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Effect of Mechano Activation on Size Parameter of Aluminosilicate Rocks

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Abstract

Background/Objectives: In this work the change of size heterogeneity of mechanoactivated aluminosilicate natural and industrial rocks is studied. **Methods/Statistical Analysis:** The following raw materials alumosilicates were used: Mukhor Talinsk perlite (Buryat Republic) as magmatogene-effusive rock; Honguruu zeolitized tuff (Yakutia) as sedimentary rock; Korkino argillite and gaize as by-product when coal production; Nizhne-Olshansk quartz sand. **Findings**: It is established the studied natural aluminosilicate raw materials have polymineral composition and contains significant quantity of amorphous silica. Differences in mineralogical and genetic characteristics of aluminosilicate rocks, amorphous phase content as well as previous heat treatment effect on variety of size parameters of raw when mechanoactivation. The kinetics of mechanical action on the raw material provided by enhancement of grindability, changing of granulometry as well as significant increasing of specific surface area is accomplished. The results obtained allow monitoring a size parameters of raw materials during mechanoactivation process. It is the important factor to improve reactivity of raw as well as optimization of grinding process. **Applications/Improvements**: The reasonability of application of aluminosilicate rocks to reduce the energy intensity at stage of raw preparation by grinding is demonstrated.

Keywords: Aluminosilicate Raw Material, Aluminosilicate Rocks, Degree of Dispersion, Mechanoactivation, Size Heterogeneity

1. Introduction

One of the main factors, influenced on structural properties of composite binders is phase-dimensional heterogeneity of raw materials. PDH parameter for raw materials of different genesis determines its energy state and, as consequence, its reactivity when chemical at physical processes during the binder hardening[1]. Mechanoactivation significantly influences on PDH parameters of mineral systems. Mechanoactivation process is suitable method for fine control by dimensional, phase parameter and reactivity for traditionally used quartz material[2,3].

At the same time, according to earlier studies using of non-traditional types of natural and industrial aluminosilicates with high content of amorphous phase is prospective. It is due to their high reactivity in comparison with crystal quartz that leads to more effective structure formation in Portland cement[4], calcium-silicate[5] and geopolymer[6,7] binders. Application of natural fine dispersed aluminosilicate allows expansion of the raw material base; solution of resource-saving problems as well as reducing negative ecological influence due to utilization of unclaimed industrial by-products. Aluminosilicates have high grinding capacity, that is why the information about variation of dimension parameters when mechanoactivation is necessary for correction of technological process taking into account reducing its energy intensity.

Goal of this investigation is to study the variation of dimensional heterogeneity of natural and industrial aluminosilicates when mechanoactivation and to choose the

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effective non-traditional raw materials for reducing of energy intensity during the grinding process.

2. Materials and Methods

In this work the following raw materials alumosilicates were used: Mukhor Talinsk perlite (Buryat Republic) as magmatogene-effusive rock; Honguruu zeolitized tuff (Yakutia) as sedimentary rock; Korkino argillite and gaize as by-product when coal production; Nizhne-Olshansk quartz sand (Table 1).

According to earlier studies devoted to investigation of thermoactivation effect on variation of dimensional parameters of aluminosilicates at mechanoactivation the modified gaize, produced by burning at 600 °C during 40 min.

For the studied aluminosilicates a polymineral composition with high content amorphous silica is typical. Presence of amorphous phase is one of the dominant factors of phase and dimensional effect in aluminosilicates determined the rock energy state and subsequently its reactivity in physical and chemical processes when the binder hardening. Determination of content (%) of amorphous phase in the studied raw materials curried out on the base of XRD-data with FullProf program (Table 2).

