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TESTING OF THE COMPLEX FOR GRAVITATIONAL WASHING OF SAND

Purpose. Performing full-scale pilot testing of a complex of equipment on the basis of an experimental-industrial installation for the gravitational processing of granular minerals with the organization of a closed cycle of water supply.

Methodology. Standard methods of experimentation with experimental and industrial washing of sand of different granulometric composition with different settings of equipment complex are applied.

Findings. A description of the complex of equipment within the experimental-industrial installation for gravitational processing of granular materials, structures of decanters with pumping and pipeline equipment for the closed water supply cycle is carried out. A description of the processes that accompany the gravitational washing of the original granular raw materials with the specified non-standard innovative equipment is carried out. The list of standard testing and measuring equipment is given. A description of the methodology for industrial testing of the complex, which involves washing of different types and compositions of granular materials, using different settings of the equipment, in order to determine the rational technological and mode parameters of the washing equipment is given. At the initial stage of the research, a trial run of the elements of the complex was performed in order to determine the possibility of uninterrupted and safe operation of the systems, to check the tightness of the hydraulic system, to adjust the mode parameters when supplying the input granular material. Experimental-industrial tests of the complex were carried out in four stages, while washing construction sands of different compositions from Buriakivske and Veliunske fields.

Originality. Innovative technology of gravitational processing of granular materials was developed and tested for the first time, it provides for the possibility of changing the settings when feeding raw materials of different composition to obtain quality construction sand.

Practical value. The experimental and industrial tests of the complex of sand processing equipment allowed testing the system of circulating water supply and substantiating the technological rationality of its application both for water cleaning and for its supply.

Keywords: *granular materials, washing, gravitational classification, recycled water supply*

Introduction. Natural non-metallic sands extracted from sedimentary fields and used in construction, production of building materials and structures, metallurgical and glass industries according to a set of basic physical and mechanical properties (modulus of size, number of clay and dust impurities) rarely meet the current quality standards. Therefore, the problem of choosing economically and technologically expedient means and technologies that allow obtaining high-quality commercial sand with the possibility of placing such equipment at processing sites within the mining enterprise is relevant. Attention should be paid to washing sand technologies that allow obtaining high efficiency of the deslamation of raw materials [1]. Important here is the complex solution of the sludge illumination issue and the organization of the circulating water supply of the technological process, especially if industrial waste procession is required [2].

Analysis of the recent research and publications. The removal of clay and dust particles from the raw minerals is usually accompanied by the use of washing technologies, which include centrifugal and gravity classification processes, with subsequent dehydration and storage of deslamed sands [3]. Often, more energy-consuming centrifugal hydraulic classification technology is used to wash the sands and screenings, the advantage of which is the compactness of the main processing unit. Gravitational hydraulic classification technologies that do not require significant specific energy consumption are commonly used in the ore dressing with extraction of valuable components from waste rocks. However, it is known that, by the criteria of minimizing the operational costs of raw sand processing, which is produced by a hydromechanized method [4, 5], the gravitational method of deslamation in the horizontal slurry stream is acceptable. Theoretical foundations of the process of slurry suction as the first stage of the process of classification of granular raw minerals are presented in the work [6].

Unsolved aspects of the problem. According to the results of theoretical study on the process of gravitational deposition of solid particles moving in the accelerated carrier flow within the sloping surfaces of the flowing part of the classifier, a method for calculating the design parameters of the horizontal classifier is substantiated. The method involves the construction of a trajectory of motion of solid particles with the determination of their coordinates along the length of the flowing part. The

validity of the obtained mathematical models and analytical dependencies is confirmed with the use of laboratory equipment: hydraulic horizontal classifier, classifier of horizontal multi-section, jet feeder. The manufacture of an industrial plant with the possibility of its use in the conditions of the open processing sites requires the execution of preliminary pilot-industrial tests of the developed complex of the technological equipment. Thus, it is rational to wash the natural or technogenic raw materials from the mining deposits of sand or waste, which are operated by existing enterprises [7].

