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The choice of high gradient magnetic separation processes for removal of Fe_2O_3 carriers from quartz raw material

Introduction

Quartz sand or sandstone from any deposit contains impurities apart from the main component. In order to remove those impurities as much as possible, various processes are used for preparation of mineral raw materials (Knezevic 2012). The choice of the process depends on the content and type of impurities, as well as on the form in which they appear in quartz raw material: as independent, on quartz grain surface, or in the quartz grains. The comminution is used in case of sandstone and coarse sand, which are most often reduced to 0.6 mm particle size. Other process are: crushing, grinding, washing, attrition scrubbing, classification, gravity concentration, flotation and magnetic separation (Sekulic et al. 2003). Sludge separation process, washing and classification are always used since this raw material contains clay as one of the impurities. Scrubbing in attrition machines is used when

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quartz surface is kaolinized and limonitized since scrubbing separates them from the grain, after which quartz is washed and classified in order to obtain clean grains. Flotation concentration process for quartz sand is used for assortments in which, apart from quartz, mica and feldspar are found, so "reversed" flotation separates mica and feldspar from quartz and leaves pure quartz. Both mica and feldspar in those cases are most frequently commercial products, which justifies introduction of this expensive process. Flotation concentration is preceded by washing and classification since clay component has to be removed as it negatively influences flotation selectivity of quartz from feldspar and mica (Banza et al. 2006), published the results of improvement of processing quartz sand Hohenbocka (Germany) washing process, atrition and classification. Magnetic separation is used when quartz raw material, apart from other impurities, contains total iron carriers – Fe_2O_3 which are magnetically susceptible (Sekulic et al. 2002; Ignjatovic et al. 1997; Sekulic et al. 2016). The authors have studied literature in the field of magnetic separation, where many researches published their results concerning the raw material that can be treated by this process and the conditions under which it has to be undertaken (Bhatti et al. 2008; Ibrahim et al. 2002: Porat et al. 2006; Augusto et al. 1999; Prakash et al. 1999, Das et al. 1991). The aim of this study was to investigate the efficiency of magnetic separation for the removal of the Fe_2O_3 carriers from the quartz raw materials in dependence of the form that these impurities are presented.

1. Magnetic properties of minerals

Magnetic properties are all the microscopic and macroscopic manifestations of the response of a material to the influence of magnetic field. Some minerals are attracted to the magnet, and we call them magnetic (paramagnetic) ones, while others are diamagnetic, i.e. they are not attracted to the magnet. This property is used for separation of minerals. Reaction of material to magnetic field is characterized by the property which is called magnetic susceptibility. According to their magnetic susceptibility, materials are divided into: diamagnetic, paramagnetic and ferromagnetic (ferrimagnetic and antiferromagnetic).

Hard ferromagnetic materials as used almost solely for making of permanent magnets. Soft ferromagnetic materials are distinct because of their narrow hysteresis loop, small hysteresis losses and high permeability. Ferrimagnetic materials (ferrites) differ from ferromagnetic materials owing to their specific resistance, which is more than 10 times higher, and the appropriate high negative linear thermal coefficient. Basic characteristics of all magneto-dielectric materials are low magnetic permeability and small losses due to eddy currents.Magnetic properties of paramagnetic materials: when paramagnetic material is placed inside an external magnetic field, a spontaneous orientation of microscopic magnetic moments towards the field occurs, which results in its magnetization. The same direction of magnetization vectors and magnetic field strength vector are the cause of positive magnetic permeability of these materials.

Substances which display diamagnetic behavior are: bismuth, copper, antimony, silver, gold, mercury, water, almost all organic substances, elementary gases (except for oxygen) and **non-metals**.

Paramagnetic substances are: aluminum, chromium, manganese, tungsten, platinum, tin, sodium, chromium alloys and vanadium.

Ferromagnetic substances group is comprised of: iron, steel, cobalt, nickel, and magnetite.

Classification of minerals according to their relative magnetic attractability of strategic and associated minerals compared to iron (taken as standard) is presented in Table 1 (Wills et al. 1986).