Table 1. Chemical composition of raw materials, mass (%)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	K_2O	Na_2O	H_2O	SO_3	LOI
Quartz sand	92,76	2,37	0,77	1,89	0,2	-	-	-	-	0,05	1,96
Perlite	70,4	12,85	0,95	0,95	0,15	0,04	3,9	3,59	5,0	-	2,17
Argillite	67,14	21,57	0,02	0,78	0,28	-	1,3	1,26	-	-	7,65
Gaize	74,55	6,75	4,56	1,75	0,7	0,05	1,1	1,38	4,88	0,03	4,25
Zeolitized tuff	59,72	11,2	0,99	2,4	1,73	0,12	1,05	2,84	8,15	-	11,8

Table 2. ScoContent of amorphous phase in the aluminosilicates

Type of aluminosilicate	Amorphous phase, %
Perlite	98,45
Argillite	50,83
Gaize	47,81
Zeolitized tuff	34,90

3. Results and Discussion

According to earlier studies[8], content of amorphous phase is main reason of high energy state of material that initiates mechanoactivation process. For correct comparison of experimental results the studies raw materials were grinded up to 100 m²/kg, after that granulometry analysis was accomplished. For activation the planetary mill with 5 mm still balls was used. "Grinded component: still balls" ratio by wt. was 1:20. Controlled parameters were specific surface area and particle size.

Study of changing of specific surface area when mechanoactivation during 6 hours took place with intermediate controlled points after 1, 2, 4 and 6 of grinding.

Changing of specific surface area value of the materials at quite a long time of mechanoactivation demonstrates high grindability of aluminosilicates of different genesis in comparison with quartz sand. Increasing of specific surface area value up to 300–400 m²/kg takes place after one hour of grinding. It is typical for all studied aluminosilicates. Aluminosilicate material having the highest content of amorphous phase – perlite – has the highest grindability.

In spite of obvious changing of, granulometry of aluminosilicates during the time varies slightly. Particle size distribution analysis was carried out with laser granulometry method. Curves of particle size distribution are shown in Figure 1.

The most growth of specific surface area associated with perlite is lightly reflected on curve of particle size distribution. Concentration of perlite particles is varied in wide range from 0,25 to 100 µm and doesn't change during 4–6 hours grinding period, that demonstrates stabile material polydispersity (Figure 1, b).

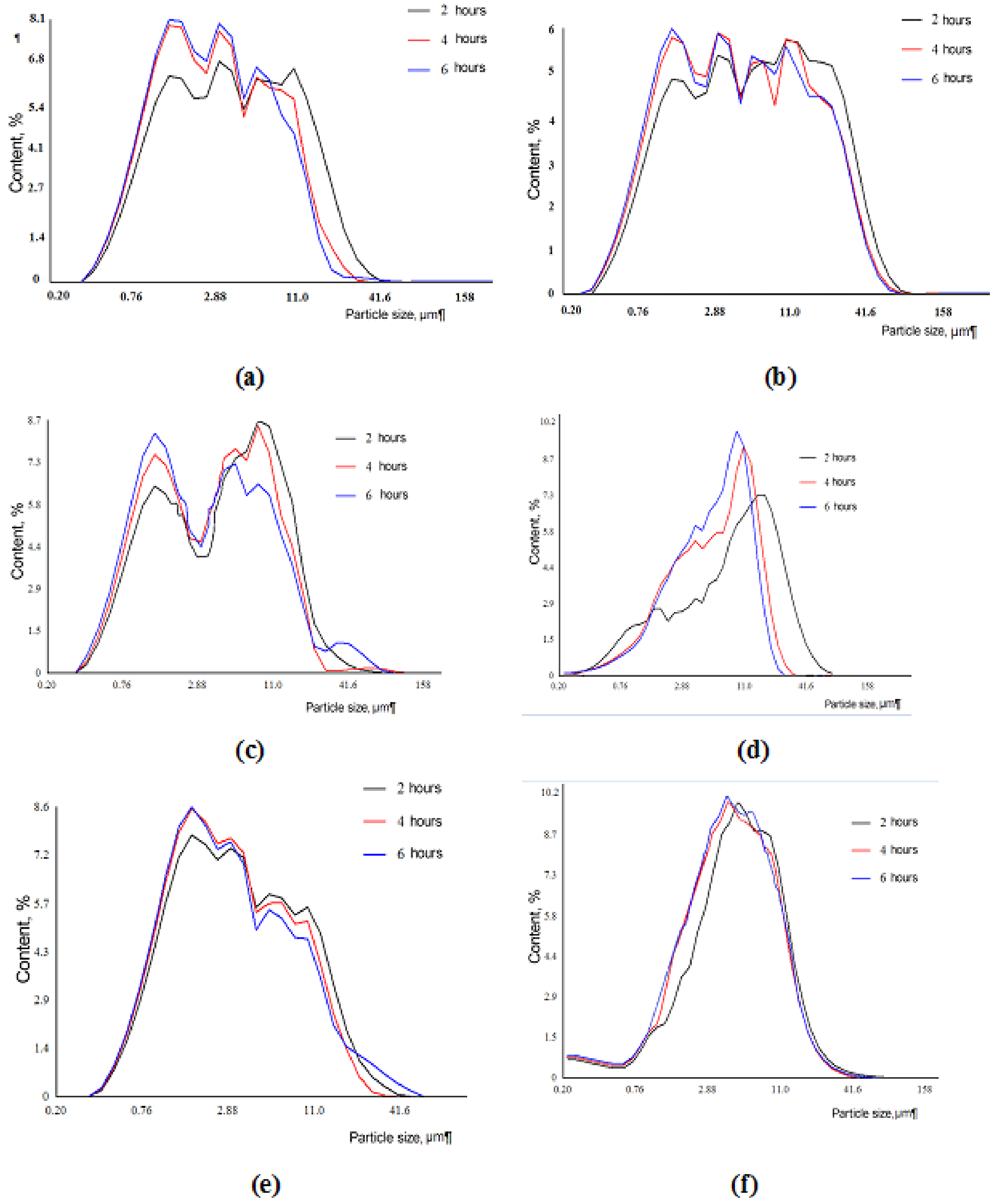
In gaize organic components, including gelified carbon components prevails. Particle size distribution curve for gaize is discontinuous. Content of organic substance (residue of diatoms) provides presence of high-dispersed particles ranges of 1–2 µm and 5–25 µm, number of which is growing during the time (Figure 1, c).