Purpose. The purpose of this work is to perform full-scale experimental testing of a complex of equipment on the basis of an experimental-industrial installation for the gravitational processing of granular raw materials with the organization of a closed cycle of water supply.

Methods. In order to achieve this goal, in the course of full-scale experimental testing of the equipment for washing the natural raw sand, standard methods for setting up an experiment with experimental-industrial washing of different granulometric composition sand, using different settings of the equipment complex were applied.

Results. Experimental-industrial tests of the complex for granular materials washing were performed at the industrial base of Kaolin Azov LLC, located in Orikhiv, Zaporizhzhia region, in the South of Ukraine. To perform the tests, the test equipment in the following composition was used: installation for washing of granular materials Turbo-washer TM-3 *1*, system of technological water supply *2*, sludge discharge system *3*, storehouse of raw sand *4*, stockpile of marketable product *5*, sludge pond, decanter water system (Fig. 1). The general technological scheme of raw material processing is shown in Fig. 2.

Installation for washing of granular materials Turbo-washer TM-3 is intended for classification of granular materials (sand and screenings, and others) in streams of slurry with reception of the commodity product of a given size, effective removal of clay and fine particles, dehydrating and storehousing of the marketable product (Fig. 1). The following components are included in the TM-3 installation: the KGG-3 classifier, the ZhK-3 feeder, the pump jet HC17-3, the support frame, the high-frequency dewatering screen, the automatic sand unloading system. One of the main elements of the TM-3 installation is the KGG-3 horizontal classifier. The technical and technological solutions put into the design of this hydraulic gravitational classifier are grounded as a result of studying the theoretical foundations of the process of gravitational sedimentation of solid particles under the action of the slurry

Fig. 1. Experimental-industrial TM-3 installation at the experimental washing site of Kaolin Azov LLC, Orikhiv:

1 – turbo-washer TM-3; 2 – system of technological water supply; 3 – sludge discharge system; 4 – stockpile of raw sand; 5 – stockpile of marketable product

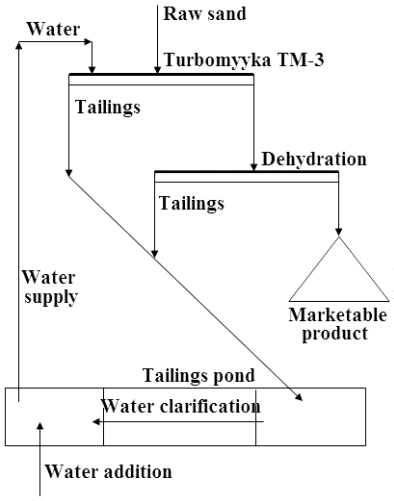

Fig. 2. Technological scheme of sand washing

movement with the input raw material, which is accelerated and decelerated within differently inclined surfaces. The design parameters of the KGG-3 classifier are substantiated by the results of the construction of the trajectory of solid particles motion with the determination of their coordinates along the length of the flowing part [3].

In general, the implementation of the raw sand washing process by the TM-3 installation is to prepare the slurry and remove fine and clay impurities from it. When applying the specified installation the following can be processed as a granular raw material: sand natural, loams and sandy loams, rock crushing screenings [8, 9], sludge of different origin. The washing process occurs in the vertical and horizontal slurry flows during gravity sedimentation of heavy classes. Installation of TM-3 is distinguished by the use of a jet pump by means of which there also occurs hydraulic activation of the mixture, non-aggressive disintegration of cemented particles, and purification of particles from mineral salts. It should be noted that the movement of the concentrated slurry is activated with minimal quantitative contact of the moving solid particles with the flowing surfaces of the jet pump. As a result of the use of the jet pump, the surface of the particles is cleaned and polished, cemented splices and weathered minerals with low strength are destroyed, while no destruction of solid particles occurs, and the mixture is minimally saturated with man-made additives from the abrasive destruction of the flowing part of the pump.

