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X-RAY RADIOMETRIC PROCESSING TECHNOLOGY FOR QUARTZ RAW MATERIAL*

The data of the preliminary studies and tests on concentration of quartz raw material from Kyshtym deposit made the basis for the experimental research into X-ray radiometric separation at Kyshtym Mine.

For the research, five samples of different coarseness (–65+20 and –30+5 mm) were taken at different stages of ore pretreatment by crushing and sorting (original ore — with and without washing off from slime; tailings of manual sorting; tailings of optical separation).Concentration by X-ray radiometry was carried out on prototype separator SRF1-150L.

It was found that at the analytical parameter PFe = 0.10 units, it was possible to extract concentrated quartz with the iron content of 0.90–0.96% from the original ore and with the iron content of 1.12–1.16% from the tailings of manual sorting and optical separation. The yield of the concentrated quartz made 43–45% after the original ore treatment and 33–36% after processing of the tailings.

For the large-scale testing, a joint sample of manual sorting tailing with the size of –65+20 mm and optical separation tailings with the size of –30+5 mm. The test separation of the joint sample allowed 38.6% recovery of the concentrate containing 83% of quarts, 14% of pegmatites (mostly, orthoclase), 2% of carbonates and 1% of other minerals. The separation tailings were discharged, and the concentrate was sent to manual sorting to remove feldspar minerals. After manual sorting of the concentrate, the treated product had quartz content of 98% at the end-to-end yield of 26.8%.

Based on the research and tests, the X-ray radiometric separation flow chart was develop and proposed for treatment of joint tailings (manual sorting and optical separation with the size of –65+5 mm.

Key words: *quartz raw material, size grades, X-ray radiometric separation, testing, sample, concentrate, tailings, process flow chart.*

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Introduction

The use of the standard process flow charts of ore pretreatment with subsequent grinding and screening, ignoring capacities of the modern automatic sorting techniques, entails considerable unreasonable loss of high purity and high cost quartz and involves unproductive hand work (manual sorting).

The task of reduction in loss of high purity quartz is to be handled starting from the first processing stages, i.e. pretreatment and pre-concentration. Quartz raw material with the size less than 400–500 mm is subjected to manual sorting. This circuit ends with the considerable loss of quartz in rejects. Large quantities of tailings with the high content of high purity quartz are typical of all stages of pre-treatment and pre-concentration.

It is necessary to reduce loss of high purity quartz at early processing stages by optimizing circuits of grinding and screening as well as by using the most efficient methods of sorting of lump quartz, for example, X-ray radiometry separation.

Preliminary studies and pretests [1] on processing of Kyshtym quartz made the basis for the field research of X-ray radiometric separation of quartz raw material –65+20 and –30+5 mm in size and tailings of manual sorting and optical separation under conditions of Kyshtym Mine [2].

Prior to experimental separation, additional adjustment of X-ray radiometric separator SRF1-150L and processing environment was undertaken. Adjustment of the measurement and control system of the separator included:

- refinement of ranges between upper and lower levels of characteristic and scattered X-ray radiation [3, 4]. For easement and automation of this procedure, the separator is equipped with the locating calibration instrument with the caliber-set target [5]. In our case, the target was an iron plate used as the locating point to start recording of radioactivity domains, adjustment, stabilization and updating of instrumental spectrum. Mostly, peak of iron, given acceleration by a detector, is set in the 64th channel (more seldom, in the 50th channel, sometimes in the 40th channel, depending on a task) [6]. As a result of the adjustment, the radioactivity domains for the main elements were refined as:

  Iron — channels 56–70 (peak in the 62nd channel);
  Calcium — channels 36–44 (peak in the 40th channel);
  Scattered radiation — channels 110–250.

- analysis and updating of a parameter P_{Fe} using representative fragments of quartz ore; approval of the optimal separation algorithm $P_{Fe} = N_{Fe} : N_S$ selected at the stage of the preliminary research and pretesting; selection of the optimal separation threshold as P_{Fe} = 0.10 units for all samples meant for field trials.

X-ray radiometric separation of quartz

The field research into quartz processing took 5 samples of different size (–65+20 and –30+5 mm) from various circuits of ore pre-treatment by grinding and sorting (crude ore — with and without washing of slime; tailings of manual sorting; tailings of

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optical separation). When X-ray radiometric separator SRF1-150L was prepared for the experiments, the samples were treated at the same values of the analytical parameter and separation threshold: $P_{Fe} = N_{Fe} : N_S$ and $P_{Fe} = 0.10$ units.

