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Granular magnesia compositions

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ABSTRACT
The results of studies of granular materials from magnesia compositions are presented. To obtain the compositions, fillers of various origins were used: sawdust, wheat husk, rubber and cork crumbs, ash microsphere. The formulations of molding mixtures that ensure the production of granules by the method of pelletizing are determined. The factors of influence on the strength of granules at various stages of the technological process are revealed. Methods for reducing the density of magnesia granular materials by combining various types of fillers and introducing a gas-forming agent are proposed. The use of caustic magnesite ensures reliable bonding of the filler particles in the granules. Features of hydrate formation of magnesia binders allows the use of low-temperature processing of raw granules. The expediency of increasing the temperature of the salt recluse to accelerate the hardening of the porous granules is shown. Magnesia granules with a bulk density of 400 – 500 kg/m³ were obtained. The work is aimed at creating a resource-saving technology of non-annealed granular aggregates for light concrete.

Keywords: Caustic magnesite, filler, composition, granules, porous structure.

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Introduction

The modern industrial policy of Kazakhstan concentrates efforts on the development of "green" technologies, the production of new efficient materials.

Concrete is the most common composite material. Aggregate is the dominant component that makes up 70 - 80% of the mass and determines the structure and properties of concrete.

Lightweight concrete based on porous aggregates are composite materials for energy-efficient construction [1 - 4]. The structural and geometrical characteristics of the porous aggregate make it possible to regulate the structure of composite materials, determine the thermal and physical and mechanical characteristics of lightweight concrete.

Porous aggregate is obtained from natural raw materials as a result of mechanical processing, as well as by chemical transformations during deep processing of the original mass. Technogenic granular materials of mineral and organic origin can serve as a raw material for the production of porous aggregates in roasting and non-firing technologies.

Improvement of firing technologies made it possible to create porous granular materials of a new generation: highly porous sodium silicate powder from liquid glass [5, 6]; glass-ceramic foam multifunctional granular materials (kerpen, thermogran) [7]; granular nanostructuring filler with prolonged action [8-10]; granular microporous material using a burnout additive [11-13]

Research aimed at reducing the density and increasing the strength of aggregates, reducing the energy intensity of production is relevant [2, 4, 14 - 17]. Non-fired aggregates technologies provide for the production of composite granules in which the filler particles are held together by a binder. Ash of heat power engineering, microsilica and other finely dispersed materials are used as fillers [3, 5, 8]. Two-layer granule technologies are effective, based on the creation of a light porous core, on which a dense layer is applied. Modern technology of porous granular materials, as a rule, is based on the use of molding sands or several raw materials, successively forming a porous structure of granules.

Most of the non-fired aggregates are produced on the basis of cements, which leads to technological difficulties in molding and relatively high values of the density of granules. To develop the technology of granular porous materials, it is necessary to expand the raw material base.

Raw materials of Kazakhstan are capable of providing the production of porous aggregates using oil shale, ash from heat power engineering, ore and coal processing waste, metallurgical slags and other technogenic materials, the properties of which are often poorly understood. When used car tires are recycled, a number of valuable materials are formed. Waste from the processing of grain crops (for example, wheat and rice husks) accumulates in regions with a developed agricultural sector.

Non-fired granules should be considered as a composite material, the matrix of which is a binder that connects the filler particles into a given structure. Porization of granules is ensured by the use of various fillers of the appropriate structure and the introduction of a special component - a pore former. Stability of highly porous granules is achieved by forming a dense shell by, for example, dusting with binders.

Analysis of technological solutions for obtaining non-fired granules made it possible to determine the criteria for the selection of raw materials for granular materials (table 1).

Table 1 - Criteria for the selection of materials for porous granules

Materials for non-firing technologies	
function in the raw mix	***criteria***
Matrix - binder	dispersion
	adhesion
	hardening intensity
	strength
Steam generating component	felting
	gassing
	porous structure
	adhesion
Dusting component - astringent	dispersion
	adhesion
	hydration activity

Magnesian binders are distinguished by intensive hardening, high strength properties, expressive adhesion to materials of various origins [18 - 21]. Information about magnesian granular materials is very limited.

The purpose of the work is to study non-fired granules based on magnesian binders.

Experimental part

To obtain granules, we used caustic magnesite powder - 75 with an active MgO content of 75 - 85%, fillers of various origins and states. Ash microsphere of energy ash - hollow solid particles with a predominant diameter of 100 - 250 microns and a bulk density of 400 kg / m^3. Wood sawdust - particles formed during cross and longitudinal sawing of timber, sawn timber, with a bulk density of 210 kg / m^3. Wheat husk - grain processing waste with a bulk density in a crushed state of 220 kg / m^3.