According to the technical requirements, the plant for washing of granular materials Turbo-washer can be used at open processing sites, also located on the territory of existing quarries [10, 11], has high reliability due to the lack of rotary actuators and friction units. Due to its ease of operation and maintenance, it does not require high qualification of service personnel.

At the final stage of the gravitational washing of granular raw minerals, it is subjected to high-frequency dehydration as a result of which the residual moisture in the pores of commercial sand does not exceed 12–15 %. This allows the further use of dump belt conveyors for warehousing of the product to open warehouses, with subsequent shipment to transport vessels [12]. Unloading of sand from classifier on a screen is carried out in a portion-distributed stream using the automatic sand unloading system.

The system of supply of technologically pure water includes: water pump K65-50-160, shut-off valves (shut-off valves coupling Dy 50 mm, valves ball brass coupling Dy 15 mm), measuring devices (pressure gauge DM 05-MP-3U), metal and rubber pipelines (Fig. 3).

The technological water supply system is designed to feed the process of washing the granular minerals with technically

Fig. 3. The pumping station of the washing site of Kaolin Azov LLC, Orikhiv

clean water with defined parameters of pressure, productivity, cleanness.

The sludge drainage system is designed for self-flowing removal of sludge from the washing process and transportation of it to the sludge pond. Precast collectors and drainage pipes made of PVC SDR 51 SN2 outer diameter of 50 and 110 mm according to DSTU B B.2.5-32: 2007 are used for this purpose. The pipelines of the sludge drainage system are calculated taking into account the calculated critical velocity values for the transport of fine sludge [13, 14].

The storehouse of the raw sand is located in close proximity to the installation to provide the desired productivity of the washing process. The input raw sand was previously cleaned of gravel particles larger than 5 mm in size using a manual sieve.

After dehydration, deslamed sand was unloaded into the output sand warehouse [15]. The surface of the warehouse is made with a slope for drainage and pre-covered with polyethylene to maintain the clearness of the sand for further study on its physical and mechanical properties.

For clarification of sludge water and organization of the circulating water supply system as a part of the washing complex, a decanter is used, which consists of two compartments: the coarse cleaning department and the sump (Fig. 4). The coarse cleaning compartment *1* is designed for draining the waste of the washing process in the form of liquid sludge and the accumulation of solid sludge. After illumination by gravitational sedimentation of solid particles, the clarified water is poured into a sump *2* from which by the pumping station *3* it is fed to feed the process of washing the granular minerals. To minimize water losses due to its seepage into the soil, the bottom and walls of the decanter were lined with polyethylene.

The loss of water for evaporation from the decanter and in the pores of the washed granular mineral was compensated by the feed system of decanter water system [16]. For this purpose, a rubber pipeline was laid and water was supplied from a nearby source.

In general, the following standard equipment was also used to carry out industrial testing and further processing of

Fig. 4. Decanter of the experimental washing site of Kaolin Azov LLC, Orikhiv

experimental data: a galvanized household bucket of 12 l GOST 20558-82; a plastic barrel for water of 100 l; plastic bags for sampling DSTU 7275:2012; manual sampling shovel DSTU 4096-2002; a 1 liter laboratory cylinder with a discretion of 2 ml; a 0.2 liter laboratory cylinder with a discretion of 0.5 ml; stopwatch "Agate" with a discretion of 0.5 s; scales VL-600 with a discretion of 0.01 g, scales with a discretion of 2 g, scales with a discretion of 5 g GOST 7327-55; a laboratory sieve of metal woven fabric SL-200 TUU 28.7-2210200135-002:2007 with hole sizes of 0.05, 0.1, 0.16, 0.2, 0.25, 0.28, 0.315, 0.4, 0.5, 0.63, 1.0, 1.8, 2.5, 5.0 mm; the laboratory funnel GOST 25336-82; a laboratory vibrating sieve shaker ACB-200; a drying cabinet.

