ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ХИМИЧЕСКОЙ ТЕХНОЛОГИИ, 2015, том 49, № 3, с. 292–294

УДК 661.634.222

ENERGY- AND RESOURCE-SAVING PROCESSING OF LOW-GRADE PHOSPHORITES

© 2015 г. T. S. Bazhirov[a], K. T. Zhantasov[a], O. B. Dormeshkin[b], K. N. Bazhirova[a], Z. D. Toltebayeva[a]

[a] M. Auezov South Kazakhstan State University, Kazakhstan
[b] Belarussian State Technological University, Belarussia
tynlybek.bazhirov@gmail.com

Received 22.12.2014

The paper considers issues of mechanical activation of phosphate fines, low-grade by its chemical composition and off-grade by its grain fineness mineral raw material. Results of the research showed that increase in the content of soluble form of P_2O_5 is more than in three times, from 17.61 to 53.15%. Specific surface of the activated phosphate fines increases from 0.25 to 0.86 m^2/g. The activation increases degree of dispersion and changes morphology of the phosphate fines disperse particles.

Keywords: phosphate fines, mechanical activation, content of phosphates' citric-soluble form, disperse composition, morphology of disperse particles.

DOI: 10.7868/S004035711503001X

In the extraction, reduction and classification, 55–60% of a phosphate rock passes into the small fraction fines of 10 mm class. By its grain fineness, it cannot be used in electro-thermic processing for production of phosphorus, by its chemical composition, it is of little use for chemical processing into wet-process phosphoric acid [1, 2]. For these reasons, a large volume of the phosphorites' small fraction fines is stored in culm banks and the problem of its efficient processing into mineral fertilizers is of important scientific, economic and environmental task [3].

Phosphorus compounds in natural phosphorites are in the form of hardly soluble hydroxyl-, carbonate-, fluor-apatite, their phosphate base is $Ca_3(PO_4)_2$ with isomorphic inclusions into a crystal latitude of CO_3^{2-}, OH^{-1}, F^{-1} ions [4, 5]. The main objective of the phosphoric fertilizers technology is conversion of insoluble natural compounds of phosphorus into the soluble one.

Traditional acid processing of the natural phosphorites into the phosphoric and complex fertilizers is multistage and requires heavy spending of power consumption and material resources. Large volumes of industrial wastes and liquid wastes are formed at that.

The alternative and promising one is acidless and wasteless technology using mechanical and mechanic-chemical activation of the phosphorites in mills-activators. The activation provides intensive complex mechanical effects on the phosphate particles, in a result of these effects, there is accumulation of internal energy, deformation of its crystal structure, increase in its amorphous degree, specific surface and, as a consequence, significant increase in its solubility [6–8].

Results of systematic researches carried out by different authors [9–12] show that method of the phosphate raw material mechanical activation can be considered as a very promising way to increase efficiency of using the low-grade phosphorites in the production of phosphoric and complex fertilizers.

In the research of the mechanical activation processes, samples of the phosphate fines, low-grade by its chemical composition and off-grade by its grain fineness, of Karatau basin Zhanatas field (Kazakhstan), with chemical composition given in Table 1, were used.

The soluble P_2O_5 determination was carried out by processing with 2% citric acid solution. The content of P_2O_5 soluble form was determined by a differential colorimetric measurements method by means of KFK-2MP photoelectric colorimeter at the length of wave (λ) equal to 440 nm. This method is based on determination of a light transmittance change of the

Table 1. Chemical composition of the initial phosphate fines

Analytes	P_2O_5	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	F	CO_2
Content, mass percent	20.89	20.73	2.58	35.82	3.11	1.68	2.14	6.12

