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STUDY ON THE KAOLIN CLAY BENEFICIATION ABILITY

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The material composition of kaolin raw materials with the content of Al_2O_3 – 17,21; SiO_2 – 66,27; Fe_2O_3 – 0,51; TiO_2 0,574 was studied. The main valuable minerals are kaolinite, halloysite, muscovite, quartz, rare marks of tourmaline, ilmenite. Particle size analysis of kaolin raw materials shows that the largest mass is represented by the size class (- 0,05+0 mm) – 43,08 %. 79,74 % of alumina with its content of 32,0 % is in the size class (- 0,05+0 mm), and it can be used as a raw material for further processing into alumina or as a universal filler for production of paper, rubber, cable, plastic and perfumery products.

Keywords: kaolin raw material, beneficiation, chemical composition, X-ray research, distribution.

INTRODUCTION

Kaolins are clayey rocks consisting of kaolinite group minerals (kaolinite, halloysite, diquite) with an admixture of quartz, potassium feldspar, muscovite, montmorillonite.

Kaolinite is formed from alumina-bearing materials, mainly feldspars and mica. The process of its formation is called kaolinization [1].

White or pale colored kaolins with low content of dark-colored mineral components represented by iron and titanium oxides have commercial value.

High dispersibility, white color, dielectric properties, chemical inertness, good dispersibility, wettability determine a wide use of kaolins as a universal filler in production of paper, rubber, cable, plastic and perfumery products. Both beneficiated and unbeneficiated kaolins can be used for production of coagulants [2,3].

Valuable properties of kaolins are due to the leading role of such kaolinite group minerals as kaolinite, halloysite, diquite and nacrite in their composition. They are all polymorphic modifications of water aluminium silicate $Al_2Si_2O_5(OH)_4$ with SiO_2 content corresponding of 46,54 %; Al_2O_3 39,5 %; H_2O 13,96 % under their material and structural features.

Currently, kaolin-consuming industries use materials with maximum content of kaolinite minerals and minimum content of all other minerals (quartz, potassium feldspar, mica, minerals of iron and titanium oxides). Moreover, each industry has its own requirements for the quality of beneficiated kaolin [4]. In this regard, most of the extracted natural kaolin clays are beneficiated (removal of sand and silty particles), and concentrate with high kaolinite minerals content is obtained.

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Kaolin ores are beneficiated by dry or wet method. Low quality of the product, significant losses of kaolin in wastes, low productivity of beneficiation plants, heterogeneity of beneficiated kaolin properties limit the use of dry beneficiation method.

Wet beneficiation is more widely used and is subdivided into electrolyte-free, elutriation, flotation, hydrocyclone and centrifuge beneficiation. Electrolyte-free beneficiation method is not economical, low-productive, requires large consumption of water and sedimentation devices with a large area.

The purpose of kaolin raw materials beneficiation process is to increase the content of valuable clay rocks (kaolinite, halloysite, diquite), reduce the amount of quartz, iron and other ore minerals.

The beneficiation technology for kaolin raw materials refers to the classification process for kaolinite and quartz grains by size, where highly dispersed kaolinite grains are separated from the larger grains of other minerals. When kaolin is processed, hydrocyclones are the preferred devices for selective separation of fine particles (kaolin) and coarse particles (sand).

The advantages of hydrocyclone beneficiation include simple design, no moving parts, small dimensions of hydrocyclones, small production area, high volumetric capacity. Centrifuges can be used both for independent beneficiation process and for improvement of the quality of the concentrate obtained by wet classification [5].

Hydraulic classification (wet gravity concentration) is based on different velocities of falling particles in the liquid stream. There are many wet gravity beneficiation methods starting from grinding to beneficiation in hydrocyclones and centrifuges used at Prosyanovsky, Glukhovetsky and Kyshtymsky kaolin enterprises [6].

MATERIALS AND METHODS

The following equipment was used for the studies: Optima 2000 DV atomic-emission spectrometer; D8 ADVANCE (Bruker) X-ray diffractometer, Cu_{α} - radiation; Thermo Nicolet Avatar 370 FTIR Spectrometer; X-ray fluorescent spectrometer Venus 200 PANalyical B.V.

