent density of 2.7 – 2.9 g/cm^3.

Choice of filler in the from of chromite concentrate and chamotte is due to their capacity to reduce the self-sintering reaction temperature for the exothermic mix to that required.

Composition 13. Self-sintering refractory composition 13 for lining or coating refractory objects includes magnesium sulphate, aluminum, chromite ore, water, and mortar MS-39. Introduction into the self-sintering composition of mortar MSh-39 increases its refractory properties and thermal shock resistance. Forsterite spinels exhibit increased thermal shock resistance (5 – 7 thermal cycles 1300°C – water), the finely porous structure of $MgAl_2O_4$ promotes a reduction in the intensity of melt penetration into joints, which also increases its thermal shock resistance, and plastifying properties of mortar MS-39 make it possible to apply the composition to a lining with a uniform smooth layer as a result of which there is an improvement in joint and coating strength properties during self-sintering, and an increase in their thermal shock resistance.

Composition 14 for manufacturing refractory objects includes magnesium sulphate, a refractory clay, aluminum, and carbon-free ferrochrome production slag. With use of refractory clay as a binder, one of the main components of which is silica, reaction with CaO and MgO, contained in ferrochrome, proceeds by the following scheme:

$$SiO_2 + 2CaO \rightarrow Ca_2SiO_4, \quad (13)$$

$$SiO_2 + 2MgO \rightarrow Mg_2SiO_4. \quad (14)$$

Refractory structure formation commences with appearance of molten SiO_2, which reacts with CaO and MgO, there is formation of highly dense (2.8 – 3.0 g/cm^3) and high-

TABLE 1. Composition of Self-Sintering Refractory Mix 15

Composition number	Content, wt.%					Ultimate strength in compression, MPa, at temperature, °C	
	barite concentrate	aluminum	copper production dump slag	chamotte	water	500	1100
1	17.5	7.5	25	40	10	75	70
2	20	10	20	42	8	70	67
3	15	8	30	40	7	67	62
4	25	5	22	38	10	60	54
5	23	7	20	37	13	45	40

strength silicate compounds, leading to cementation and compaction of raw material mix particles, and consequently an increase in strength properties. Presence of calcium-magnesia silicate compounds, the mineralizers of high-temperature processes during refractory structure formation, provide a good sintering mix, strength, absence of cracks, and successful use for manufacture in linings in the form of high-strength refractory objects. The ultimate strength in compression of objects after firing is 165 – 170 MPa, and at 900°C it is 29 – 30 MPa. During occurrence of exothermic reactions there is liberation of a considerable amount of heat, and reaction products are melted. Therefore within the mixture there is filler in the form of production slag of carbon-free ferrochrome slag in an amount reducing the self-sintering temperature to the optimum (1100 – 1850°C) and simultaneously the slag participates in self-sintering and formation of silicate compounds.

Composition 15. Self-sintering refractory mix 15 for manufacture of refractory objects includes chamotte, barite concentrate, aluminum, dump slag from copper production, and water as a binder (Table 1). The self-sintering reaction proceeds with reaction of oxidizing agent, i.e. barite concentrate with reducing agent, i.e., aluminum:

$$2BaSO_4 + 4Al \rightarrow 2BaO{\cdot}Al_2O_3 + S_2. \qquad (15)$$

The self-sintering process of the exothermic mix proceeds with considerable heat liberation, and reaction products are prepared in a molten condition, and therefore within the mix there is filler in the form of copper production dump slag and chamotte. The self-sintering temperature of the exothermic mix varies within the limits of 850 – 1850°C.

As x-ray structural and phase analyses have shown, the content of aluminum oxide in refractory objects of this mix increase by more than a factor of two compared with its original content in a mix. Consequently, their refractory properties will increase. In particular, the ultimate strength in compression of objects at 500°C is 45 – 75 MPa, and at 1100°C it is 40 – 70 MPa.

It is important to note that use within the proposed refractory mix of dump slag from copper production, of no economic importance, and cheap Kazakhstan natural raw material in the barite concentrate of the Karagailin deposit, cheapens the process for preparing refractory objects. Barite concentrate of the following composition was used, wt.%: $BaSO_4$ 80, SiO_2 7.5, Pb 0.15, Zn 0.1; concentrate fineness 0 – 20 μm.

Composition 16 for preparing refractory objects includes barite concentrate, aluminum, chromite-periclase broken material of fraction 0 – 15 mm, chromite ore, and water as a binder (Table 2). Introduction of barite concentrate in combination with chromite-periclase broken material of objects of fraction 0 – 15 mm within the composition of self-sintering mix, and presence within it of chromite ore and water in the from of a binder reduces object open porosity.