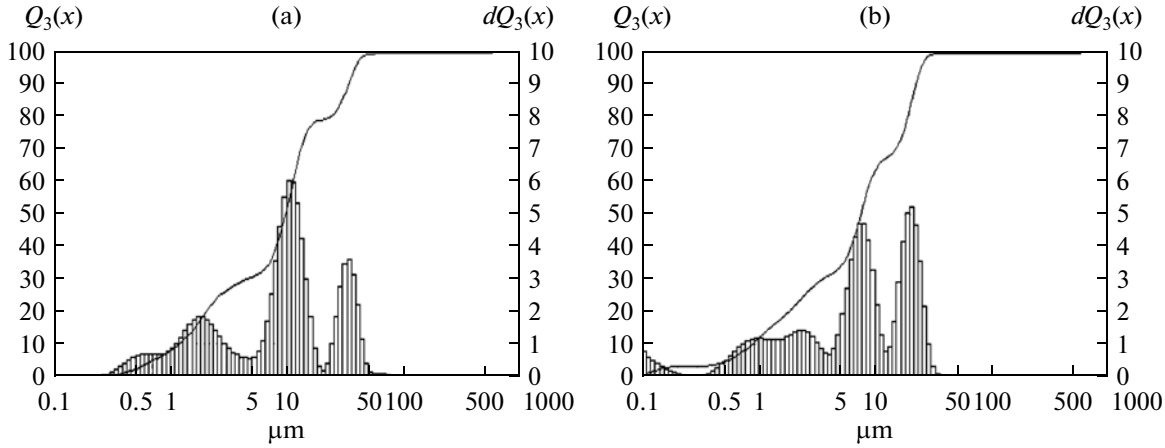

Fig. 1. Disperse range of the phosphate fines samples (a) – nonactivated; (b) – activated.

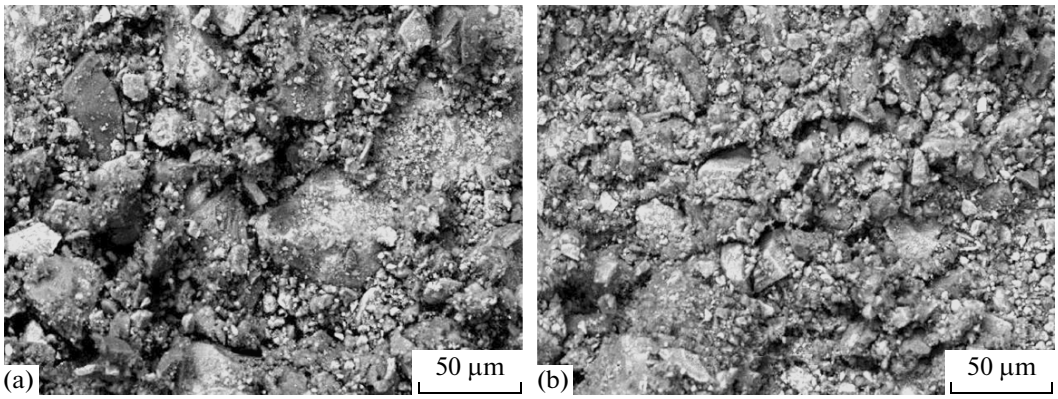

Fig. 2. Electronic pictures of the phosphate fines samples (a) – nonactivated; (b) – activated.

formed yellow phosphorus-vanadium-molybdenum complex.

The phosphate fines mechanical activation was carried out in an activator epicyclic mill. Steel spheres by 6mm diameter were used in the quality of grinding bodies. The drum rotation rate was 400 rpm. The ball load was 10 : 1. The ball load was determined as a mass ratio of the grinding bodies to the mass of activated material (m_{sph}/m_m).

Research results of a dependence of the content of P_2O_5 citric soluble form in the phosphate fines on the activation time are given in Table 2.

It is seen from the given data that in a result of the phosphate fines mechanical activation, relative content of available P_2O_5 increases from 17.61% to 53.62–53.15%, i.e. in more than three times.

As research results of the disperse powders show, using PSH-8A device in the phosphate fines mechanical activation, the specific surface increases from 0.25 m^2/g to 0.86 m^2/g, i.e. on 3.5 times.

Researches of the activated phosphate fines disperse composition were carried out on a laser analyzer "Analizette 22" ("MicroTec Fritsch GmbH", Germany). The results are given in Fig. 1. The activated sample is a polydisperse material, its basic component is finely dispersed fraction from 0.5 to 10 mcm, 5–50 mcm fraction prevails in the nonactivated phosphorites.

Researches on the morphology of the phosphate fines nonactivated and activated samples' particles carried out using "JSM-5610 LV" scanning election microscope show (Fig. 2) that the phosphate fines activated sample has no coarse grains, as the activation reduced their medium size in more than 2 times in comparison with the phosphate fines nonactivated sample. Shapeless particles of indefinite configuration prevail in the phosphate fines activated sample. However, particles with more pronounced flat faces prevail in the phosphate fines nonactivated sample.

Thus, the researches show high efficiency of the phosphate fines mechanical activation, resulted in significant increase of the content of soluble phosphorus pentoxide in the phosphate fines. Increase in the content of P_2O_5 soluble form allows consider that the activated phosphate fines can be efficient component of complex phosphorus-containing fertilizers.