As a result of the studies and field testing, a processing flow chart for tailings –65+5 mm in size based on X-ray radiometric separation was developed and proposed for implementation at Kyshtym Mining and Processing Plant (see **Fig. 1**).

The test samples were 160 to 300 kg in weight each, depending on size of material. The data of the field research intro X-ray radiometric separation of quartz raw material at Kyshtym Mining and Processing Plant are given in the **table** [7–9].

Based on the data of the experimental research into X-ray radiometric separation of different products (crude ore and pre-treatment tailings) at Kyshtym Mining and Processing Plant, the conclusions below have been drawn:

- X-ray radiometric separation allows extraction of quartz particles with high metal content (iron, manganese and other admixtures) [10] and barren rocks;
- it is impossible to extract feldspar particles into the separation tailings. Calcium-bearing minerals are partly extracted into the separation tailings (at the separation threshold $P_{Fe} = 0.07–0.10$ units). The basic mineral species of feldspar — albite [$Na(AlSi_3O_8)$] — is not extracted into the tailings by X-ray radiometric separation;
- the yield of concentrated quartz from the original raw material made 43–45%. The value of the concentrated quartz yield was independent of coarseness of material (–65+20 and –30+5 mm) and washing of slime from particles. With slime washed off from particles –65+20 mm in size, the concentrated quartz yield grew merely by 1.5% at the reduced iron content by 0.06%;
- the concentrated quartz yield considerably decreased in treatment of tailings of manual sorting and optical separation — almost by 10% (from 43–45 to 33–36%). The cause of it is the presence of very many high-mineral lumps in the tailings fed to X-ray radiometric separation. The iron content of concentrated quartz (as against the initial feedstock) halves — from 2.0–2.21 down to 1.12–1.16%.

The experimental separation also took a joint sample of tailings of manual sorting –65+20 mm in size and optical separation tailings –30+5 mm in size with the total weight of 295 kg. Prior to separation the joint sample was screened to remove small size grade of –5 mm amply present in the tailings.

The X-ray radiometric separation on the chosen separator was carried out at the pre-set analytical parameter $P_{Fe} = N_{Fe} : N_S$ and threshold $P_{Fe} = 0.10$ units. The other parameters of X-ray radiometric separation (domains of characteristic and scattered radiation of iron and calcium, voltage and current in X-ray tube, number of filters, etc. [11, 12]) were the same as in the previous tests.

The separation of the joint sample of the pre-treatment tailings –65+5 mm in size produced:

Concentrate ($P_{Fe} < 0.10$ units) in amount of 114 kg, which makes 38.6% of the initial sample;

Tailings ($P_{Fe} > 0.10$ units) in amount of 181 kg, which makes 61.4% of the initial sample.

The concentrate of the X-ray radiometric separation, as per the mineralogy analysis, contained 83% of quartz, 14% of pegmatite (mostly orthoclase), 2% of carbonate and 1% of other minerals.

