Concentration Procedure and Mineralogical and Chemical Composition of Raw Quartz Sand

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ABSTRACT: The investigation, presented in this paper, was carried out on raw quartz sand from three different deposits "Slatma", Cucuge" and "Avala", within the locality of Ub (Serbia) Main scope of the mvestigation was determination of the optimal concentration procedure for production of the quartz sand concentrate adequate for application m the glass industry

Performed investigation undoubtedly showed that concentration procedure depends on mmeralogical and chemical composition of raw quartz sand

The optimal concentration procedure for quartz sand "Slatma", consisting of quartz, chalcedony, feldspar, mica, amphıbolıtes, carbonates and clay minerals, involved washing, classifying and attrition scrubbing For quartz sand "Ğucuge", which mmeralogical composition includes quartz, chalcedony, feldspar, hornstone and limomte-goethite, it was necessary to involve the high intensity magnetic concentration together with washing, classifying and attrition scrubbing At the end, quartz sand "Avala" that consists of quartz chalcedony mass, potassium feldspar, limonite goethıte, mica and rutile, required washing, classifying, attrition scrubbing, high intensity magnetic concentration and flotation concentration in order to obtain the concentrate of required quality

Key words *quartz sand, glass industry, sizing, attrition scrubbing, magnetic concentration, flotation concentratwn*

1. INTRODUCTION

The Company "Kopovi", Ub (Serbia) produce quartz sand Within the Company there are three quartz sand deposits In these deposits, the gram size of the raw quartz sands is different, as well as their mmeralogical and chemical composition [1] The mvestigations, presented m this paper, were earned out on raw quartz sand from these three deposits The samples were denoted as "Slatma", Cucuge" and "Avala",

The main application of high quality quartz sand concentrate is in the glass industry [1] Glass industry [2] has high criteria concerning the quality of the quartz sand, as follows

Granulometnc composition

> 0,500 max 0 0 5 %
< 0,100 max 1 %

Chemical composition

$A1_2 0_3$ max 0 5 %
$Fe_2 0_3$ 0 035 % (+/- 0 005)
TlO2 max 0 08 %
$K_2 O$max0 25%
$Na_2 0$ max 0 006%
CaOmax 0 05 %
MgO max 0 05%
ILmax 0 30 %

In our previous papers, the investigation results related with various possibilities for obtaining high quality quartz sand concentrate, were presented [3,4] as well as the results concerning the application of various reagents m the process of flotation concentration [5,6]

In this paper, the investigation results of selection of concentration procedure in dependence on mmeralogical and chemical composition of raw quartz sand are presented

2. EXPERIMENTAL

2.1. Material properties

2 11 Granulometric composition of raw quartz sand samples

Granulometric composition of investigated samples was determined by wet sieving, with standard laboratory sieves The obtained results are presented in Table 1

From the results presented m Table 1 it can be seen that quartz sand "Ğucuge" has 2 42% of class +0 5 mm and 5 71% of class -01+0 0 mm Quartz sand "S tatma" has 0 84% of class +0 5 mm and 2 40% of class -0 1+0 mm, while quartz sand "Avala" has 1 42% of class +0 5 mm and 13 96% of class -0 1+0

Table 1 Granulometric composition of raw quartz sand samples

Class, mm	Sample								
	"Cucuge"			"Slatina"			"Avala"		
	W,%	1	2W% Î	W,%	zw% /	T	MW%	sw%	zw% T
+0 5	2 42	2 42	100 00	0 84	0 84	100 00	142	142	100 00
-0 5+0 3	34 01	36 43	97 58	76 41	77 25	99 16	185	3 27	98 58
-0 3+0 2	52 76	89 19	63 57	18 28	95 53	22 75	12 70	15 97	96 73
-0 2+0 1	5 10	94 29	10 81	2 07	97 60	4 47	70 07	86 04	84 03
-0 1+0 0	5 71	100 00	5 71	2 40	100 00	2 40	13 96	100 00	13 96
Feed	100 00			100 00			100 00		