The study of particle size distribution in kaolin raw materials of Alekseyevski deposits and the distribution of major elements in size classes was performed with the use of a 750 g sample. The sedimentation analysis with elutriation was carried out through distillation without preliminary pulp stabilization to separate the fine materials into narrow size classes of 0 - 10, 10 - 20 microns, i.e. without introduction of reagents that increase pulp stability and prevent slurry particles from coalescing.

Elutriation was performed in a beaker at a liquid to solid ratio of 10 : 1. Falling velocity of mineral grains was calculated by Stokes formula

Sedimentation duration t was calculated from equality:

$$\mathrm{h} = \mathrm{vt},\ t = \frac{h}{v}, \tag{1}$$

where: h = 200 mm is the distance covered by the particle vertically.

Sedimentation time of slurry for separation of mineral particles with a certain size is presented in Table 1.

Table 1 **Initial data for sedimentation analysis**

Coarseness of mineral grains / mm	Standing time
0,01	47 min
0,02	11 min 45 sec

Each fraction was distilled until complete clarification of the drain.

Kaolin clays from one of the deposits in Kazakhstan were the study object. The sample of kaolin raw materials in appearance is a loose sand of whitish color with the density of 2,06 g/cm^3, bulk density of 1,36 kg/cm^3. There are areas with kaolinite clay of commercial quality suitable for sale without beneficiation at the deposit but the main part of the material requires beneficiation.

RESULTS AND DISCUSSION

Chemical composition of kaolinite clay sample / weight. %: Al_2O_3 – 17,21; SiO_2 – 66,27; Fe_2O_3 - 0,51; Na_2O - 0,119; SO_3 - 0,006; K_2O – 0,9; TiO_2 0,574; Ga_2O_3 0,004; V_2O_5 0,012; ∑rare earth metals 0,08521, other 14,555, alumina to silica ratio (μ_{si}) - 0,47.

Table 2 **Results of X-ray phase analysis of the initial kaolinite raw materials**

Name	Formula	Content / %
Kaolinite	$Al_2Si_2O_5(OH)_4$	31,4
Muscovite	$KAl_2(AlSi_3)O_{10}(OH_1F)_2$	1,1
Quartz	SiO_2	67,5

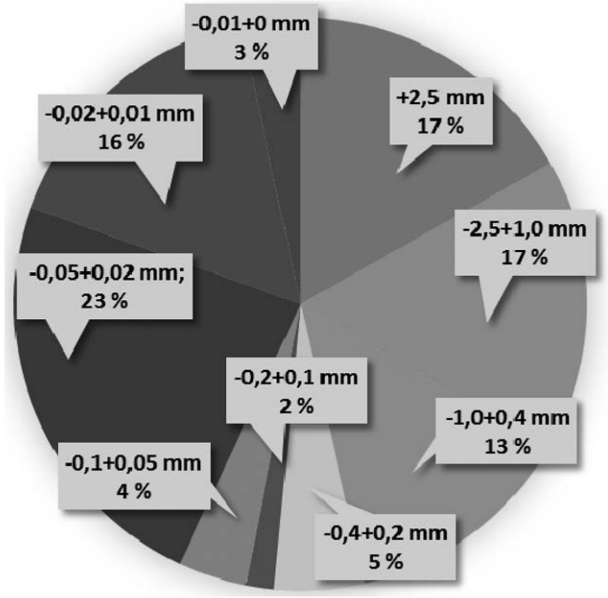

Figure 1 Granulometric characteristics of kaolin raw materials

The main minerals are kaolinite, muscovite and quartz (Table 2).

The results of the sieve and dispersion analysis are shown in Figure 1.

The particle size analysis of the clay material shows that the largest mass is represented by the particle size class – 0,05 + 0,02 mm – 23,0 %, the other classes range from 2,0 % to 17,0 %.

The distribution of the main elements Al_2O_3; Fe_2O_3; SiO_2; by size classes is shown in Figure 2.