Table 1. Relative Magnetic Attractability of Strategic and Associated Minerals

Tabela 1. Względna atrakcyjność magnetyczna mineralnych surowców strategicznych i towarzyszących

	Mineral	Relative Attractability
Strongly magnetic	Iron (taken as standard	100.00
	Magnetite	40.18
	Franklinite	35.38
	Ilmenite	24.70
Weakly magnetic	Siderite	1.82
	Hematite	1.32
	Tantalite	1.20
	Columbite	1.01
Non-magnetic	Garnet	0.40
	Quartz	0.37
	Rutile	0.37
	Cassiterite	0.30

Data from this table show which minerals are easier and which are harder to separate from quartz raw mineral (by high gradient magnetic separators).

2. Examples of quartz sand magnetic separation

2.1. Magnetic separation of quartz sand from Srbokvarc Rgotina deposit near Zaječar

Based on the researches of quartz sand from Rgotina in the Institute for Technology of Nuclear and Other Mineral Raw Materials, we present the results which refer to magnetic separation. Two samples were analyzed.

The polarizing microscope Carl-Zeiss, model "JENAPOL-U" equipped with 10×, 20×, 50×, 100× (oil immersion) objectives and a system for a photomicrography ("Axiocam105 color" camera and "Carl Zeiss AxioVision SE64 Rel. 4.9.1." software package with „Multiphase" module) was used for microscope investigations in transmitted light.

In mineralogical terms, the samples were highly qualitatively and quantitatively similar. The most dominant minerals were quartz and feldspar, and far less mica (biotite and muscovite). Muscovite was a more dominant type of mica. Biotite was regularly altered, i.e. chloritized. Feldspar was found as potassium feldspar and plagioclase feldspar. Limonite-goethite minerals appeared as coating on primary minerals, as well as loose grains, too. The „yellow" sample was more altered (changed) relative to the „white" one, and that explains its slightly darker color. Accessory minerals appear as inclusions in primary minerals, but also as loose grains. Micro-images of the samples are given in Fig. 1a and 1b.

Laboratorial (sample mass 1kg) and increased laboratorial research (sample mass 10 kg) on 1.4T electromagnet „SALA HGMS" by „wet" process gave the following results (Table 2).

Fe_2O_3 content removal rate is calculated in the following manner (Chen et al. 2012, 2016).

$$IR_{nm} = 100\% - \left(\frac{\beta}{\alpha}\right) \cdot M_{nm}\%$$

where:
IR_{nm} – iron removal rate [%],
α = grades Fe_2O_3 % for feed,
β = grades Fe_2O_3 % for non-magnetic,
M_{nm} – mass weight [%] non-magnetic products.

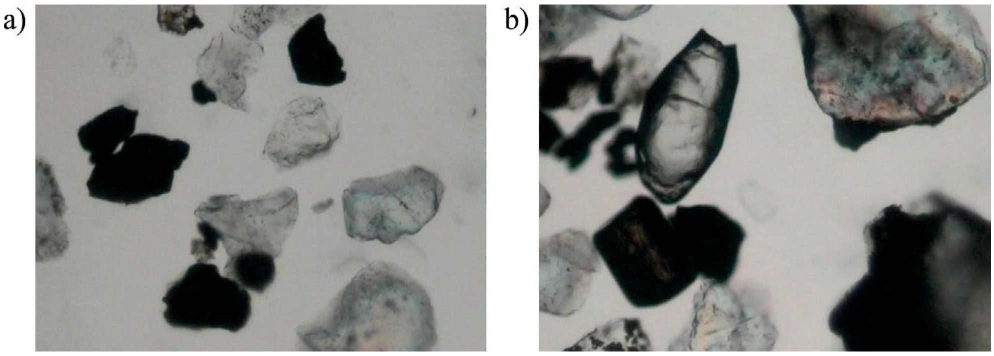

Fig. 1. Micro-images of Rgotina quartz sand
a) Limonite-goethite grains in the "Rgotina-yellow MI" sample,
b) Crystals of apatite and rutile in "Rgotina-yellow MI" sample

Rys. 1. Mikroobrazy piasku kwarcowego Rgotina
a) ziarna limonitowo-getytowe w próbce „Rgotina-yellow MI",
b) kryształy apatytu i rutylu w próbce „Rgotina-yellow MI"

Table 2. Fe_2O_3 iron removal rate after magnetic separation of Rgotina quartz sand sample

Tabela 2. Stopień usunięcia Fe_2O_3 po separacji magnetycznej próbki piasku kwarcowego Rgotina