Methodology of experimental-industrial testing of the complex for raw grained minerals washing. Experimental and industrial tests of the complex on the basis of the TM-3 installation provided washing of various types and compositions of granular minerals. Various equipment settings were also used to determine the rational technological and operating parameters of the washing equipment.

At the initial stage of the research, a trial run of elements of the complex was performed in order to determine the possibility of uninterrupted and safe operation of the systems, check the tightness of the hydraulic system, and ensure the possibility of adjusting the mode parameters when supplying the input granular mineral. The trial run was performed as follows. After pouring the flowing part and the suction pipe, the pump K65-50-160 was put into operation (Fig. 3) and water was supplied to the water supply system, with the help of valves a stable mode of water supply to the feeder and pump jet was set, the operation of the jet pump was visually observed and the flow of water to the classifier KGG-3 was controlled, the drain from the drain pipes of the feeder ZhK-3 and the classifier KGG-3 to the system of sludge draining and then to the sludge pond was visually observed. The operation of the water pump, valves, pressure gauges, tightness of pipelines supplying technologically clean water, process apparatuses, sludge discharge system, decanter water system was checked. After the trial start-up of the complex and the verification of its technological and electrical systems [17], experimental and industrial tests were performed with the feed of the granular mineral.

Experimental-industrial testing of the complex for raw sand washing based on the installation TM-3 was performed in four stages:

1. Raw sand washing of the Buriakivske deposit (Orikhiv district, Ukraine).
2. Raw sand washing of the Veliunske deposit (Rivne region, Ukraine) with determination of washing modes.
3. Raw sand washing of the Veliunske deposit (Rivne region, Ukraine) at a productivity of raw material of 1.84 m^3/h with a boundary particle size of 0.16 mm.
4. Raw sand washing of the Veliunske deposit (Rivne region, Ukraine) at a productivity of raw material of 1.84 m^3/h with a boundary particle size of 0.3 mm.

In general, the industrial-scale washing of sand by a complex based on the Turbo-washer TM-3 installation was performed in the following sequence. The complex was started and the correctness of all its systems was controlled. With the help of the control valve of the water supply system, water was supplied to the ZhK-3 feeder and the HC17-3 jet pump. Pressure in the water supply system was monitored by pressure gauges. The cavities of the KGG-3 classifier and connecting pipes by water were filled up. Complete filling was controlled by the presence of water draining from the classifier. A portion of the control granular mineral (sand) with a metal bucket was poured into the receiving hopper of the ZhK-3 feeder with a distributed stream. Feeding process was controlled by a stopwatch. The prepared slurry was fed to the receiving pipe of the KGG-3 classifier by the jet pump HC17-3. Visually were observed the processes: classification of sand in horizontal flow; operation of the automatic sand unloading system and unload-

ing of the washed granular mineral to the dehydrating high-frequency screen and further to the storehouse of deslamed marketable sand (Fig. 5); drainage of sludge from drainage pipes of the ZhK-3 feeder and the KGG-3 classifier, drainage of sludge to the sludge pond.

In the course of the research studies, the productivity on the raw mineral, the amount of raw sand, and the washed commodity sand was recorded; sampling of sand and sludges was carried out. The sludge flow to the decanter was controlled by the volumetric measurement method. The obtained values were recorded in the research journal. The classification process was stopped after completion of the sand supply to the feeder ZhK-3 receiving hopper. Water supply to the ZhK-3 feeder and jet pump HC17-3 was stopped. The experiment cycle was completed after removal of granular mineral from the sand hopper of the classifier KGG-3.

The obtained samples of input raw sand, washed sand and sludge were transported to the laboratory. After drying in the drying cabinet, a sieve analysis was performed. The obtained data were recorded in the research journal. During the pilot-industrial testing of the complex on the basis of the Turbo-washer TM-3 installation, 4 cycles of experiments were performed, 40 samples of processed granular mineral were obtained. In total, about 9 m^3 of sand of different granulometric composition and physical and mechanical properties were processed.