2 12 Chemical analysis of raw quartz sand samples

Results of chemical analysis of raw quartz sand samples from three deposits are presented in Table 2

According to results, given in Table 2, it can be seen that content of SlO2 in investigated samples was 92 53% - sample "Avala", 96 50% - sample "Ğucuge" and 98 23% - sample "Slatina" The con tent of Fe_2O_3 in samples varied from 0 214% to 0 390% This chemical composition of investigated samples indicated that for obtaining required quality of quartz sand concentrate for the glass industry the application of concentration procedures was necessary

Table 2 Chemical composition 0 F raw quartz sand samples

Sample	Content, %								
	SiO_2	AI2O3	Fe_2O_3	K,0	Na_2O	CaO	MgO	TiO_2	EL
"Cucuge"	96 50	166	0 39	0 34	0 024	0 042	0 054	0 133	0 68
"Slatina"	98 23	0 832	0 214	0 16	0 02	0 028	0 019	0 050	0 49
"Avala"	92 53	3 97	0 33	1 16	0 07	0 22	0 032	0 40	125

2 13 Mıneralogıcal analysis of raw quartz sand samples

Microscopic analysis of the sample "Slatina"

Mineral composition quartz, chalcedony, feldspar, mica, amphibohtes, carbonate and clay minerals Micro description Mica minerals (bıotıte, uncommonly muscovite) were found in minor quantities The rest of minerals occured in insignificant percentage Feldspar and quartz minerals were partly on completely alternated (sencited) The grains of all present minerals were uniformed m size and had oval to isometric shape

Microscopic analysis of the sample "Cucuge"

Mineral composition quartz, chalcedony, feldspar, mica, amphibohtes, carbonates and clay minerals Micro description Form, size and the level of alternation are very similar to one of "Slatina" quartz sand

Microscopic analysis of the sample "Avala"

Mineral composition: quartz-chalcedony mass, quartz-muscovite mass, potassium feldspar, limonite-goethite, micas and rutile.

Based on the mineralogical composition of investigated samples, the following may be concluded:

- >In quartz sand "Slatina", the main impurities are feldspar, carbonates and clay minerals
- >Feldspar, mica, amphibolites, carbonates and clay minerals are the main impurities in quartz sand "Cucuge"
- >In quartz sand "Avala", the main impurities are potassium feldspar, limonite-goethite, rutile and mica minerals

Due to different mineralogical origin of the impurities, different concentration procedures are needed for their separation and removal from quartz sand.

2.2. Classifying, attrition **scrubbing and washing procedure**

Classifying (wet sieving) was the first procedure applied, on raw quartz sand samples previously soaked in water. Vibration sieves were used. The results of chemical analysis of obtained products is presented in Table 3

Table 3 Chemical composition of classifying products

Content, %						
Cucuge deposit						
	SiO_2	Al_2O_3	Fe_2O_3,	K_2O	Na_2O	Loi
Feed	96.50	1.660	0.390	0.340	0.024	0.68
Classifying product	99.33	0.265	0.049	0.041	0.008	0.25
Slatina deposit						
Feed	98.23	0.832	0.214	0.16	0.02	0.49
Classifying product	99.20	0.34	0.054	0.113	0.011	0.22
Avala deposit						
Feed	93.015	3.78	0.326	1.039	0.072	1.109
Classifying product	97.03	1.43	0.08	0.83	0.06	0.23

As it can be seen in Table 3, for all samples, classifying is unable to provide satisfying quality of quartz sand concentrate. The content of Fe_2O_3 is ranged from 0.049% to 0.08%.

Attrition scrubbing tests were performed in laboratory attrition machine, under the following conditions: pulp density during the attrition was 75% of solid, time of procedure was 15 minutes. After attrition, samples were washed on vibration sieve. Mass balances are presented in Table 4.

Results presented in Table 4, indicate that attrition scrubbing, gave the satisfying quality of the final product only for the quartz sand "Slatina" (content of Fe_2O_3 was 0.031%) and for this sample further treatment is not needed, while other two samples from "Avala" and "Cucuge" deposits required additional treatment.