Sample	White		IR_{nm}	Yellow		IR_{nm}
	Fe_2O_3, %	M_{nm},%		Fe_2O_3, %	M_{nm},%	
Increased research						
Before magnet	0.045	97.95	32.52	0.184	96.98	60.47
After magnet	0.031			0.075		
Laboratorial research						
Before magnet	0.086	97.64	59.13	0.174	97.29	65.33
After magnet	0.036			0.062		

3.2. Magnetic separation of quartz sand from “Bela Reka” – Bor Company deposit

Mineralogical composition: Primary mineral is quartz, participating with 85-87%. Feldspars’ content was about 8%, it appeared mostly as orthoclase, and less as plagioclase. Clay materials (kaolinite and others) made about 3.0–4.0%. The yellow coloration comes from iron hydroxide content. Other colored materials are tourmaline and muscovite. Laboratorial and increased research of dry electromagnetic separation on 2T separator were performed since the product was supposed to be dry and –0.6+1 mm class and –0.355+0.125 mm class. Laboratorial and increased research on electromagnetic 2 T dry separator BOXMAG RAPID IRB 2.250 gave the following results (Table 3).

Table 3. Fe_2O_3 iron removal rate from Bela Reka quartz sand sample prior to and after magnetic separation

Tabela 3. Stopień usunięcia Fe_2O_3 z próbki piasku kwarcowego Bela Reka przed i po separacji magnetycznej

Sample	–0.6+0.1 mm	M_{nm},%	IR_{nm}, %	–0.355+0.125 mm	M_{nm},%	IR_{nm}, %
Before magnet	0.014 (α)	99.2	29.14	0.0114(α)	99.1	38.29
After magnet	0.01 (β)			0.0071(β)		

3.3. Magnetic separation of quartz sand from the Kopovi Ub Company deposits

Mineralogical analysis of the sample class -0.63+0.1 mm (Sekulic et al. 2002). Mineral composition: quartz, chalcedony, plagioclase, muscovite, ilmenite, rutile, tourmaline, garnet, goethite-limonite. The mineral appearing in the highest percentage is quartz (about 90%). Chalcedony appears in rather small percentage as the characteristic cryptocrystalline aggregates of it, which are semi-transparent or clear. Quartz is for the greatest part colorless or slightly colored by yellowish coating of limonite-goethite. Feldspar appears in smaller percentage (orthoclase – up to 5%), as well as chalcedony and mica. Muscovite is the predominantly mica type. Rutile, ilmenite tourmaline and garnet appear in the smallest percentages (Fig. 2c). Limonite-goethite appears as coating and dendrite in quartz grains. Potassium feldspars are altered. Quartz grains are slightly rounded to semi-rounded (Fig. 2d). Ilmenite and tourmaline are the heavy minerals appearing, and they are free minerals – iron carriers (Fig. 2a and 2b).

Laboratorial (sample mass 1 kg) and increased laboratorial research (sample mass 10 kg) on electromagnet by „dry“ and „wet“ process. Dry, high-intensity magnetic separator “BOX-MAG RAPID IRB 2-250”. Wet magnetic separator “SALA HGMS”. The results obtained are presented in Table 4.

