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TECHNOLOGICAL PROCEDURE FOR PROCESSING THE QUARTZ RESOURCES IN ORDER TO OBTAIN THE ASSORTMENT FOR WATER GLASS**

Abstract

Tests on quartz raw material from the deposit "Bijela Stijena - Skočić" have included: grading, washing, grinding and magnetic separation. Test results have shown that the assortment of required sand quality can be obtained for water glass. The required quality condition for assortment of water glass, set by the company "Alumina" Zvornik, is that Fe_2O_3 content does not exceed 0.04% and the grit of $-0.4 + 0.05$ mm. The results obtained after washing and grading starting sample used in these tests to a class of $-0.4 + 0.05$ mm showed that content of Fe_2O_3 from 0.131% was reduced to 0.075%, and after treatment at high gradient electromagnetic separator at 0.038%. Microscopic analysis showed that the initial sample has: quartz, chalcedony, feldspar, mica, cherts, magnetite, limonite-goethite, shells, fossil remains, and that after the magnetic separation of magnetite sample was removed and most of the other carriers magnetic fraction. Based on this, a flow diagram is defined for procedure of obtaining the quartz sand for water glass on the basis of quartz raw materials from the deposit "Bijela Stijena - Skočić".

Keywords: quartz raw materials, the range of water glass, grinding, high gradient magnetic separator

INTRODUCTION

Quartz is, by the chemical composition, silicon dioxide SiO_2 and it is one of the most common minerals in nature. It is on the seventh place on the Mos scale of hardness. Quartz crystallizes hexagonally, can be colorless or colored differently depending on the impurities. Quartz is used very widely in the production of modern high technology products. Quartz raw material is used in the production of water glass. Water-glass is solution of sodium silicate salt in water. By the chemical composition is sodium metasi-

licate, and appears in the following forms: Na_2SiO_3 and $Na_2SiO_3 \cdot 9H_2O$. There are other forms (e.g., Na_4SiO_4 orthosilicate), and their common characteristic is solubility in water with formation of vitreous emulsions. Water glass is widely used in manufacture of synthetic zeolite, silica gel and silica-sol as well as in production of detergent. It is added to the concrete mix in order to reduce permeability of water in concrete. It is also used as a binder for preparing a mold and coating procedure code of casting in order to allow

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easier separation of the castings. Also, water glass is widely used in the textile and paper industry as a bleaching agent [1-4]. Data about the deposit of quartz raw material "Bijela Stijena - Skočić" are given in the study of Geology and Mining of Project of exploitation [5]. The company "Kesogradnja" from Kozluk has the right to exploit quartz sand from this deposit. "Birač" Zvornik or "Alumina" Zvornik, as manufacturer of water glass needs to around 30 000 tons/year assortment of quartz sand of certain quality. Previous tests on raw material from said deposit has indicated that the range of -0.4 + 0.05 mm can be obtained by methods of preparation the mineral raw materials [6-8]. As the raw material in deposit is not loose, and the required range of products is represented by a class of -0.4 + 0.05 mm, it is necessary to comminute large classes that are separated in the process of separation, and classification. This paper presents the results of tests and technological scheme for obtaining the products for water glass -0.4 + 0.05 mm [8].

EXPERIMENTAL PART

Material and Methods

The initial sample for tests presented in this paper is the raw quartz sand from the deposit "Bijela Stijena - Skočić".

Chemical composition: The initial sample of quartz sand CaO content is determined by the volumetric method, while the content of SiO₂ and loss on ignition (900°C) were determined by gravimetric method (JUS B.B8. 070). For determining of Al₂O₃, Fe₂O₃, Cr₂O₃, TiO₂, MgO, Na₂O and K₂O, an atomic absorption spectrophotometer, type "Perkin Elmer 703 Analyst 300", was used.

Magnetic concentration: It was carried out on high gradient magnetic separator, type "SALA-HGMS", which works with the possibility of discontinuous change in magnetic field strength, speed washing water content of the solid phase and retention time of material in the matrix. Terms of device during testing which are presented in this paper are: solids content of 10%, magnetic induction 1T, speed washing water 0.1 m/s and the residence time of material in matrix 15s.

Determination the Bond's index: Determination of the work index grindability was performed in the Bond's ball mill "Bico Braun International" by dry milling process.

Determination the bulk density: The method involves determining the mass of buried free sample without compression, in the dish of known volume and weight according to the formula:

$$\Delta = \frac{m_1 - m}{V}, \quad \left[\frac{t}{m^3} \right]$$

where:

- Δ - bulk density of sample;
- m₁ - mass of sample and dish;
- m - mass of dish;
- V - volume of dish.

