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Mini Review

Lightweight Ceramic Materials Based on Industrial Waste of Uzbekistan

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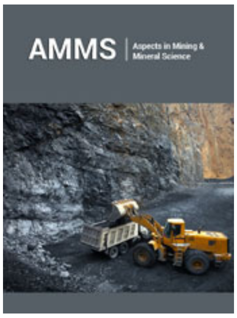

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Annotation

The possibility of obtaining a high-quality porous material with high physical and mechanical properties based on local clay raw materials and man-made waste has been established. It is shown that the chemical industry wastes used accelerate the process of glass formation during firing, reducing the temperature of agglomeration and swelling by 20-40 °C, while obtaining a durable porous material. Regularities of the influence of physical and chemical features, used clay materials and flotation wastes of the Almalyk Mining and Metallurgical Plant on the mechanism of pore formation during the production of agglomerate are revealed.

Keywords: Lightweight; Flotation waste; Phosphogypsum; Solid waste from soda production; Mechanism; Sintering; Swelling; Roasting

Introduction

In connection with the rise in the cost of energy carriers, there is an urgent need to store the generated heat in buildings and structures. And in regions with a hot climate, reduce the cost of air conditioning and ventilation. To implement these important tasks, new inexpensive heat-insulating materials are needed using local natural and technogenic raw materials. One of the building materials obtained exclusively with the use of industrial waste as a raw material component is agloporite, an artificial porous aggregate obtained by sintering sandy-clay materials on the grate of a sintering machine [1-3]. It can be obtained by replacing valuable natural raw materials - highly plastic clays with local industrial wastes: aluminosilicate flotation wastes from copper and lead processing plants of the Almalyk MMC, unenriched kaolin from the Angren deposit, and inorganic wastes from the chemical industry - solid waste from soda production and phosphogypsum. In industrial practice, there are a number of projects to create a technology for the production of expanded clay based on slightly intumescent clays and man-made waste [4,5]. In a number of scientific sources, the main criterion for the suitability of the raw materials used is the ability to swell during heat treatment in the range of 1050-1200 °C and form a material with a cellular structure with a density in the range of 200-1000kg/m3. In addition, attempts are being made to solve the problem of obtaining an effective porous lightweight filler based on slightly intumescent clays and aluminosilicate wastes by adding burnable additives in the form of diesel oil, coal, thermal power plant ash, etc. [6-8].

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The purpose of our research is to develop a technology for obtaining granular porous sintered material (agloporite), using technology using effective swelling intensifiers, in the role of which chemical production wastes - phosphogypsum and solid waste from soda production can be used. Of the variety of natural and technogenic raw materials of Uzbekistan, the most interesting as raw materials for the production of aggloporite can be aluminosilicate waste - flotation waste from the Almalyk Mining and Metallurgical Plant, the amount of which in dumps is hundreds of millions of tons. Flotation wastes from copper and lead (CCP and LCP) concentrating plants are used as a clay-replacing component in the synthesis of agloporite. The study of the characteristics of the used components of raw mixtures was carried out by X-ray phase, petrographic and infrared-spectroscopic, petrographic and other modern methods of physical and chemical analysis. The temperature of the beginning of the formation of the liquid phase and swelling of the aggloporite, the degree of swelling and a number of other physico-chemical processes occurring during the agglomeration of silicate mixtures. The CCP flotation waste is a gray sandy powder with a fractional grain size ranging from 1.00-0.01 mm. The main amount is grains 0.25-0.01mm in size, containing mainly quartz and feldspar crystals. The chemical composition of the flotation waste is mainly quartz SiO_2 - 65%, Al_2O_3 - 14.12%, Fe_2O_3 - 9.05% (Table 1). The flotation waste from the enrichment of Lead-Containing Ore (LCP) contains residual amounts of lead and zinc in the amount of 0.24 and 0.20%, respectively. The main chemical component is silica, the content of which reaches 45% by weight. X-ray diffraction analysis of raw materials [9] was performed on an XRD-6100 diffractometer (Shimadzu, Japan) with a vertical 4-90°. The study of flotation waste by the X-ray phase method revealed the presence of the following main crystalline phases, the interplanar distances of which correspond to: quartz with d=(0.369; 0.334; 0.181; 0.153)nm, $CaCO_3$ with d=0.303; 0.191; 0.181nm, feldspars with d= (0.202; 0.166)nm and hydromicas with d=(0.442; 0.254; 0.148)nm (Figures 1 & 2).