2.3. Magnetic concentration procedure

Magnetic concentration tests were carried out in high intensity magnetic separator "BOXMAG RAPID IRB 2-250. Magnetic induction used in these tests was 2.0 Tesla The obtained results are shown in Table 5.

The magnetic concentration was efficient procedure for sample from "Ğucuge" deposit with which the content of Fe_2O_3 in non magnetic fraction decreased to 0.034%. The obtained concentrate satisfied the criteria which regulates glass industry. For quartz sand "Avala", magnetic concentration was insufficient to provide required quality and this sample needs the additional treatment.

2.4. Flotation concentration procedure

The flotation concentration was done on sample of quartz sand "Avala", using the procedure of an inverse flotation. R-825, ARMAC-C, FLOTIGAM-ENA and AERO 3030C were used as collectors of impurities (heavy metal minerals, mica, feldspar). NaF was used as deprimator for quartz sand.

The three experiments (Tests, 1, 2 and 3) with different regimes of reagents were done with the aim to

investigate the efficiency of applied reagents in flotation concentration of quartz sand

Test procedure were carried out according to the flow sheets, illustrated in Figures 2A, 2B and 2C, while the mass balance is shown in Table 6

Table 4 Results of attrition tests

Product	M,% per fraction	M,% per raw sample	Content, %					
			SiO,	$A1_20_3$	Fe_20_3	K_20	Na_20	Loi
Sample Cucuge								
FEED	100 00	91 87	99 33	0 265	0 049	0 041	0 008	0 25
Attrition product	96 13	88 31	99 35	0 265	0 046	0 039	0 008	0 19
Attrition slurry	3 87	3 56	98 83	0 265	0 124	0 091	0 008	1740
Sample Slatina								
FEED	100 00	96 76	99 2	0 34	0 054	0113	0011	0 22
Attrition product	98 38	95 19	99 5	0 189	0 031	0 034	0 005	0 18
Attrition slurry	162	157	80 98	9 510	1451	4911	0 375	2 649
Sample Avala								
FEED	100 00	84 62	97 03	143	0 08	0 83	0 06	0 23
Attrition product	98 69	83 51	97 26	135	0 08	0 75	0 05	0 20
Attrition slurry	131	1 11	79 70	7 74	0 08	7 05	0 526	231

Table 5 Results of magnetic concentration tests at majnetic induction of 2 0 T

Product	M, %per fraction	M %per raw sample	Content, %					
			$Si0_2$	$AI_20,$	Fe_20_3	K_20	Na_20	Loi
Sample Ğucuge								
Feed (Attnüon product)	100 00	88 31	99 35	0 265	0 046	0 039	0 008	0 19
Non magnetic fraction	99 60	87 96	9949	0 227	0 034	0 038	0 005	0 10
Magnetic fraction	0 40	0 35	64 49	9 727	3 034	0 288	0 755	22 60
Sample Avala								
Feed (Attrition product)	100 00	83 51	97 26	135	008	0 75	0 05	0 20
Non-magneuc fracUon	98 82	82 52	98 54	1 02	0 049	0 73	0 05	0 16
Magnetic fraction	1 18	0 99	67 60	3 10	10 91	140	011	17 80

Comparing results of flotation concentration obtained in these three tests, it can be concluded that the best quality of quartz sand concentrate was achieved with collector AERO 3030C, used in amount of 400 g/t (Test 3) Thus, the obtained quartz sand concentrate contain 99 28% of SIO2, 0 26% of $A1_20_3$, 0 031% of Fe_2Oj, 0005% of Na_20 and 0 05% of K_20