Samples of sand of the Veliunske deposit in accordance with current mining and processing rules [18, 19] were preselected from a depth of about 2 m, packed to big bags and delivered by road transport from Rivne region to the site of industrial testing, located at the production site of Kaolin Azov LLC in Orikhiv, Zaporizhzhia region.

The following are the characteristics of the sand of the Veliunske deposit. The main indicators of the physical and chemical properties of the sands are shown in Table 1.

The table shows that the content of particles passing through a sieve of 0.14 mm sand does not meet the requirements of GOST 8736-77 (field average value of 14.7 % against requirements – 10 %).

According to the size modulus, the sands belong to the group of small and very small sands. The weighted average granulometric composition of sand in the deposit is shown in Table 2.

The weighted average granulometric composition of sand in the Veliunske deposit meets the requirements of GOST 8736-77.

Fig. 5. The stockpile of deslamed marketable sand

Table 1

Basic indicators of physical and chemical properties of sands by wells, counting blocks and average by whole deposit

№	Name of indicators	By wells		By counting blocks		Average by whole deposit
		from	to	from	to	
1	Total residue on a 0.63 mm sieve as a percentage of the mass	2.4	5.9	3.8	3.9	3.9
2	The content of particles passing through a sieve of 0.14 mm as a percentage of the mass	7.1	20.8	13.7	15.4	14.7
3	Size module	1.1	1.4	–	1.2	1.2
4	Content of dusty, silt and clay particles, %	0.3	2.6	0.6	0.7	0.7

Table 2

Weighted average granulometric composition of sand in the deposit

Weighted average granulometric composition, % dimensions of control sieves, mm							Passing through a sieve of 0.14 mm	Content of dusty, silt and clay particles	Size module
Bigger than 10	5	2.5	1.25	0.63	0.315	0.14			
1	2	3	4	5	6	7	8	9	10
2	–	–	0.1	3.8	28.4	53.0	14.7	0.7	1.2

The average bulk density of the sand is:
- in loose condition – 1500 kg/m^3;
- in a compacted state – 1.8 kg/m^3.

The characteristics of the sands by chemical composition are shown in Table 3.

The purpose of preliminary washing of the Veliunske deposit sand was to determine the mode parameters of the TM-3 installation that correspond to the maximum efficiency of the raw material washing process and its purification from fine particles (deslamation). The washing of the raw sand was carried out in accordance with the above method. In doing so, they changed the feed performance of the raw sand according to the series 1.2; 1.84; 3.6 m^3/h. According to the test results, averaged samples of granular mineral and sludge were selected. The parameters of the sampling process are shown in Table 4.

Based on the previously obtained studies on the rational value of feeding productivity in order to determine the parameters of technological regulations necessary to substantiate the rational technological and structural parameters of the equipment of the complex for washing granular minerals, further studies were performed with feeding productivity of 1.84 m^3/h. Sand processing was performed in 2 steps of 45 min each. Averaging samples of washed sand and sludge were selected after washing process.

At the final stage of the pilot-industrial tests of the TM-3 complex, in order to determine the possibility of increasing the value of the boundary particle size and, thus, reducing the output of finely dispersed classes to the product, the mode parameters of the TM-3 installation were changed; at the same time, the value of feeding productivity was retained of 1.8 m^3/h. Sand processing with this mode setting was performed for 30 min. Averaging samples of granular mineral and sludge were selected after washing process.