Rubber crumb is particles of 1.5 - 3.0 mm in size, formed during the processing of car tires, with a bulk density of 610 kg / m^3. Cork chips is granular mass with a particle size of 2.5 - 3.0 mm, obtained from production and consumption waste of bottle corks, with a bulk density of 160 kg / m^3.

Molding mixtures were prepared by thorough mixing of caustic magnesite with different proportions of filler. For mixing the molding sands, a magnesium chloride solution with a density of 1230 kg / m^3 was used. The content of the salt grout provided forming properties at close values of the water-binding ratio. Formation of granules with a diameter of 10 - 12 mm was carried out by the method of rolling using a laboratory granulating device. The strength of the raw granules was assessed by the compressive load with fixation of the moment of the appearance of cracks and destruction of the granules. The strength of the hardened granules was determined using a hydraulic press. To accelerate hardening, the granules were heat treated at a temperature of 50 ° C.

Discussion of the results

The rolling of magnesia mixtures occurs with the participation of gravity forces, dry friction, mechanical engagement, electrostatic interaction; in the presence of a liquid phase - forces of capillary-adsorption interaction, viscous resistance. The role of these forces is reduced to both structure formation and the preservation of the properties of the structure. The strength of the granules is ensured by the presence of structural bonds. The results of the study of granulation of magnesia mixtures of various compositions indicate that with an increase in the amount of filler, the cohesion of the masses and the strength of the raw granules decrease (table 2).

Comparison of the characteristics of molding sands with sawdust of various sizes indicates that with the enlargement of particles, pelletizing becomes more difficult. This limits the proportion of woody component in the mixture.

For magnesia mixtures that exhibit a weak ability to pelletize, the pressing method is advisable.

To form a coherent molding mass and obtain stable granules from wheat husks, it is advisable to grind the material to particles with a size of 0.315 - 0.63 mm.

Particles of cork and rubber crumb are larger than the fine fraction of sawdust, but the lumpiness of these mixtures is superior to magnesian wood pulps. Cork and rubber chips have irregular shape geometry, are distinguished by elasticity, low water absorption, which promotes rounding with the help of magnesia suspension, which is characterized by high adhesion to surfaces of various compositions and conditions.

The smooth surface of the ash microsphere is capable of increasing the molding properties of the magnesia mixture. On the other hand, the high specific surface area of the porous filler particles emaciates the molding mass. The ash microsphere is characterized by the smallest grain size and exhibits the worst granulation properties under experimental conditions. Therefore, the size of the filler particles determines the pelletization of only compositionally related masses and does not apply to other mixtures.

Heat treatment at a temperature of 50 ° C for 4 hours accelerates the hardening of the granules. The choice of the drying temperature is due to the rate of hardening of the magnesian binder and the peculiarities of hydrate formation.

The properties of the granules depend on the type of filler (table 3). The quality factor, defined as the ratio of strength to density of the material, was used for the comparative evaluation of the granules. By the type of filler, the granules are arranged in descending order of the quality factor: wheat husk → sawdust → ash microsphere → cork crumb → rubber crumb.

To reduce the density of magnesia granules, the possibility of additional porosity of the molding mass based on sawdust with the help of a gas generator - perhydrol was investigated (table 4).

When adding a blowing agent, the raw mixture swells, the molding mass acquires increased plasticity. This allows you to reduce the proportion of the liquid component in mixtures with a low content of sawdust. The cohesion and granularity of the molding materials are increased, including 25 and 35% filler.

Table 2 - Influence of the composition of the molding mixture on granulation

Molding sand composition, %				***Visual assessment of mixture connectivity***	***Strength raw granules, N / granule***
caustic magnesite	***filler***		**magnesium chloride solution**		
	type	***quantity***			
52	sawdust, 0,14 – 1,25 mm	15	33	high	25
38		25	37	high	23
26		35	39	medium	20
52	sawdust, 1,25 – 2,5 mm	10	38	high	20
45		15	40	medium	19
37		20	43	low	17
51	wheat husk, 0,315 – 0,63 mm	15	34	high	26
40		25	35	high	23
27		35	38	medium	21
54	cork chips, 1,25 – 2,5 mm	15	31	high	26
40		25	35	high	23
28		35	37	medium	20
54	rubber crumb, 1,25 – 2,5 mm	15	31	high	26
40		25	35	high	24
28		35	37	medium	19
56	ash microsphere, 0,05 – 0,10 mm	10	34	high	22
47		15	38	medium	19
37		20	43	low	13