Table 6 Results of flotation concentration of quartz sand AVALA

Tests	Product	M,% per fracuon	M,% per raw sam pie	Chemical composition %					
				$Si0_2$	$A1_20_3$	Fe_20_3	K_20	Na_20	Loi
I	Feed	100 00	82 52	98 54	102	0 049	0 73	0 05	0 16
	C/$Si0_2$	91 19	77 99	9903	0 34	0 05	0 06	001	0 17
	C/C(tmpunues)	8 81	4 53	78 94	1180	0 35	7 89	0 45	051
2	Feed	100 00	82 52	98 54	102	0 049	0 73	0 05	0 16
	C/$Si0_2$	93 50	77 16	98 81	0 45	0 06	011	0016	0 17
	C/C(ımpuntıes)	6 50	5 36	74 96	14 30	0 37	9 94	0 539	0 63
3	Feed	100 00	82 52	98 54	102	0 049	0 73	0 05	0 16
	C/S1O2	90 10	74 35	99 28	026	0 03	0 05	0 005	0 16
	C/C(impunties)	9 90	8 17	78 87	1127	0 53	7 12	0 460	0 56

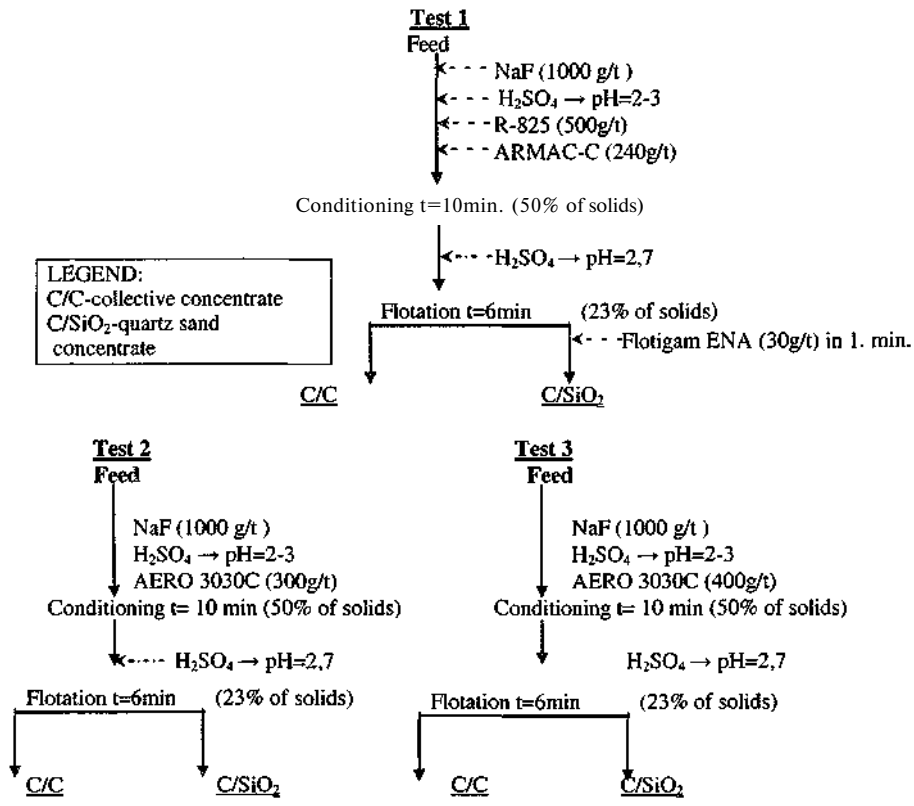

Figure 1. Flotation concentration procedure and conditions

Based on the results of chemical analysis (Table 6) it can be seen that with flotation concentration, the quartz sand concentrate which had the satisfying quality for application in glass industry was obtained, especially in third test

3. DISCUSSION

Summarized results of chemical composition, through the different concentration phases, are presented in Table 7. On obtained quartz sand concentrates, chemical analysis was done. These results are summarized in Table 8, together with the data for quality of quartz sand concentrate required for the glass industry. According to results of performed investigation, the technological procedures for valorization of quartz sand from three different deposits are proposed and illustrated in Figure 3A, 3B and 3C.