Table 3

The characteristics of the sands by chemical composition

Number, %	Composition					
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO
From	97.33	0.51	0.43	0.04	< 0.05	< 0.05
To	98.24	0.68	0.80	0.06	0.09	< 0.05
Number, %	Composition					
	P_2O_5	K_2O	Na_2O	SO_3	P.P.P.	H_2O
From	< 0.01	0.26	0.10	< 0.02	0.10	n.d.
To	< 0.01	0.37	0.29	0.02	0.32	0.06

Table 4

Grain material sampling technology

Parameter	Raw material feed productivity, m^3/h		
	1.2	1.84	3.6
The total amount of washed raw material, m^3	0.5	1	1.5
Total washing time, min	30	30	16
Sampling time, min	10, 20, 30	10, 20, 30	5, 10, 15

To determine the rational mode of the feeding of washing process of construction sand with using a complex based on the installation Turbo-washer TM-3, an analysis of the classification parameters was performed and the value of the extraction by size classes – 0.1, – 0.16, – 0.2 mm was determined, in accordance with the feeding productivity of 1.2, 1.84, 3.6 m^3/h. The main parameters that qualify the process of washing raw materials in quantitative terms are extraction, coarsening, shredding, and efficiency. To determine the rational value of the feed productivity of the classification process by raw material, it is sufficient to know the maximum value of extraction of the useful component in the washing process. The extraction is calculated by the formula

$$\varepsilon = \frac{\beta(\alpha-\theta)}{\alpha(\beta-\theta)}100,$$

where α is the content of the useful component in the raw product; β is the content of the useful component in the concentrate; θ is the content of the useful component in the tails.

As a useful component, in the case of washing or deslamation of construction sand, granular material larger than 0.1, 0.16, 0.2 mm is accepted. According to the results of the extraction value calculations, the graph is shown in Fig. 6.

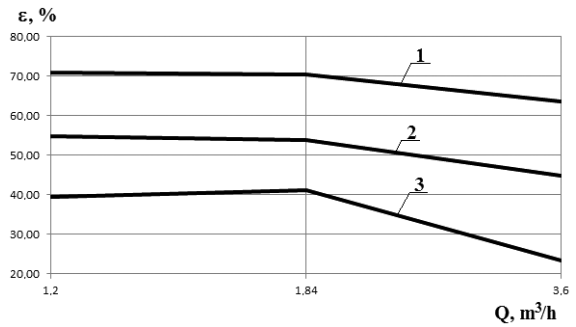

Fig. 6. The extraction value of the grain classes:
1 – –0.1 mm; 2 – –0.16 mm; 3 – –0.2 mm

The graph shows that the extraction of certain classes of –0.1, –0.16 and –0.2 mm retains an almost constant value when changing the feeding productivity from 1.2 to 1.84 m^3/h. But with an increase in feeding productivity up to 3.6 m^3/h, the extraction figures deteriorate significantly. Based on this fact, a collegial decision was made to carry out the following stages of pilot testing at feeding productivity of raw material of about 1.84 m^3/h.

It is known that the boundary size in hydraulic classification is the size of the granular material, the value of the extraction of which is equal to 50 %. According to the graph (Fig. 6), this size is about 0.16 mm at a productivity that may slightly exceed 1.84 m^3/h. It is known that in accordance with the current national standards governing the quality of construction sands, such as DSTU B B.2.7-32-95, the content of dust and clay particles in commercial sand is limited to 5 %. To determine the correspondence of the physical and mechanical properties of the raw sand, as well as the commercial sand obtained by the results of pilot testing of the TM-3 installation, the size of the raw and washed sand and sludge of the washing process were analyzed. The sieve analysis of the granular material is given in Table 5.

Graphic analysis of the granulometric composition of the granular material before, after washing on the TM-3 installation, as well as the sludge is shown in Figs. 7, 8.