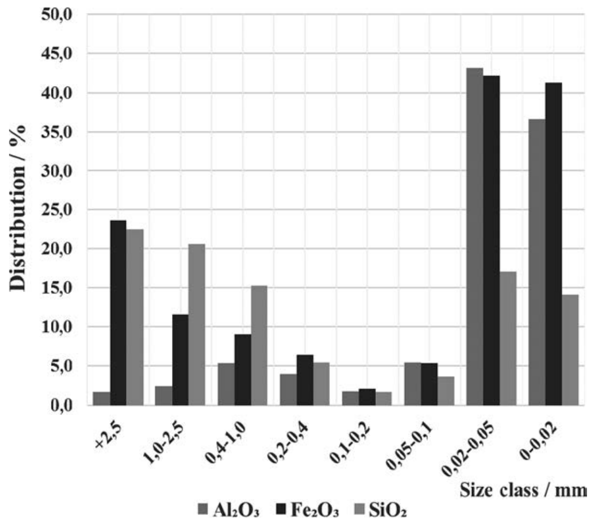

Figure 2 Distribution of major elements by size classes in kaolin raw material

It should be noted that the Fe_2O_3 content is fairly uniform in all size classes and ranges from 0,313 % to 0,634 %. SiO_2 content is 66,27 % in the original sample, and its distribution is uneven across the size classes. The SiO_2 content in the upper size classes i.e. 5 + 2,5; -2,5 + 1,0; - 1,0 + 0,5 mm is 88,34%, 81,98 % and 78,13 %, respectively. In the same size classes, the Al_2O_3 content ranges from 1,64 % to 7,05 %, indicating a high silica content and low alumina content.

The Al_2O_3 content is ~ 32,0 %, the Fe_2O_3 content is 0,57 % in the size classes (- 0,05 + 0 mm) with the yield of is 43,08 % in this class, so it can be used as a raw material for further processing into alumina or as a universal filler for production of paper, rubber, cable, plastic and perfumery products. 79,74 % of alumina is concentrated in the size class (- 0,05 + 0 mm) with its content of 32,0 %, and it is required to consider this raw material as a source for aluminum production.

The mineralogical composition study of kaolin raw materials showed that the sand fraction (- 2,5 + 0,05 mm) is mainly represented by quartz grains with sharp and angular shape; there are single grains of weathered ilmenite (Table 3).

Table 3 **X-ray phase analysis of sand fraction (0,05 - 2,5) mm**

Name	Formula	Content / %
Quartz	SiO2	95
Ilmenite	$FeO{\cdot}TiO_2$	Less 1 %

Study of mineralogical composition of kaolin raw materials showed that the clay fraction (- 0,05 + 0 mm) is mainly represented by clay minerals, i.e. kaolinite - 62,9 % and halloysite - 15,0 % and quartz (Table 4).

Table 4 **X-ray phase analysis of (0 - 0,05) mm fraction**

Name	Formula	Content / %
Kaolinite-1A	$Al_2(Si_2O_5)(OH)_4$	63,0 %
Quartz	SiO_2	12,0 %
Halloysite	$Al_2Si_2O_5(OH)_4{\cdot}2H_2O$	15,0 %

Thus, the study results obtained for the material composition of kaolinite raw materials characterize the sample as clayey one with kaolinite content of up to 31,4 %, quartz - 67,5 % and low content of iron and titanium.

Analysis of the material composition results enables to draw a conclusion about expediency of beneficiation of kaolin raw materials by the scheme including the disintegration, crushing and classification processes in the hydrocyclone with clay fraction of 0 + 0,05 mm obtained and suitable as a filler in the manufacture of paper, rubber, cable, plastic and perfumery products. Sand fraction is represented by quartz minerals

CONCLUSION

The material composition of kaolin raw materials with the content of Al_2O_3 - 17,21; SiO_2 - 66,27; Fe_2O_3 - 0,51; TiO_2 - 0,574 was studied. The main valuable minerals are kaolinite, halloysite, muscovite, quartz, rare marks of tourmaline, ilmenite.

Particle size analysis of kaolin raw materials shows that the largest mass is represented by the size class (- 0,05 + 0 mm) - 43,08 %. 79,74 % Al_2O with its content of 32,0 % is concentrated in the size class (- 0,05 + 0 mm), and it can be used as a raw material for further processing to produce paper, rubber, cable, plastic and perfumery products and as a raw material for alumina production.

The sand fraction (-2,5 + 0,05 mm) is mainly represented by quartz grains ~ 95 % that can be used in the glass industry.

Acknowledgments

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Note: The responsible for English language is Kurash A.A., Almaty, Kazakhstan