Table 3 - Influence of the type of filler on the properties of magnesia granules

Type and content of filler in the mixture				
Sawdust, 0,14 – 1,25 mm 25%	Wheat husk, 0,315 – 0,63 mm 25%	Cork crumb, 1,25 – 2,5 mm 20%	Rubber crumb, 1,25 – 2,5 mm 20%	Ash microsphere, 0,05 – 0,10 mm 15%
Density, kg / m³				
740	720	830	890	780
Strength of granules, MPa				
5,8	6,5	5,5	5,9	5,5
				

Table 4 - Influence of perhydrol on the properties of magnesia mixture and granules

Content of wood filler in the mixture, %	Gas generator additive, %	Attitude "Liquid: solid"	Bulk density of granules, kg / m³
15	0	0,50	580
	1,5	0,50	560
	2,5	0,48	470
	3,5	0,46	410
25	0	0,58	520
	1,5	0,58	490
	2,5	0,58	420
	3,5	0,57	380
35	0	0,65	460
	1,5	0,64	430
	2,5	0,64	370
	3,5	0,64	340

The influence of the blowing agent is extreme. An improvement in the forming properties is observed at a content of 2.5% perhydrol, a subsequent increase in the proportion of the blowing agent is accompanied by a decrease in the stability of the granules: a tendency to sticking is manifested. The introduction of a blowing agent into the molding mixture made it possible to reduce the bulk density of the granules by an average of 25 - 30%.

Caustic magnesite is the basis of magnesian molding materials, characterized by intensive hardening. However, for porous molding sands, there are difficulties in hardening in a technologically acceptable time.

An increase in the temperature of the salt grout makes it possible to increase the strength of the raw granules, to accelerate the hardening of the hardened granules (figure 1). The use of a grout, heated to 35 ° C, provides an increase in strength to the technologically required values during heat treatment for 3 hours. A subsequent increase in the temperature of the saline solution and an increase in the duration of the thermal effect on the granules are inappropriate due to low efficiency.

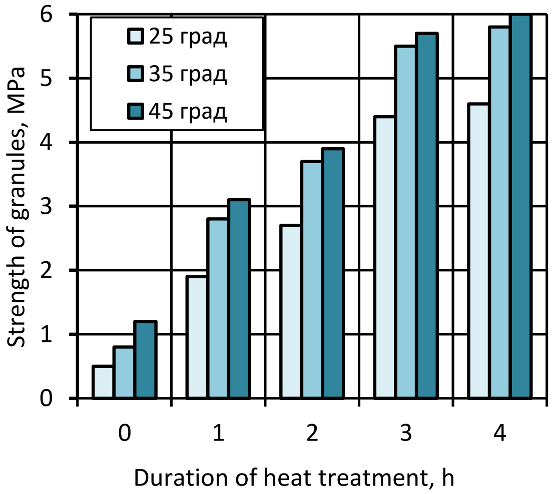
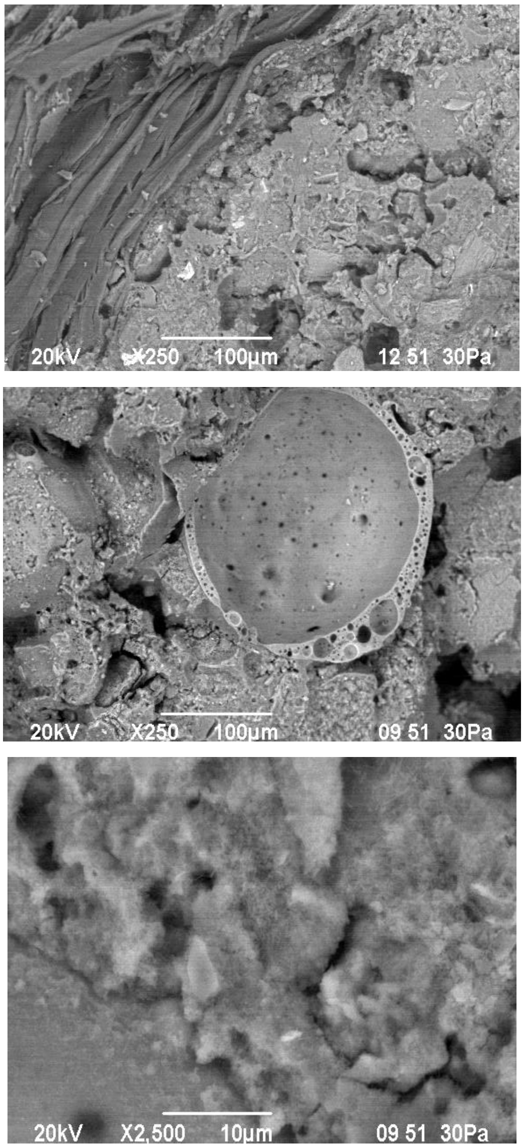


Figure 1 - Influence of the temperature of the grout on the hardening of magnesia granules based on wood filler

The high strength of the granules is facilitated by the reliable contact of the fillers with the magnesian matrix, the crystalline base of which is formed by fibrous magnesium hydroxychlorides (Figure 2).