On the results, it is apparent (Table 5) that after classification and washing on the TM-3 installation, the product sand was obtained, which according to the size indexes fully corresponds to DSTU B B.2.7-32-95. For example, if the content

Table 5

Sieve analysis according to feeding productivity 1.84 m^3/h

Size, mm	Raw sand		Washed sand		Sludge	
	Yield, %	Σ, %	Yield, %	Σ, %	Yield, %	Σ, %
1.8	0.0	0.0	0.0	0.0	0.0	0.0
1.8–1.0	0.2	0.2	0.5	0.5	0.0	0.0
1.0–0.63	3.0	3.2	5.6	6.1	0.3	0.3
0.63–0.5	3.5	6.6	6.3	12.4	0.5	0.7
0.5–0.4	5.8	12.4	8.1	20.5	1.1	1.8
0.4–0.315	17.4	29.8	22.2	42.7	5.0	6.8
0.315–0.28	9.5	39.3	9.1	51.8	4.3	11.1
0.28–0.25	0.8	40.1	0.7	52.5	0.5	11.5
0.25–0.20	27.7	67.9	25.9	78.4	21.0	32.5
0.2–0.16	17.3	85.2	13.7	92.1	25.4	58.0
0.16–0.100	8.7	93.9	6.0	98.1	21.6	79.6
<0.1	6.1	100.0	1.9	100.0	20.4	100.0
Total:	100.0	–	100.0	–	100.0	–

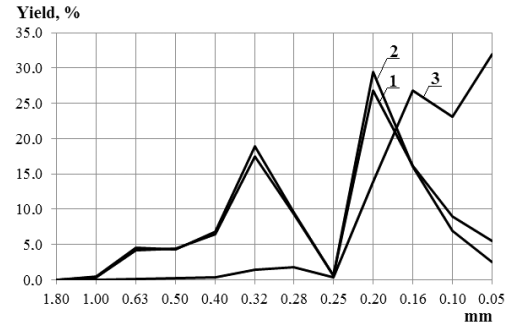

Fig. 7. Yield of the raw sand (1), washed sand (2), sludge (3)

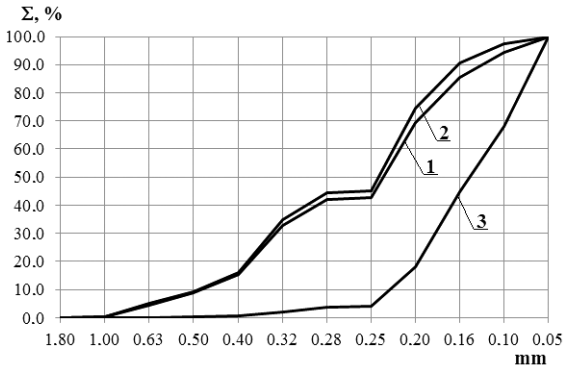

Fig. 8. Granulometric composition of the raw sand (1), washed sand (2), sludge (3)

of fine particles with a particle size of less than 0.1 mm in the raw sand was 6.1 %, then after washing the content of such particles is not more than 2 %.

Thus, it is technologically feasible to use the Turbo-washer installation to obtain a high-quality sand composition whose properties meet the requirements of DSTU B B.2.7-32-95.

Conclusions. As a result of the performed research studies, a full-scale testing of a complex of equipment [20] on the basis of an experimental-industrial installation for gravitational processing of granular minerals Turbo-washer TM-3 was carried out with the organization of a closed cycle of water supply. Developed and tested for the first time, innovative washing sand technology that provides the ability to change settings when feeding raw materials of different composition and obtaining quality construction sand. The results of pilot-industrial tests indicate the possibility of applying the developed technology to obtain high-quality commercial sand with the possibility of placing a complex of equipment at processing sites within the mining enterprise, as well as a comprehensive solution to the issue of sludge water clarification with the organization of circulating water supply of a technological process.

The name and number of the project under which the presented results are obtained. The work is associated with the scientific direction of the Department of Engineering and Design in Machinery Industry of National TU Dnipro Polytechnic and is based on the results of the development of "Scientific research report on industrial testing of the plant Turbomyyka TM-3 for the washing of granular minerals".

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Дослідне тестування комплексу для гравітаційного промивання піску

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Мета. Натурне дослідне тестування комплексу обладнання на базі дослідно-промислової установки для гравітаційної переробки зернистих матеріалів з організацією замкнутого циклу водопостачання.