Table 1: The chemical composition of the materials used. LOI*- weight loss on ignition.

Name	Content of Oxides, %								*LOI
	SiO2	Al2O3	Fe2O3	CaO	MgO	Na2O	K2O	SO3	
CCP Tailings	61,18	14,61	9,86	1,32	0,11	2,31	1,76	5,69	4,10
LCP Tailings	45,75	8,72	7,19	14,59	7,10	2,00	0.98	2,98	8,83
Unenriched kaolin	58,6	18,95	1,87	3,91	0,53	0,12	1,11	0,12	14,72
Waste TOSP	1,10	0,40	-	47,1	4,2	-	-	3,8	42,40
Phosphogypsum	10,43	0,42	0,15	28,3	-	0,04	0,04	40,5	19,64

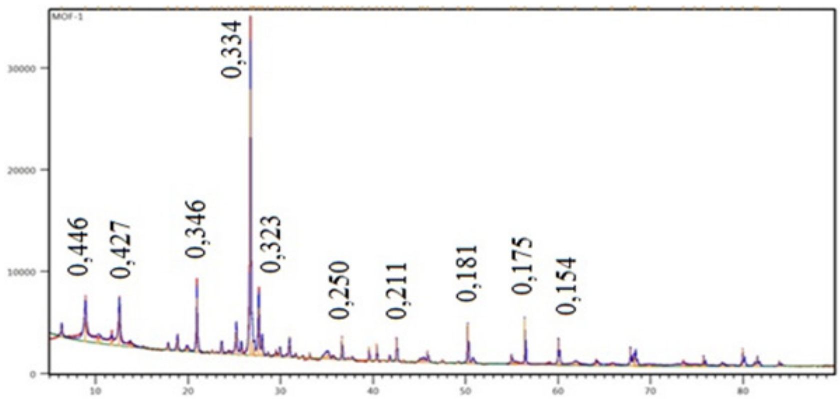

Figure 1: Radiographs of flotation waste CCP.

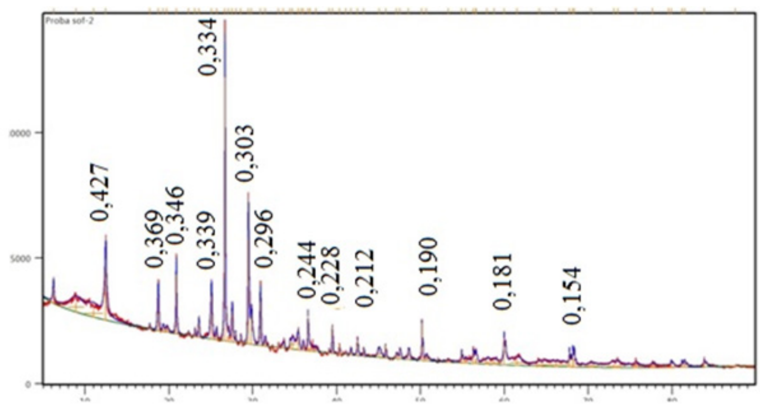

Figure 2: Radiographs of flotation waste LCP.

The characteristics of the chemical production wastes used are as follows. Phosphogypsum is a solid waste from the production of phosphoric acid by the sulfuric acid method. For 1 ton of phosphoric acid, from 3.5 to 6 tons of phosphogypsum are obtained in terms of dry matter. Depending on the conditions for obtaining phosphoric acid, $CaSO_4$ $2H_2O$ dihydrate, $CaSO_4$ 0.5 H_2O hemihydrate, or anhydrous calcium sulfate are formed in the precipitate, which determines the corresponding name of the products - phosphogypsum, phosphohemihydrate and phosphoanhydrite. Phosphogypsum is a gray fine-grained clumping powder with a moisture content of 25-30% containing up to 94% $CaSO_4$ per dry matter. The main impurities in it are unreacted phosphates, fluorine and strontium compounds, as well as unwashed phosphoric acid, and organic substances. Solid waste from the soda production of the Kungrad soda plant is formed in the process of ammonia regeneration and brine purification, as well as overburning and other limestone calcination waste. The most voluminous waste from the production of soda ash by the ammonia method is the distiller suspension, which is formed in the amount of 8-10m^3 per 1 ton of soda. It is a solution of calcium and sodium chlorides, calcium hydroxide and calcium sulfate. The solid residue of the distiller liquid (calcium carbonate sludge) in dry form is a light gray mass with a density of about 970kg/m^3, 70-80% consisting of particles 0.1-0.2mm in size.