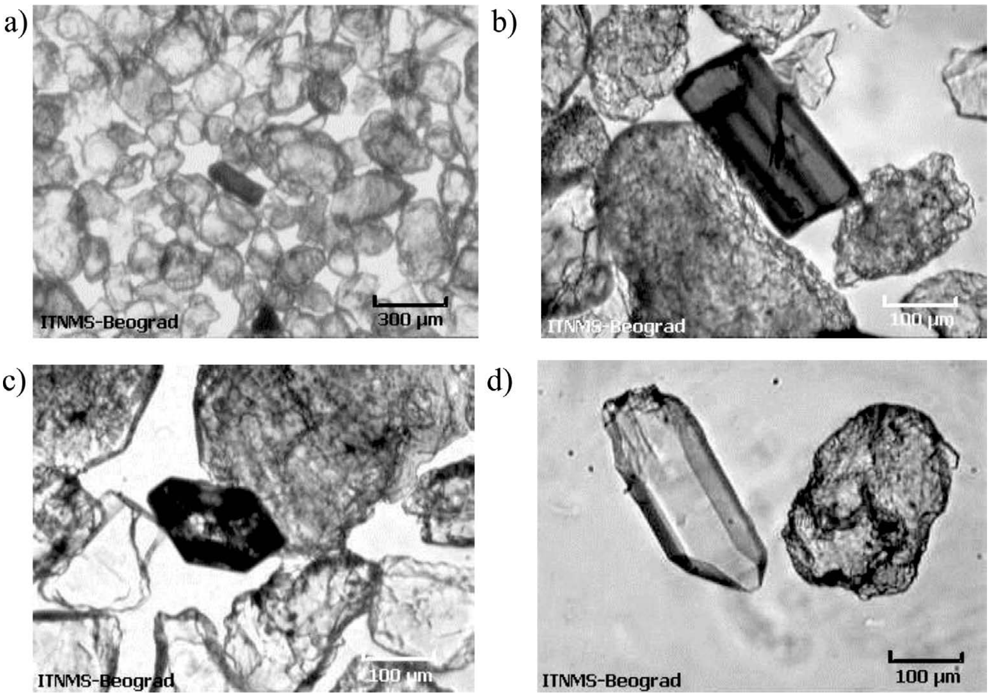

Fig. 2. Micro images of Avala-Kopovi Ub quartz sand sample: a) Dark central crystal is tourmaline, while the black grain of ilmenite is presented in the lower part; b) Tourmaline crystal; c) garnet crystal; perfectly developed quartz crystal and its aggregate; d) Quartz grains are slightly rounded to semi-rounde

Rys. 2. Mikroobrazy próbki piasku kwarcowego Avala-Kopovi Ub
a) ciemny kryształ centralny to turmalin, a czarne ziarno ilmenitu jest przedstawione w dolnej części,
b) kryształ turmalinu, c) kryształ granatu, doskonale rozwinięty kryształ kwarcowy i jego agregat,
d) ziarna kwarcu są lekko zaokrąglone do półkuli

Table 4. Iron removal rate from Avala-Kopovi Ub quartz sand samples prior to and after magnetic separation

Tabela 4. Stopień usunięcia żelaza z próbek piasku kwarcowego Avala-Kopovi Ub przed i po separacji magnetycznej

Sample	Dry, 2T	Mnm, %	IRnm, %	Wet, 2T	Mnm, %	IRnm, %
Before magnet	0.08 (α)	98.82	39.47	0.08 (α)	91.32	57.7
After magnet	0.049 (β)			0.037 (β)		

Results of magnetic concentration (Table 4) of quartz sand class –0.5+0.125 mm show that Fe_2O_3 content decreased to 0.049, i.e. 0.037%, which is acceptable for glass industry. According to the standard SRPS B.B5. 020, maximum content of the Fe_2O_3 in the quartz raw material that can be used for the production of the glass (category IV–X) is 0.03–0.30%.

3.4. Magnetic separation of quartz sand from “Kesogradnja”-Kozluk, Zvornik, deposit

The following mineral composition was found: quartz, chalcedony, feldspar, mica, chert, magnetite, limonite-goethite, garnet, fossil residues. Micro description: quartz and chalcedony appear in highest percentage in the sample, while feldspars appear far less. Quartz is mostly clear, sporadically yellowish due to limonite coating and to some extent kaolinized. Feldspar minerals are mostly kaolinized. Limonite-goethite appears in traces. Garnets are accessory minerals. Microscopic analysis indicates the problem of accreting materials containing Fe_2O_3, which can be separated only by high-gradient electromagnet.

Class –0.4+0.1 mm may be the final product if it satisfies the request regarding chemical composition, above all less than 0.04% Fe_2O_3 content. For that reason, this class underwent magnetic separation in high gradient magnetic separator „SALA“, with magnetic induction of 1.4 T. The mass of the sample was 1 kg

Fe_2O_3 content after magnetic separation was 0.038%, which satisfies requests of water glass producer regarding its quality. The results of electromagnet are shown in Table 5.

Micro images of sample class –0.4+0.1 mm before and after treatment are presented in Fig. 3.

Iron removal rate from examples is presented in Table 6, in percentages.