Методика. Застосовані стандартні методи постановки експерименту з дослідно-промисловим промиванням пісків різного гранулометричного складу із застосуванням різних налаштувань комплексу обладнання.

Результати. Виконано опис комплексу обладнання у складі дослідно-промислової установки для гравітаційної переробки зернистих матеріалів, споруд декантаторів з насосним і трубопровідним забезпеченням реалізації замкнутого циклу водопостачання. Виконано опис процесів, що супроводжують гравітаційне промивання вихідної зернистої сировини зазначеним нестандартним інноваційним обладнанням. Приведено перелік стандартного дослідного й вимірювального устаткування. Приведено опис методики дослідно-промислових випробувань комплексу, що передбачає промивання різних типів і складу зернистих матеріалів, із використанням різних налаштувань обладнання, з метою визначення раціональних технологічних і режимних параметрів промивного устаткування. На початковому етапі досліджень був виконаний пробний пуск елементів комплексу задля визначення можливості безперебійної й безпечної роботи систем, перевірки герметичності гідравлічної системи, регулювання режимних параметрів при подаванні вихідного зернистого матеріалу. Дослідно-промислові випробування комплексу були проведені в чотири етапи, при цьому промивалися будівельні піски Буряківського та Велюнського родовищ різного складу.

Наукова новизна. Уперше розроблена й випробувана інноваційна технологія гравітаційної переробки зернистих матеріалів, що передбачає можливість зміни налаштувань при подачі вихідної сировини різного складу для отримання якісного будівельного піску.

Практична значимість. Виконані дослідно-промислові випробування комплексу обладнання для переробки піску дозволили тестувати систему оборотного водопостачання та обґрунтувати технологічну раціональність її застосування як для освітлення води, так і для її постачання.

Ключові слова: *зернисті матеріали, промивання, гравітаційна класифікація, оборотне водопостачання*

Опытное тестирование комплекса для гравитационного промывания песка

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Цель. Натурное исследовательское тестирование комплекса оборудования на базе опытно-промышленной установки для гравитационной переработки зернистых материалов с организацией замкнутого цикла водоснабжения.

Методика. Применены стандартные методы постановки эксперимента с опытно-промышленным промыванием песков разного гранулометрического состава с установкой разных настроек комплекса оборудования.

Результаты. Выполнено описание комплекса оборудования в составе опытно-промышленной установки для гравитационной переработки зернистых материалов, сооружений декантаторов с насосным и трубопроводным обеспечением реализации замкнутого цикла водоснабжения. Выполнено описание процессов, сопровождающих гравитационное промывание исходного зернистого сырья указанным нестандартным инновационным оборудованием. Приведен перечень стандартного исследовательского и измерительного оборудования. Приведено описание методики опытно-промышленных испытаний комплекса, предназначенного для промывания разных типов и состава зернистых материалов, с использованием разных настроек оборудования, с целью определения рациональных технологических и режимных параметров промывного оборудования. На начальном этапе исследований был выполнен пробный пуск элементов комплекса для определения возможности бесперебойной и безопасной работы систем, проверки герметичности гидравлической системы, регулирования режимных параметров при подаче исходного зернистого материала. Опытно-промышленное испытание комплекса было проведено в четыре этапа, при этом промывались строительные пески Буряковского и Велюнского месторождений различного состава.

Научная новизна. Впервые разработана и опробована инновационная технология гравитационной переработки зернистых материалов, предусматривающая возможность изменения настроек при подаче исходного сырья различного состава для получения качественного строительного песка.

Практическая значимость. Выполненные опытно-промышленные испытания комплекса оборудования для переработки песка позволили тестировать систему оборотного водоснабжения и обосновать технологическую рациональность ее применения как для осветления воды, так и для ее подачи.

Ключевые слова: *зернистые материалы, промывание, гравитационная классификация, оборотное водоснабжение*

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