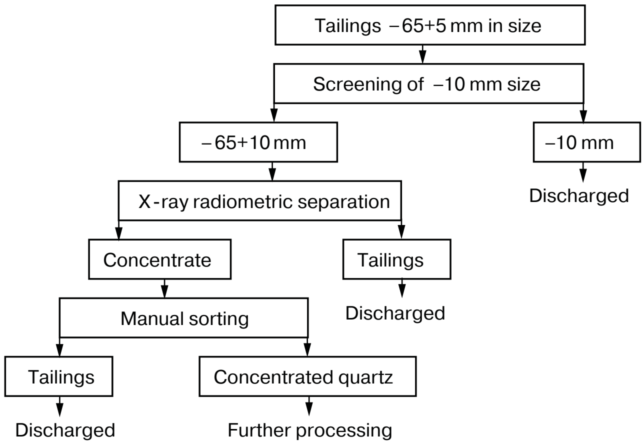

Fig. 1. Recommended processing circuit for tailings

Experimental research results

Separation product	Yield		Iron, %	
	kg	%	Content	Recovery
Sample no. 1 (original quartz raw material, –65+20 mm size grade)				
Concentrated quartz	128	43.8	0.96	26.8
Tailings	164	56.2	2.05	73.2
Initial sample no. 1	292	100.0	1.57	100.0
Sample no. 2 (original quartz raw material, -65+20 mm, washed)				
Concentrated quartz	144	45.3	0.90	26.5
Tailings	174	54.7	2.07	73.5
Initial sample no. 2	318	100.0	1.54	100.0
Sample no. 3 (original quartz raw material, –30+5 mm, washed)				
Concentrated quartz	72	42.9	0.92	24.5
Tailings	96	57.1	2.13	75.5
Initial sample no. 3	168	100.0	1.61	100.0
Sample no. 4 (manual sorting tailings, –65+20 mm)				
Concentrated quartz	88	33.3	1.12	18.2
Tailings	176	66.7	2.51	81,8
Initial sample no. 4	264	100.0	2.05	100.0
Sample no. 5 (optical sorting tailings, –30+5 mm)				
Concentrated quartz	60	36.4	1.16	19.1
Tailings	105	63.6	2.81	80,9
Initial sample no. 5	165	100.0	2.21	100.0

The tailings of this separation stage were discharged, and the concentrate was sorted manually on a belt to remove feldspar (**Fig. 2**).

The manual sorting of the separation concentrate and removal of feldspar produced — 9 kg of concentrated quartz (**Fig. 3**), which makes 69.3% of the manual sorting stage or 26.8% of the yield of the previous-stage tailings –65+5 mm in size. The concentrate product contained 98% of pure quartz in accordance with the data of the mineralogical analysis.

— tailings (represented mostly by feldspar) in amount of 35 kg, which makes 30.7% of the manual sorting stage or 11.8% of the yield of the previous-stage tailings–65+5 mm in size. The tailings contain no more than 10–12% of quartz added with pegmatite and granite.

The sorting stage to pick up concentrated quartz from the X-ray radiometric separation product took 10 min. So, production output of four sorting operators can be 474 kg/h.

Fig. 2. Additional manual sorting of separation concentrate

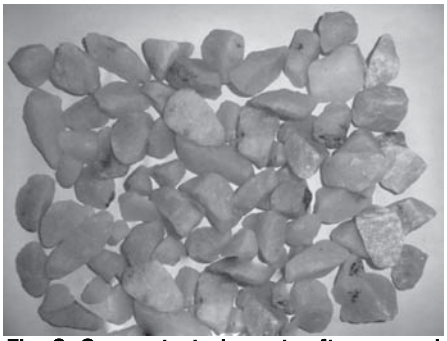

Fig. 3. Concentrated quartz after manual sorting

Thus, it is possible to produce up to 3 t of pure quartz per 8-hour shift (with rest breaks).

At the present time, the end-to-end yield of high purity quartz concentrate produced at the stage of ore pre-treatment at Kyshtym Mining and Processing Plant makes 45.7%. Considering the results of the X-ray radiometric separation of tailings of manual sorting and optical separation, the high purity quartz concentrate yield may increase to 49.1%.

Conclusion

The outcome of the preliminary research, tests and field research into processing of Kyshtym quartz allows drawing some conclusions explicated below.

1. X-ray radiometric separation is the most efficient in joint treatment of manual sorting tailings –65+30 mm in size and optical separation tailings –30+5 mm in size.

2. The pre-treatment tailings –65+5 mm in size are expedient to be subject to screening before the X-ray radiometric separation in order to withdraw and discharge size grade of –10 mm. Removal of slime and fine tailings –10+5 mm enhances efficiency of the X-ray radiometric separation. Inspection of the process of quartz selection from tailings –65+5 mm in size fed from grinding and sorting stage shows that size grade –10+5 mm is not sorted out, remains on a belt and is discharged. The cause is the fineness of this size grade, which prevents from reaching high output of sorting of this size quartz.

3. Quartz-bearing raw material –65+10 mm in size is to be sent to the X-ray radiometric separation. Industrial separator of the type of SRF4-50 is advisable to install at the upper platform of the mentioned processing plant.

4. The X-ray radiometric separation concentrate is transported by the existent line (belts) to a sorting room for manual sorting of concentrate quarts.

5. Sorting operators pick up mineral-bearing pieces and feldspar from the X-ray radiometric separation concentrate, reject them and store concentrate quartz in big-bags for transportation for further processing.

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