Table 5. Fe_2O_3 content in Kesogradnja quartz sand sample prior to and after magnetic separation

Tabela 5. Zawartość Fe_2O_3 w próbce piasku kwarcowego Kesogradnja przed i po separacji magnetycznej

Sample	Fe_2O_3, %	M_{nm}, %	IR_{nm}, %
Before	0.075 (α)	93.43	52.28
After 1.4T magnet	0.0383 (β)		

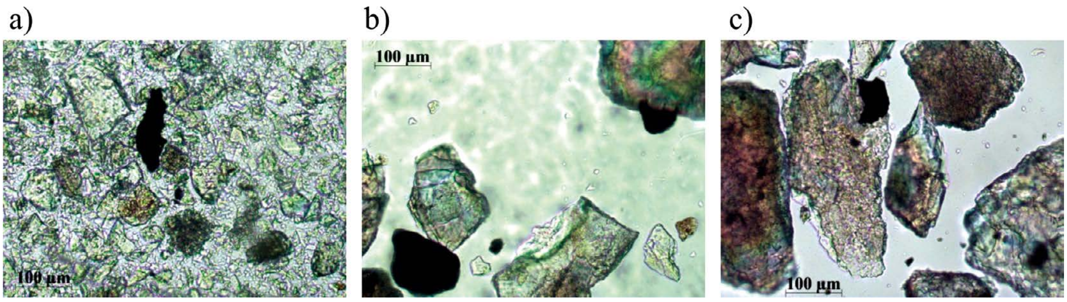

Fig. 3. Micro images of sample class –0.4 +0.1 mm prior to
a) Magnetite in quartz-chalcedony aggregate in the starting sample;
b) Quartz with limonite-goethite aggregate in the starting sample;
c) Limonite-goethite accretion with quartz in the sample after magnet

Rys. 3. Mikroobrazy próbki –0,4 +0,1 mm przed separacją magnetyczną
a) magnetyt w agregacie kwarcowo-chalcedonowym w próbce wyjściowej,
b) kwarc z agregatem limonitowo-getytowym w próbce wyjściowej,
c) zwiększenie agregatu limonitowo-getytowego z kwarcu w próbce po jej namagnesowaniu

Table 6. Fe_2O_3 content from examples prior to and after magnetic separation

Tabela 6. Zawartość Fe_2O_3 z podanych przykładów przed i po separacji magnetycznej

Sample	IR_{nm}, %	Process
Rgotina	32.52–65.33	1.4 T, wet process
Bela Reka	29.14–38.29	2 T, dry process
Kopovi Ub	39.47–57.7	2 T, dry and wet process
Kesogradnja	52.28	1.4 T, wet process
Min/max	29.14/65.33	

These examples show that results of Fe_2O_3 removal rate are not consistent. Namely, it may not be claimed that a precise Fe_2O_3 content will be removed because of electromagnet. We may say that some Fe_2O_3 content will be removed, and that removal rate will be in definite ranges, while all that will depend on the form of magnetically susceptible minerals occurring.

4. Possible occurrences of minerals in quartz sand sample

Results of the research allow creation of an overview of occurrence of magnetic minerals which appear as impurities in quartz sand.

Independent or semi-independent minerals

Quartz	SiO_2
Limonite	$FeO(OH)\cdot nH_2O$
Chalcedony	SiO_2
Feldspars	(orthoclase. $KAlSi_3O_8$.)
Mica	(muscovite $KAl_2(OH,F)_2AlSi_3O_{10}$, biotite $K(Mg,Fe^{2+},Mn^{2+})_3(OH,F)_2(Al,Fe^{3+},Ti^{3+})Si_3O_{10}$)
Ilmenite	FeTiO3
Rutile	TiO_2
Tourmaline	$(Al,Fe,Li,Mg,Mn)_3(Al,Cr, Fe,V)_6(BO_3)_3(Si,Al,B)_6O_{18}(OH,F)_4$
Garnet	
Pyrope	$Mg_3Al_2Si_3O_{12}$
Almandine	$Fe_3Al_2Si_3O_{12}$
Spessartine	$Mn_3Al_2Si_3O_{12}$
Andradite	$Ca_3Fe_2Si_3O_{12}$
Grossular	$Ca_3Al_2Si_3O_{12}$
Uvarovite	$Ca_3Cr_2Si_3O_{12}$
Magnetite	Fe_3O_4
Goethite	$\alpha FeO(OH)$

Heavy minerals, i.e. pyroxenes, amphiboles, spinels, rare earth minerals (monazite, xenotime, allanite, etc.).