The water content of less than 4 wt.% in the refractory mix makes it friable. Consequently there are no conditions for development of binder properties for components within the refractory mix. With a water content above 7 wt.% the exothermic mixture on heating cracks and there is an increase object open porosity. The content of filler in a mix was dictated by a requirement for obtaining a stable self-sintering exothermic mixture for preparing objects without pores and cavities. The composition is recommended for use in manufacturing refractory objects and plates of normal dimensions.

Composition 17. With the aim of giving mix 17 binder properties initially barite-containing component (barite or witherite concentrate) was mixed with silica and 65 – 70 wt.% water of its total volume, and the mixture was stirred for 80 – 90 sec (Table 3). Aluminum was added to the binder mix obtained giving it plasticity and uniformity,

TABLE 2. Composition of Self-Sintering Mix 16, wt.%

Composite number	Barite concentrate	Aluminum	Chromite-periclase fraction 0 – 15 mm	Water	Chromite ore	Component open porosity, %
1	14	7	50	7	22	8
2	12	6	50	6	26	8
3	8	5	49	5	33	9
4	5	3	49	7	36	10
5	3	2	48	4	43	10

TABLE 3. Composition of Self-Sintering Mix 17

Composition number	Content, %							Brick refractoriness, °C
	barite-containing concentrate		silica	aluminum	chamotte fraction, mm		water	
	barite	witherite			0 – 10	10 – 20		
1	17	—	27	7	17	17	15	1870
2	—	24	27	8	13	13	15	1870
3	8	—	42	5	13	13	19	1870
4	24	—	25	2	17	17	15	1840
5	14	—	29	5	17	17	18	1850
6	21	—	29	8	13	14	15	1870
7	8	—	39	12	13	13	15	1870
8	30	—	25	3	13	14	15	1840
9	—	17	25	7	18	18	15	1870

thereby creating production conditions for introducing chamotte grains of 0 – 10 mm. The binding mix absorbs and envelops chamotte grains during mixing, which lasts 80 – 90 sec. This excludes subsequent formation of cracks during heat treatment, promotes increased refractoriness, and consequently refractory wear resistance. Then the next fraction of chamotte of

10 – 20 mm with the remaining part of water was added with stirring for 80 – 90 sec in order to increase mix strength before heat treatment, providing easier molding and also providing it with a ready-mix (facing) surface during laying in a mold and subsequent heat treatment at 850 – 900°C fro 15 – 20 min.

This sequence of operation in manufacturing refractory objects, use additionally of a barite-containing component, silica, and aluminum, and also use of chamotte fractions 0 – 10 mm and 10 – 20 mm, makes it possible at 850 – 900°C, and sintering duration of 15 – 20 min for a mix with a certain weight ratio of reagents, to obtain objects with increased refractoriness (1840 – 1870°C), elasticity, and to cheapen the process of manufacture by excluding labor-consuming operation of compaction, reducing electrical energy consumption, and heat treatment duration, i.e., to reduce the duration of the production process as a whole. The self-sintering refractory mix for manufacturing objects self ignites at 850 – 900°C. Self-sintering of the mix proceeds as a result of exothermic reactions between oxidizing agents, i.e., barite-containing components and silica, and reducing agents, i.e., aluminum, during 15 – 20 min. The filler is chamotte and silica. Combustion products are obtained in a molten condition. The chamotte gives a mix strength in molding before heat treatment, and makes it possible to obtain a ready-mix surface, reduces the temperature of the mix for solid product sintering. Strong refractory objects are prepared.

Thus, on the basis of results of previous studies for developing scientific and theoretical bases for controlled synthesis of refractory materials and establishing physicochemical phase equilibria, a number of new compositions have been proposed for self-sintering refractory mixes, objects of which have high technical and economic indices. Non-traditional technology has been created for preparing moldable refractories based on occurrence of self-sintering high-temperature synthesis.

On the whole creation of technology for preparing refractory materials local mineral raw material by SHS-technology is a contribution to science in solution of the problem of supplementing currency resources of the country as a result of organizing import substitution high-tech products. Use of cheap local raw material resources (barite and witherite concentrates of the Karagailin deposit, Arkalyk clay, chromite-periclase broken material, dump slag from copper production, chromite ore, etc.) make it possible to create new import substitution refractory materials, whose testing under laboratory and semi-industrial conditions points to an increase in the service life of Waelz kiln linings on average by 60%. As a result of research non-traditional technology has been created for preparing moldable import substitution refractory materials from cheap local raw material resources with the aim of replacing expensive imported refractories. An advantage of the compositions developed in use of production wastes, for example dump slag from copper production of no ecological importance, and cheap local natural raw materials, which markedly cheapens the process for preparing refractory objects with good operating properties.

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