Table 2. Influence of the mechanical activation on the content of soluble P_2O_5 in the phosphate fines

Activation time, minutes	General content of P_2O_5, %	Content of P_2O_5 citric soluble form, %	
		absolute	relative
–	20.91	4.52	17.61
5	20.89	9.76	46.63
10	20.93	11.01	52.62
15	20.92	11.08	52.94
20	20.91	11.12	53.15

DESIGNATION

λ—length of wave of the visible spectrum;

m^2/g—specific surface area;

m_{sph}/m_m—the mass ratio of the grinding bodies to the mass of activated material;

×500—magnification.

REFERENCES

1. *Bishimbayev V.K., Zhantasov K.T., Bazhirova K.N.* Chemical and mineralogical characteristics and technological properties of the formation of ore fines and dropout rates phosphorite // Khimicheskaya promyshlennost segodnya. 2013. № 2. P. 15–18. [*Бишимбаев В.К., Жантасов К.Т., Бажирова К.Н.* Химико-минералогические характеристики и технологические свойства пластовых руд и отсева мелочи фосфорита // Химическая промышленность сегодня. 2013. № 2. С. 15–18.]
2. *Zhantasov K.T.* Technique of yellow phosphorus production. Shymkent, 2013. P. 437. [*Жантасов К.Т.* Технологическое оснащение производства желтого фосфора. Шымкент. 2013. 437 с.]
3. *Bugenov Ye.S., Dzhusipbekov U.Zh.* Physical-chemical fundamentals of phosphorus production from low-grade phosphorites. Almaty: KNTU, 2005. P. 384. [*Бугенов Е.С., Джусипбеков У.Ж.* Физико-химические основы производства фосфора из низкосортных фосфоритов. Алматы: КНТУ, 2005. 384 с.]
4. *Pozin M.Ye.* Technology of mineral fertilizers. L.: Chemistry, 1989. P. 352. [*Позин М.Е.* Технология минеральных удобрений. Л.: Химия, 1989. 352 с.]
5. Technology of phosphoric and mineral fertilizers / Under the editorship of Evenchik S.D., Brodsky A.A. M.: Chemistry, 1987. P. 464. [Технология фосфорных и комплексных удобрений / под ред. Эвенчика С.Д., Бродского А.А. М.: Химия, 1987. 464 с.]
6. *Chaikina M.V.* Mechanochemistry of natural and synthetic apatites. Novosibirsk: Science, 2002. P. 218. [*Чайкина М.В.* Механохимия природных и синтетических апатитов. Новосибирск: Наука, 2002. 218 с.]
7. *Boldyrev V.V.* Mechanochemistry and mechanical activation // Materials of scientific forum. 1996. Vol. 225–227. P. 511.
8. *Avvakumov Ye.G., Gusev A.A.* Mechanical methods of activation in processing of natural and technogenic raw material. Novosibirsk: Academic press "Geo", 2009. P. 155. [*Аввакумов Е.Г., Гусев А.А.* Механические методы активации в переработке природного и техногенного сырья. Новосибирск: Акад. изд-во "Гео", 2009. 155 с.]
9. *Heinicke G. Tribochemistry.* Berlin, Akademie-Verlag, 1984. P. 495.
10. *Chaikina M.V.* Physico-chemical basis of mechanical activation of phosphate complex systems and its applications: Author. dis. ... Doctor of Chem. Sciences. Novosibirsk, 1996. P. 37. [*Чайкина М.В.* Физико-химические основы механической активации сложных фосфатсодержащих систем и их прикладные аспекты: Автореф. дис. ... докт. хим. наук. Новосибирск, 1996. 37 с.]
11. *Dorzhiyeva S.G.* Patterns of change in physico-chemical properties of natural phosphates under mechanical activation with additives: Author. dis. ... Cand. of Chem. Sciences. Irkutsk, 2005. P. 22. [*Доржиева С.Г.* Закономерности изменения физико-химических свойств природных фосфатов при механической активации с добавками: Автореф. дис. ... канд. хим. наук. Иркутск, 2005. 22 с.]
12. *Temuujin J., Mijidsuren A., Erdentuya T.* Characterization of mechanically activated Aldarkhaan (Mongolia) phosphorite // Chemistry in the interests of sustained development. 1999, Ed. 7. P. 725. [*Temuujin J., Mijidsuren A., Erdentuya T.* Characterisation of mechanically activated Aldarkhaan (Mongolia) phosphorite // Химия в интересах устойчивого развития. 1999. Вып. 7. С. 725.]