RESULTS AND DISCUSSION

Characterization of Starting Sample

At the initial sample was determined by grain size and chemical composition, moisture, bulk density and Bond Index. Results of determination of particle size distribution are shown in Table 1 and graphically in Figure 1.

On the basis of particle size distribution, it can be seen that the average grain diameter of sample is d₅₀ = 2,08 mm, the upper limit grit u_{gsl} = 16.81 mm.

Table 1 Particle size distribution of raw quartz sand

Size class, mm	M, %	Reflection %	Sieving material, %
+15.00	7.20	7.20	100.00
-15.00+4.00	35.34	42.54	92.80
-4.00+2.00	6.62	49.16	57.46
-2.00+0.60	12.89	62.05	50.84
-0.60+0.30	15.33	77.38	37.95
-0.30+0.10	15.74	93.12	22.62
-0.10+0.05	1.88	95.00	6.88
-0.05+0.00	5.00	100.00	5.00

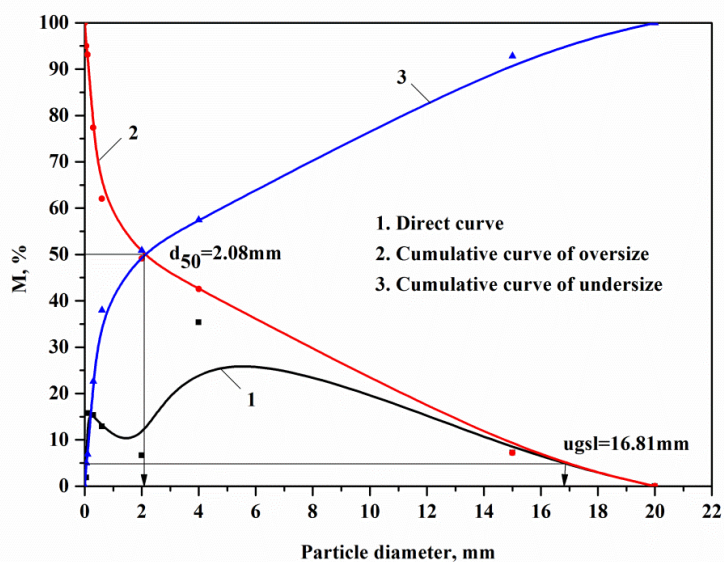


Figure 1 Particle size distribution of raw quartz sand

Chemical analysis was performed on a sample of raw quartz sand, then on the class of -0.4 + 0.05 mm which represents the required

granularity for use in the production of water glass and after washing and electromagnet. The obtained results are shown in Table 2.

Table 2 Chemical composition of raw quartz sand and classes -0.4 + 0.05 mm after washing and electromagnet

Sample	Content, %									
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Cr ₂ O ₃	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	L.I.
Row sand	97.82	1.24	0.131	0.0012	0.068	0.04	0.02	0.007	0.086	0.51
-0.4+0.05 mm after washing	99.15	0.29	0.075	0.0003	0.007	0.04	0.008	0.003	0.0032	0.09
-0.4+0.05 mm after the electromagnet	99.49	0.174	0.0301	0.0002	0.039	0.028	0.007	0.0014	0.022	0.09

From the presented chemical composition, it can be seen that the raw sample contains 0.131% Fe₂O₃. It also shows that content of Fe₂O₃ in class -0.4 +0.05 mm after washing 0.075%, which is above the prescribed values for use in the production of water glass, which is 0.04% max. That is why the magnetic concentration was done on class -0.4 +0.05 mm with high gradient magnetic separator in order to remove Fe₂O₃. After magnetic separation, Fe₂O₃ content is reduced to 0.0301%, what meets the required quality required by the user.

It was determined on initial sample that the moisture is 5.0%, while the apparent density is 1.852 t/m³ and Bond Index is 14.0 kWh/t. It was also determined the

apparent density of the class -0.4 +0.05 mm, which represents the required granularity for use in the production of water glass and it is 1.42 t/m³.

Determination the Particle Size Distribution of Quartz Sand, Obtained in Separation

Having in mind the fact that the required grit silica sand for use in the production of water glass is a class of -0.4 to +0.05 mm, it was necessary to determine the grain size distribution of quartz sand, obtained in separation. Connecting ways of classes that go on re-grinding to obtain the required granularity are shown in Table 3.