Possible combinations of minerals in quartz sand

- possible films

Limonite-goethite coating on quartz

Limonite as coating on quartz

- possible accretings

Garnet in quartz

Kaolinite in quartz

- possible inclusions

Ilmenite in quartz

Rutile in quartz

Magnetite in quartz

Garnet in quartz

- Possible altered grains

Chalcedony

4.1. Minerals in quartz sand which contain iron may be separated by electromagnet of 1.4T intensity

Limonite	$FeO(OH)\cdot nH_2O$
Mica: biotite	$K(Mg,Fe^{2+},Mn^{2+})_3(OH,F)_2(Al,Fe^{3+},Ti^{3+})Si_3O_{10}$

Ilmenite	$FeTiO_3$
Tourmaline	$(Al,Fe,Li,Mg,Mn)_3(Al,Cr, Fe,V)_6(BO_3)_3(Si,Al,B)_6O_{18}(OH,F)_4$
Garnet: almandine	$Fe_3Al_2Si_3O_{12}$
Magnetite	Fe_3O_4
Goethite-	$\alpha FeO(OH)$
Pyroxenes	divalent iron appears

5. Parameters that influence the election and the effects of the magnetic separation of the quartz raw material

As we may see, there is a wide array of combinations in which mineral carriers of Fe_2O_3 in quartz sand appear, which directly influences the possibility of their separation by electromagnet.

As we have mentioned, quartz sand sample may contain various combinations of minerals which represent impurities in quartz from the standpoint of the possible application. It is particularly important to mention that various combinations of minerals which are total iron carriers are possible.

The effect of magnetic separation as well as magnetic separation on high gradient magnetic separator with 1.4 T induction (which is most frequently used) depend on those combinations.

The best effect (Fe_2O_3 content removal) may be expected when very magnetic minerals are „independent“. Following that, a very good effect may be expected with weakly magnetic minerals which are „independent“. Also, the effect diminishes with the increase of the number of accretings, included grains and/or grains forming coating.

In practice, there are „independent“, accreted grains, coatings, included and altered minerals in quartz sand samples. Therefore, most frequently all sorts of combinations appear. That is why the possibility to remove that content from quartz sand depends directly on the percentages of these combinations of minerals as Fe_2O_3 carriers in quartz sand.

The experience of the authors of this paper indicate removal of Fe_2O_3 content is possible in the range from 28-64% (Table 6.) relative to Fe_2O_3 content before 1.4 T electromagnet. This implies that the best removal occurs when there are most of “easily approachable and highly magnetic” minerals, such as free grains of magnetite, limonite, goethite and biotite. The smallest decrease in Fe_2O_3 content can be achieved when there are no these “easily approachable and highly magnetic“ minerals, but almost all of them are inclusions or appearing as accretings and coating with quartz.

- Removal of about 20% of Fe_2O_3 content, e.g. from 0.1 to 0.8%:
  - Minimum content of “easily” approachable and highly magnetic minerals: magnetite, limonite, goethite and biotite, most of accretings, inclusions
- Removal of about 40% of Fe_2O_3 content, e.g. from 0.1 to 0.06%:
  - Equal presence of “easily” approachable and highly magnetic minerals (magnetite, limonite, goethite and biotite) and accretings, inclusions

- Removal of about 60% of Fe_2O_3 content, e.g. from 0.1 to 0.04%:
  - Maximum content of “easily” approachable and highly magnetic minerals, magnetite, limonite, goethite and biotite and minimal presence of accretings, and inclusions.

Experience of this group of authors and research results imply that these effects are not constant in the same deposit, and that they depend on natural composition of minerals in the deposits. In addition to that, these expectations have to be tested every time some quantity of the sample is treated in laboratorial high gradient separator in order to decide on justification of application of this process for Fe_2O_3 carrier removal from quartz sand.

Conditions when the ‘dry’ magnetic separation process is applied

Since clay and silicate impurities are removed by wet processes, it is obvious that for removal of Fe_2O_3 carriers so called “wet” process magnetic separation will be used. All this refers to the choice of high gradient wet magnetic separator. If dewatered or micronized quartz sand product is requested for some purposes with 0% moisture and minimum Fe_2O_3 content, after separation and dewatering, “dry” magnetic separator is introduced.

Evaluation of the magnetic spearation effects.

Effects of magnetic separation are evaluated by chemical determination of Fe_2O_3 content in the assortment, i.e. product. That is only one of the indicators of success of electromagnet operation. Apart from that, microscopic and XRD analysis is to be done so as to know how mineralogical composition of the sand is changed after treatment by electromagnetic separator.