Another way to reduce the density of magnesia granules is the use of combined fillers, for example, wood particles and ash microspheres (Figure 3).



Picture 2 - Microstructure of magnesia granules

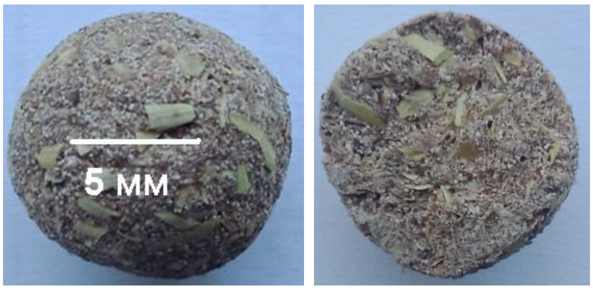


Figure 3 - Magnesia granule with combined filler

The combination of fillers of various shapes allows you to adjust the molding properties of the raw materials and the structure of granules with a bulk density of 470 - 550 kg / m^3.

Conclusions

The possibility of obtaining granular materials based on magnesian compositions has been proven.

High adhesion of caustic magnesite ensures the cohesion of the molding mixtures, reliable adhesion of filler particles of various origins.

Compositions based on technogenic fillers of plant origin or their combination with an ash microsphere are preferred.

To obtain granules of reduced density, it is effective to introduce a blowing agent into the molding mixture.

Intensive hardening of caustic magnesite provides hardening of the granules during low-temperature drying. The crystalline base of magnesium hydroxychlorides contributes to the formation of a strong structure of granular magnesia materials.

Conflicts of interest. the corresponding author states that there is no conflict of interest.

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Түйіршіктелген магнезиалды композициялар

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ТҮЙІНДЕМЕ

Мақалада магнезия композицияларынан алынатын түйіршікті материалдарды зерттеу нәтижелері келтірілген. Композицияларды алу үшін әр түрлі толтырғыштар қолданылды: ағаш үгінділері, бидай қауызы, резеңке және тығын қоқымдары, күлді микросфералар. Тегістеу арқылы түйіршіктер алуды қамтамасыз ететін қалыптастырушы қоспаларының дайындау әдістері анықталды. Технологиялық процестің әртүрлі кезеңдерінде түйіршіктердің беріктігіне әсер ететін факторлар анықталды. Әр түрлі толтырғыштарды біріктіру, газ түзгішті енгізу арқылы магнезиалды түйіршіктелген материалдардың тығыздығын азайту әдістері ұсынылды. Каустикалық магнезитті қолдану түйіршіктерде толтырғыш бөлшектердің сенімді байланысуын қамтамасыз етеді. Магнезия байланыстырғыштарының гидрат түзу ерекшеліктері өңделмеген түйіршіктерді төмен температурада өңдеуге мүмкіндік береді. Кеуекті түйіршіктердің қатаюын тездету үшін тұзды еріткіштің температурасын жоғарылатудың пайдалылығы көрсетілген. Сусымалы тығыздығы 400 – 500 кг/м^3 магнезиалды түйіршіктер алынды. Бұл жұмыс жеңіл бетон үшін қажетті күйдірілмеген түйіршікті толтырғыштардың ресурс үнемдеу технологиясын жасауға бағытталған.

Түйін сөздер: Каустикалық магнезит, толтырғыш, композиция, түйіршіктер, кеуекті құрылым.

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АННОТАЦИЯ

Приведены результаты исследований гранулированных материалов из магнезиальных композиций. Для получения композиций использованы наполнители различного происхождения: древесные опилки, пшеничная шелуха, резиновая и пробковая крошка, зольная микросфера. Определены рецептуры формовочных смесей, обеспечивающие получение гранул методом окатывания. Выявлены факторы влияния на прочность гранул на различных этапах технологического процесса. Предложены способы снижения плотности магнезиальных гранулированных материалов за счет сочетания наполнителей различного вида, введения газообразователя. Использование каустического магнезита обеспечивает надежное скрепление частиц наполнителя в гранулах. Особенности гидратообразования магнезиальных вяжущих позволяют использовать низкотемпературную обработку сырцовых гранул. Показана целесообразность повышения температуры солевого затворителя для ускорения твердения поризованных гранул. Получены магнезиальные гранулы с насыпной плотностью 400 – 500 кг/м^3. Работа направлена на создание ресурсосберегающей технологии безобжиговых гранулированных заполнителей для легкого бетона.

Ключевые слова: Каустический магнезит, наполнитель, композиция, гранулы, пористая структура.

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