Table 3 Particle size distribution of silica sand with classes that will be obtained by separation

Size class, mm	M, %	Oversize, %	Undersize, %	Class name (mm) and content (%)	
+15.00	7.20	7.20	100.00	+15.00	7.20
-15.00+4.00	37.80	45.00	92.80	-15.00+0.40 class for re-grinding	63.46
- 4.00+2.00	4.16	49.16	55.00		
- 2.00+0.60	12.89	62.05	50.84		
- 0.60+0.40	8.61	70.66	37.95		
- 0.40+0.05	24.34	95.00	29.34	0.40+0.05 final product	24.34
- 0.05+0.00	5.00	100.00	5.00	-0.05+0.00	5.00
raw material	100.00	-	-		100.00

It can be seen from Table 3 that it is necessary to connect all classes between -15.00 + 4.00 + -0.60 mm and 0.40 mm into class -15.00 + 0.40 mm that will go to re-grinding. Class -0.40 + 0.05% is the final product to the proportion of total sample

mass of 24.34%, and that can go into direct use.

After re-grinding the coarse classes of quartz sand in a ball mill, the grain size distribution was determined, and the results are shown in Table 4 and graphically in Figure 2.

Table 4 Particle size distribution of quartz sand after grinding of large classes

Size class, mm	M,%	Oversize, %	Undersize, %
+0.60	4.35	4.35	100.00
- 0.60+0.40	7.75	12.1	95.65
- 0.40+0.05	81.51	93.61	87.9
- 0.05+0.00	6.39	100.00	6.39
Total output from mill	100.00	-	-

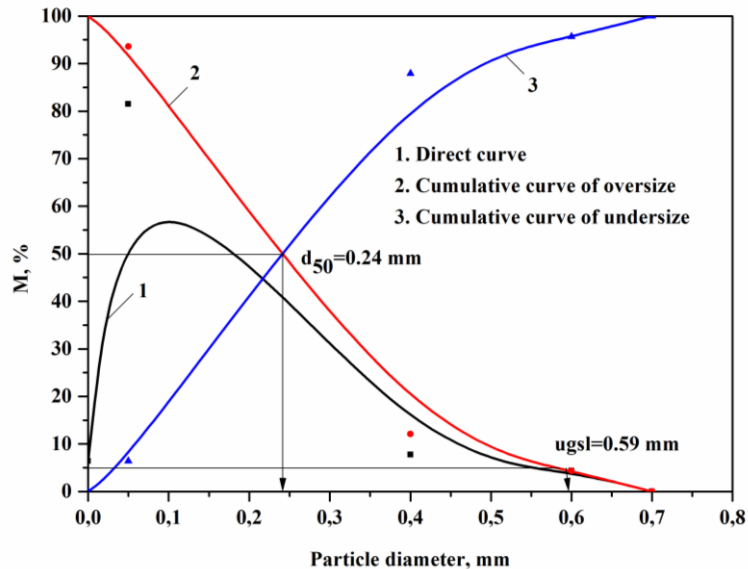


Figure 2 Particle size distribution of quartz sand after grinding of large classes

Based on the results obtained by determination the particle size distribution, it can be seen that by grinding of class -15.00 + 0.40 mm, the average diameter decreased from 2.08 mm as it was in the run-of-mine sample at 0.24 mm, what it is after re-grinding. Also, upper grain size limit decreased from 16.81 mm to 0.59 mm.

Technological Procedure of Processing the Quartz Raw Material

On the basis of tests, it came down to the technological scheme for valorization of this raw material. This scheme is given in Figure 3.

Description the Technological Process of Separation

Quartz sand from the deposit “Bijela Stijena - Skočić” is transported by truck to the landfill and from there loaded into the receiving hopper (pos. 1.). Then dosed the vibrating feeder (pos. 2) on the conveyor belt (pos. 3) carrying the raw material in the

drum slurry (pos. 4). Water is added into drum for washing to achieve proper density pulp. The resultant pulp comes on the grate opening of 15 mm, which is the output part of drum. Here, the isolated class + 15 mm, falls on conveyor belt (pos. 5) which goes to the landfill near the building of separation. Class -15 +0 mm comes into chute and from there to the vibration sieve (pos. 6). Vibro sieve is supplied with water from the pump position 29. In the vibrating sieve, which has two floors allocated ranges -15 +4 mm and -4 + 2 mm (pos. 7 and pos. 8) that are transported by conveyor belts to the anticipated concrete boxes. These assortments are ground to obtain the class -0.4 + 0.05 mm. Class -2 + 0 mm goes by gravitation from vibrating sieve into the rotation sieve (pos. 9) where stands out the product -2 + 0.6 mm which falls on the conveyor belt (pos. 10), and after that carries it into concrete box. This product can be commercial or ground with the other classes of size -15 + 0.4 mm. Sieving material from rota-ting sieve -0.6 + 0 mm, by gravity, goes to the recycle pump (pos. 11). The pump transports this class to

hydrocyclone (pos. 12). Hydrocyclone overflow (pos. 12) goes by gravity into a common collector pipe that takes it into lagoon

about 150 meters from the plant. Sand hydrocyclone, pos. 12, goes to scrubbing in attrition machine (pos. 13).