Conclusion

Magnetic separation by high gradient electromagnet as the process for removal of magnetic impurities from quartz sand is applied after classification into commercial assortments and is always used for the assortment which has to have minimal Fe_2O_3 content.

High percentage of Fe_2O_3 content removal when high gradient magnetic concentration is used may be expected only if Fe_2O_3 carrier is magnetic mineral component which is “easily approachable” (loose grains or very little of accretings).

Appearance of magnetic properties carriers varies from one deposit to another, but also in the same deposit during exploitation time and valorization of quartz raw material, as the works on a pit progress. These oscillations may occur daily. Therefore, Fe_2O_3 removal rate after magnetic separation is not a constant, but an interval. This interval should, according to the buyer’s request, be from 0-0.4%. However, the interval may be achieved only if carriers of magnetic properties are approachable, i.e. loose in the quartz raw material.

The choice of “dry” or “wet” magnetic separation also depends on the fact whether the desired assortment is to be delivered to the market as dry or wet, but also on the percentage and appearance of magnetic impurities.

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WYBÓR PROCESÓW SEPARACJI MAGNETYCZNEJ WYSOKOGRADIENTOWEJ DO USUWANIA NOŚNIKÓW FE_2O_3 Z SUROWCA KWARCOWEGO

Słowa kluczowe

surowiec kwarcowy, zanieczyszczenia, minerały, procesy wzbogacania,
separacja magnetyczna wysokogradientowa

Streszczenie

W artykule dokonano przeglądu badań nad zastosowaniem procesów separacji magnetycznej wysokogradientowej w celu usunięcia nośników Fe_2O_3 z surowca kwarcowego za pomocą separatora elektromagnetycznego o natężeniu pola magnetycznego wynoszącego 1,4 T. Przegląd opiera się na aktualnym doświadczeniu autorów podczas fazy badań, a także fazy planowania projektu i początkowej eksploatacji obiektów w kilku miejscach. Kwarcowy surowiec mineralny w tych miejscach występował jako piaskowiec lub luzem. Poza tym surowiec kwarcowy z tych miejsc zawierał różne zanieczyszczenia, np. nośniki Fe_2O_3. Wybór tego procesu w celu usunięcia Fe_2O_3 zależał od składu mineralogicznego, kształtu i zawartości minerałów, a stopień usuwania Fe_2O_3 w tym procesie wynosił od 29 do 65%. Separacja magnetyczna jest indukcją magnetyczną o natężeniu pola 1,4 T. Stosuje się ją do handlowych asortymentów, które były wcześniej poddawane procesom przemywania i klasyfikacji. Zawsze jest to asortyment, który musi mieć najniższą zawartość Fe_2O_3. Wybór „suchej" lub „mokrej" separacji magnetycznej (z płukaniem wodą) zależy również od tego, czy pożądany asortyment jest przeznaczony do sprzedaży na sucho czy na mokro, a także od składu zanieczyszczeń magnetycznych. W większości przypadków stosowany jest proces mokry.

THE CHOICE OF HIGH GRADIENT MAGNETIC SEPARATION PROCESSES FOR REMOVAL OF FE_2O3 CARRIERS FROM QUARTZ RAW MATERIAL

Keywords

quartz raw material, impurities, minerals, preparation processes,
high gradient magnetic separation

Abstract

This review article surveys the subject of choice of high gradient magnetic separation processes for removal of Fe_2O_3 carriers from quartz raw material by electromagnetic separator with magnetic field intensity of 1.4 T.

The review is based on current experience of authors during research phase, as well as project development phase and initial operation of facilities in several locations. Quartz mineral raw material in those locations appeared as sandstone or as loose material. In addition to that, quartz raw material from those locations contained various impurities, i.e. Fe_2O_3 carriers. The choice of this process for Fe_2O_3 removal depended on mineralogical composition, shape and the content of minerals, and Fe_2O_3 removal rate after this process was from 29 to 65%.

Magnetic separation is magnetic induction of 1.4 T. It is applied on commercial assortments which were previously subjected to washing and classification processes. It is always the assortment which has to have the lowest Fe_2O_3 content. The choice of „dry“ or „wet“ magnetic separation (with water flush) also depends on the fact whether this desired assortment is intended for market as dry or wet, as well as on the composition of magnetic impurities. In most cases, the process applied is the wet one.