The summarized results of performed investigations, presented in Table 7, clearly show that selection of concentration procedure, for valorization of quartz sands form "Avala", "Slatina" and "Cucuge" deposits, directly is dependent on mineralogical and chemical composition of raw quartz sands. Therefore, for "Slatina" quartz sand valorization, classifying and attritional scrubbing were sufficient to apply, for obtaining high quality final product with 99.5% of $Si0_2$, and only 0.189% of $A1_20_3$ and 0.031% of Fe_20_3 Quartz sand "Cucuge", besides classifying and attritional scrubbing, required additionally magnetic concentration, in order to increase the concentrate quality to the satisfactory level. In this concentrate the content of $Si0_2$ was 99.49%, $A1_20_3$ 0.227% and 0.034% of Fe_20_3 However, in order to obtain high quality concentrate from quartz sand "Avala", it was necessary to apply flotation concentration subsequent to classifying, attrition scrubbing and high intensity magnetic concentration. With flotation concentration the feldspar was successfully removed, using collector Aero 3030C, and the final quartz sand concen-

träte had 99.28% of $S10_2$ 0.26% of $A1_20_3$ and 0.03% of Fe_20_3

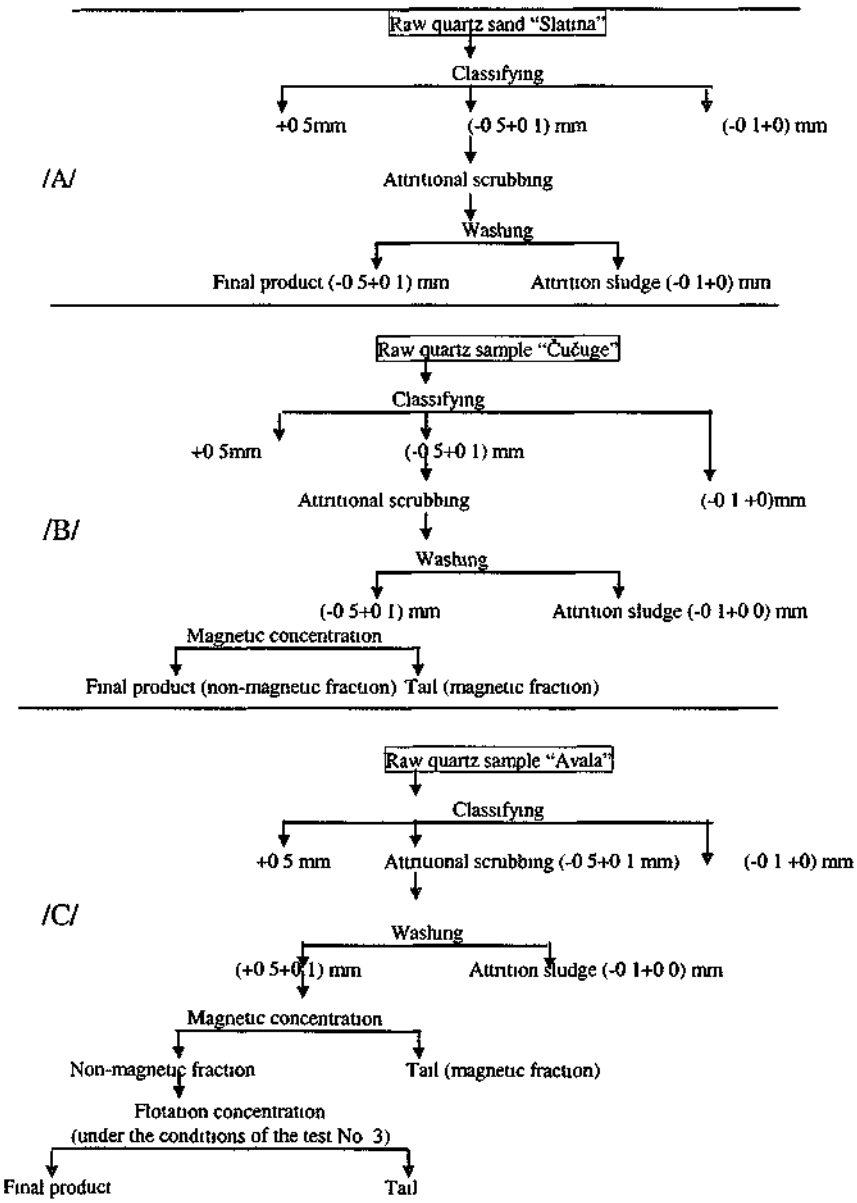

Figure 2 Proposed technological flow sheet for valorization of raw quartz sands from. A/ Slatina deposit, B/ Ğucuge deposit and C/ Avala deposit

emical composition of quartz sand concentrates, obtained with different technological procedures