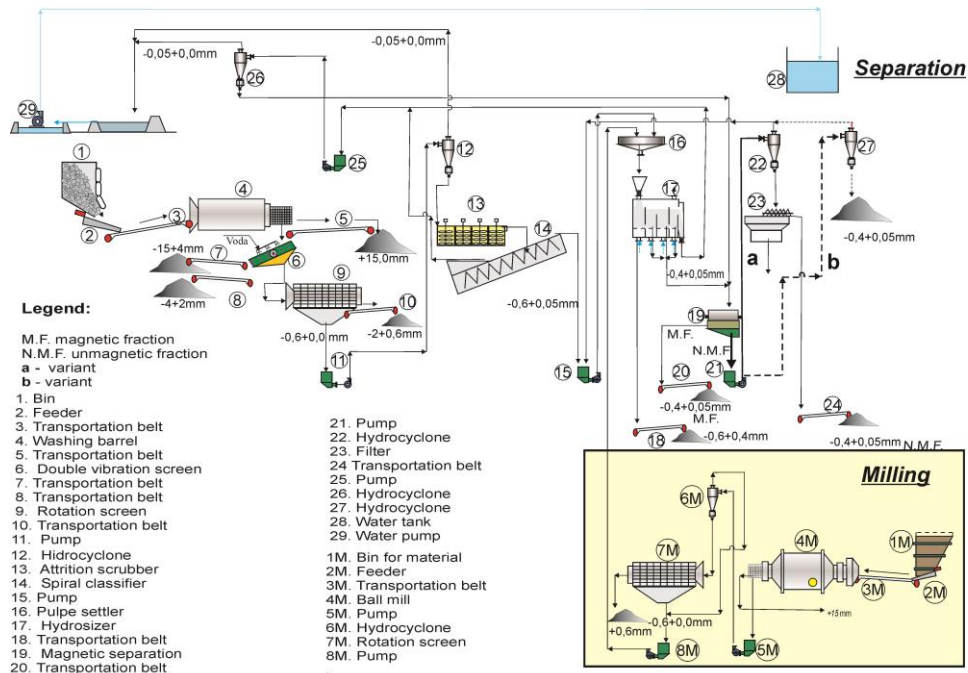


Figure 3 Figure of quartz sand separation and milling - Kozluk

After attrition and scrubbing, material goes into gravitational classifier with spiral (pos. 14) in which the required amount of water is added. Overflow of classifier $-0.05 + 0$ mm, goes by gravity into the pump basket, pos. 25. Pump transports overflow to the hydrocyclone thickeners, pos. 26. Sand of this cyclone goes to high gradient magnetic separator, pos. 19, and overflow in lagoon together with hydro-cyclone overflow, pos. 12. The sand of classifier, class $-0.6 + 0.05$ mm, goes by gravity to the basket of centrifugal pumps (pos. 15). Pump is conveyed the material in the "silencer" (pos. 16), which is the point of joining material from separation and material from grinding, which is delivered by pump (pos. 8M). From there, the material goes by gravity in hydrosizer (pos. 17). Hydrosizer role is to

classify the material into classes of 0.6 mm + 0.4 mm; $-0.5 + 0.05$ mm and -0.05 mm + 0 with the aid of water under constant hydrostatic pressure that comes from the reservoir supplying the whole process by water (pos. 28). In the first chamber of hydrosizer, the separated class $-0.6 + 0.4$, mm which falls by gravity onto conveyor belt (pos.16), continues into its concrete boxing. Class $-0.05 + 0$ mm from hydrosizer goes into t collector and after that into pump, pos. 25. Class $-0.4 + 0.05$ mm from hydrosizer comes by gravity into electromagnetic separator (pos. 17). Here, magnetic fraction is obtained, which falls by gravity onto conveyor belt (pos. 18) which brings this material on concrete dump. Non-magnetic fraction goes into the basket pump (pos. 21) which has two outputs with valves:

A variant: Allows the material to be sent to the hydrocyclone pos. 22. Dressing of hydrocyclone, pos. 22, goes by gravity to the basket pump, pos. 15. Sand of hydrocyclone, pos. 22, goes to the plan filter (pos. 23). The role of plan filter is that the material is so concentrated that the product has a moisture around 6%. Filtered quartz sand filter with a plan comes flowing by gravity onto conveyor belt (pos. 24) which does the storage of filtered quartz sand into position. This is the final product (-0.4 ± 0.05 mm) which is used for water glass.