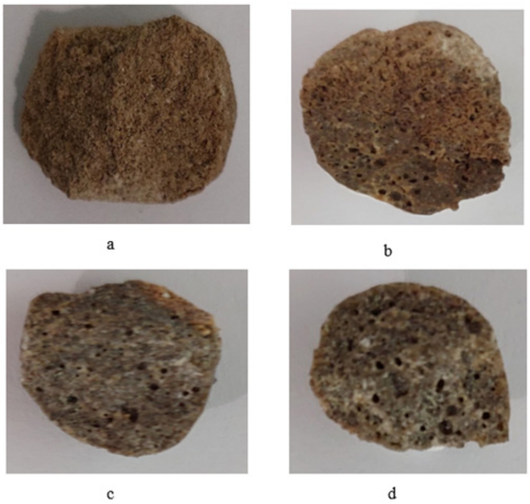

Figure 3: Photographs of light weight samples with CCP and LCP flotation waste: (a,b) charge No. 4, (c,d) charge No. 1.

The raw materials were first dried and ground in a laboratory ball mill to a specific surface area of 1300-1500g/cm^2. Then the components were weighed in stoichiometric quantities and mixed in a dry state. After that, water was added to the dry mixture. Granules with a diameter of 10-15mm were made from the resulting mixture and fired in an electric muffle furnace with silicate heaters to temperatures of 1050-1200 °C (Table 2). The temperature of the beginning of the formation of the glass phase and the completion of the sintering of raw mixtures based on flotation waste with the addition of kaolin clay, as well as phosphogypsum and solid waste from the production of soda, as a result of which the patterns of the influence of the physicochemical properties of the components on the process of sintering and swelling, were established. A number of physical and chemical studies carried out have established that raw mixtures with CCP flotation waste have a higher ability to expand. Table 3 reflects the technological parameters of the light weight obtained, synthesized on the basis of charges with CCP flotation waste, reflecting the intensifying effect of inorganic additives TOSP and phosphogypsum on the optimal firing temperature, bulk density, expansion coefficient, expansion interval (Figure 3). The minimum volumetric weight of the optimal charge composition - sample No. 4 with the addition of 25% TOSP and phosphogypsum together, approaches 1.35 and the expansion coefficient increases to 1.95, in addition, the synthesis temperature decreases by 25 -35 °C.

Table 2: The compositions of the studied raw materials for the production of porous silicate filler, in %.

No. Charges	Flotation Wastes	Rover Gray	TOSP	Phosphogypsum	Coal
1	80	14	-	-	6
2	80	14	20	-	6
3	80	14	-	20	6
4	80	14	20	20	6

Table 3: Swelling of batches based on CCP flotation waste.

Compound Charges	Optimum Swelling Temperature, T °C	Minimum Volumetric Weight of Fired Granules, g/cm3	Swelling Coefficient	Swelling Interval, T °C
1	1145	1.55	1,55	55
2	1138	1,48	1,61	55
3	1136	1,45	1,78	60
4	1122	1,38	1,96	65

Conclusion

Photographs of the lightweight samples obtained with flotation waste used as the main raw material show the formation of a material with a large number of pores ranging in size from 0.5 to 0.01mm. when phosphogypsum and TOSP wastes are added as a pore formation intensifier in an amount of 20%, while in samples without chemical additions of pores much less and the density of the material is higher. Photographs of the lightweight samples obtained with flotation waste used as the main raw material show the formation of a material with a large number of pores ranging in size from 0.5 to 0.01mm when phosphogypsum and TOSP wastes are added as a pore formation intensifier in an amount of 20%, while in samples without chemical additions of pores much less and the density of the material is higher.

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