Applied technological procedure	Content, %					
Raw quartz sand from Slatina deposit	$Si0_2$	$A1_20_3$	Fe_20_3	K_20	Na_2O	Loi
Wet sieving	99.20	0.34	0.054	0.113	0.011	0.22
Attritional scrubbing	99.50	0.189	0.031	0.034	0.005	0.18
Raw quartz sand from Cucuge deposit						
Wet sieving	99.33	0.265	0.049	0.041	0.008	0.25
Attritional scrubbing	99.35	0.265	0.046	0.039	0.008	0.19
Magnetic concentration	99.49	0.227	0.034	0.038	0.005	0.10
Raw quartz sand from Cucuge deposit						
Wet sieving	97.03	1.43	0.08	0.83	0.06	0.23
Attritional scrubbing	97.26	1.35	0.08	0.75	0.05	0.20
Magnetic concentration	96.54	-	0.049	-	-	-
Flotation concentration, Test 1	99.03	0.34	0.05	0.06	0.011	0.17
Flotation concentration, Test 2	98.91	0.45	0.06	0.11	0.016	0.17
Flotation concentration, Test 3	99.28	0.26	0.03	0.05	0.005	0.16

Table 8 Comparative review of achieved quartz sand concentrates as well as the required quality of quartz sand for glass industry

Particle size, mm	Required quality	Achieved quality		
		Čučuge	Slatina	Avala
>0,500	max 0.05 %	0 %	0 %	0 %
<0,100	max 1 %	0 %	0 %	0.2 %
Chemical composition, %				
Al_2O_3	max 0.5 %	0.27 %	0.18 %	0.26 %
Fe_2O_3	0.035 % (+/- 0.005)	0.034 %	0.026 %	0.03 %
TiO_2	max 0.08 %	0.033 %	0.033 %	0.01 %
K_2O	max 0.25 %	0.082 %	0.034 %	0.05 %
Na_2O	max 0.006 %	0.005 %	0.005 %	0.005 %
CaO	max 0.05 %	0.005 %	0.005 %	0.04 %
MgO	max 0.05 %	0.010 %	0.012 %	0.008 %
IL	max 0.30 %	0.10 %	0.11 %	0.26 %

Comparing the quality of quartz sand concentrates obtained in these investigations by treatment of raw quartz sand from three deposits, with the quality of concentrate required for application in glass industry, it can be concluded that produced concentrates fully satisfy the criteria regarding to granulometric composition as well as to chemical composition.

4. CONCLUSION

Investigations were carried out on raw quartz sand samples from three different deposits ("Slatina", "Cucuge" and "Avala"), with the aim to determine the optimal valorization procedure for production of high quality quartz sand for application in glass industry. From obtained results following can be concluded:

- The main impurities in raw quartz sand "Slatina" are clay minerals while Fe_20_3 is present in the form of limonite, which enables their separation and removal by classifying and attritional scrubbing. The quality of produced concentrate is satisfactory for application in glass industry.

According to mineralogical and chemical composition, quartz sand "Cucuge" is very similar to one from "Slatina" deposit but the main and most important difference is the form of the iron minerals. Free goethite grains, present in this quartz sand, may be removed only with magnetic concentration.

Quartz sand "Avala" differs from previous two quartz sands in mineralogical and chemical composition: the content of $Si0_2$ is much lower and the content of potassium feldspar is higher. Therefore, it is necessary to apply the flotation concentration subsequent to classifying, attrition

scrubbing and magnetic concentration m order to obtain the concentrate of satisfactory quality

- Based on the obtained results, a complete technological process is proposed, for quartz sand from each deposit, which will provide the final quartz sand concentrate with the required quality for the glass industry

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