B variant: Makes possible that material by pump pos. 21 is sent to the hydrocyclone pos. 27 which is located on an open landfill on the tower height of about 10 meters. Hydrocyclone has four output cones and comes to form the four cone landfills of final product - sand of hydrocyclone - class -0.4 + 0.05 mm. The moisture of such disposed products after natural squeezing is about 12%. Overflow of this hydrocyclone goes into collector pipe and into recycle pump, pos. 15. Thus, leaving hydrocyclone overflow, pos. 12, and hydrocyclone overflow, pos. 26, in the lagoon. Two pipelines, connected merge into one, and finally sets a flexible hose that allows maneuvering in filling the lagoon with this material. The overflow water from lagoon moves in the water catchment from which pump, pos. 29, supplies water to the entire process. Pump, pos. 29, puts water in water tank, pos. 28. Tank (pos. 28) is at the required height that allows the constant pressure required to operate hydrosizer. Sprayers of the sieve, pos. 5, pos. 9 and pos. 7M, are supplied with water from the pipe pumps 29. Water pump equipment for sealing the pumps is supplied with water from the reservoir 28. For thickening material that enters the lagoon from time to time and, if necessary, the flocculent A1 is used. This flocculent is in the powder state and for preparation and mixing with water is performed in special stirrers, located at the required height in order to be performed in the same dosage at the exit piping that goes to the lagoon. From the process of quartz

sand separation, most of the range larger than 0.6 mm goes to grinding to obtain class 0 + -0.6 mm, which returns to the process of separation in order to increase the content of class -0.4 + 0.05 mm.

Description of Grinding Scheme

The classes -15 + 4 mm, -4 + 2 mm, -2 + 0.6 mm and 0.6 + 0.4 mm are separated from separation process and go on grinding. It is also expected that after the control sieving in the rotary sieve (pos. 7M), the over-size -2 + 0.6 mm goes on grinding. After working a few hours of separation and creation of an initial stock of materials that are intended for grinding, the process of grinding is carried out. These assortments are dosed in a loader carrying a metal basket (pos. 1 M) which is located on the line for grinding. Below trash feeder (pos. 2M), this material is metered onto a conveyor belt (pos. 3M), which carries the same into the mill with metal balls and rubber linings (pos. 4M). Selection of this mill was carried out to achieve the required amount of class -0.4 + 0.05 mm, which will then be treated to a high-intensity electromagnetic separator by wet procedure. Fresh water from the reservoir (pos. 28) is added into the mill relationships to achieve solid-liquid T: T = 1: 1. The ground material comes into the basket of pump (pos. 5M), which sends it to the hydrocyclone (pos. 6M). Sand of hydrocyclone goes by gravity in the rotary sieve, diameter 0.6 mm (pos. 7M). Dressing of this hydrocyclone (water) goes to the basket pump (pos. 8M). On a rotary sieve, a control sieving of material is carried out in order to obtain the upper limit of size of the final grinding product of 0.6 mm. Therefore, the adequate net is put on mesh that makes access to some class -0.6 mm. At the rotary sieve, the fresh water is fed from the , pos. 28 Sieving material goes by gravity to the basket pump (pos. 8M), which is transported the same into silencer located in the separation, pos. 16. It is the connection point of material from grinding and separation.

CONCLUSION

Tests have shown that from the raw material of quartz from deposit "Bijela Stijena - Skočić", the grain size can be obtained for water glass, i.e. fraction $-0.4 \text{ mm} + 0.05$. The content of this class in the initial sample was 24.34%. It is necessary to comminute larger classes in the ball mill to this fineness. The necessary quality requirements for the range of water glass are that the content of Fe_2O_3 does not exceed 0.04%. Chemical analyses of the starting sample, used in these tests, have showed Fe_2O_3 content of 0.131%. Product $-0.4 + 0.1 \text{ mm}$, obtained after washing and grading, has content of 0.075% Fe_2O_3 . However, after magnetic concentration of this product, Fe_2O_3 content is reduced to 0.038%, which meets the conditions required by the manufacturer of water glass. Based on these results, the scheme of valorisation the quartz raw materials from deposits "Bijela Stijena - Skočić" is designed, which is given in the paper.

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