Thermal activation of gaize is significant factor influenced on dimensional parameters after mechanoactivation by growing of specific surface area value (Table 3) and replacement of particle size to 10–12 µm (Figure 1, d). Gradual degradation of clay minerals and their restructuring under high temperature lead to porosity increasing and formation of high-disperced new formation.

Coarsening of mineral particles is connected with their aggregation due to excess of internal energy in the system, initiated with dehydration of layered aluminosilicate[9,10]. Mechanoactivation effects on particle size variation. Under long time mechanoactivation (4–6 hours of grind-

Table 3. Effect of grinding period on specific surface area of materials

Raw material	Specific surface area, m²/kg after grinding period, hours			
	1	2	4	6
Quartz sand	274	354	417	520
Perlite	429	722	743	798
Zeolitized tuff	365	517	657	747
Gaize	332	423	533	678
Thermoactivated gaize	412	576	673	732
Argillite	352	483	497	620



(a) (b) (c) (d) (e) (f)

Figure 1. Granulometry analysis for followings rocks: a – quartz sand; b – perlite; c – gaize, d – gaize thermoactivated; e – argillite; f – zeolitized tuff.

ing) the concentration of particles of size range 1– 11 µm is growing.

Granulometry of argillite during of full mechanoactivation period change non-significantly. At time period of 4–6 hours some of 5–7 µm particles replace to zone of lower dimensional values: 1–2 µm.

Argillite has a high content of clay component with typical presence of separate particles of clay minerals as well as their aggregates with different dispersity without certain size fraction (Figure 1, e).

Particle size area for zeolitized tuff under mechanoactivation stays homogenous. This rock in comparison others ones contains 34,9 % of amorphous phase (Table 2), at the same time changing of specific surface area takes place in high range of values. Also in this material the particles up to 1 µm and, perhaps, nanoparticles present (Figure 1, f).

High grindability of raw materials is relevant for opportunity of reducing of energy consumption of the most long-term and energy-intensive technological stage – grinding as well as reducing of time-period of the binder production. According to data obtained the maximal reducing of energy consumption versus quartz sand is 40% (Figure 1, f. see also Figure 2).

4. Conclusion

Thus, according to the studies we can conclude the differences of mineral and genetic characteristics of aluminosilicates, content of amorphous phase as well as previous thermal treatment influence on dimensional parameters of raw materials during mechanoactivation and lead to growing of specific surface area of material, changing of particle size distribution are dominant factors providing with enhancement reactivity of aluminosilicate raw materials as well as optimize grinding process.

It should be noted, study of size heterogeneity of mechanoactivated aluminosilicates with different genesis is the subject of follow-up studies.

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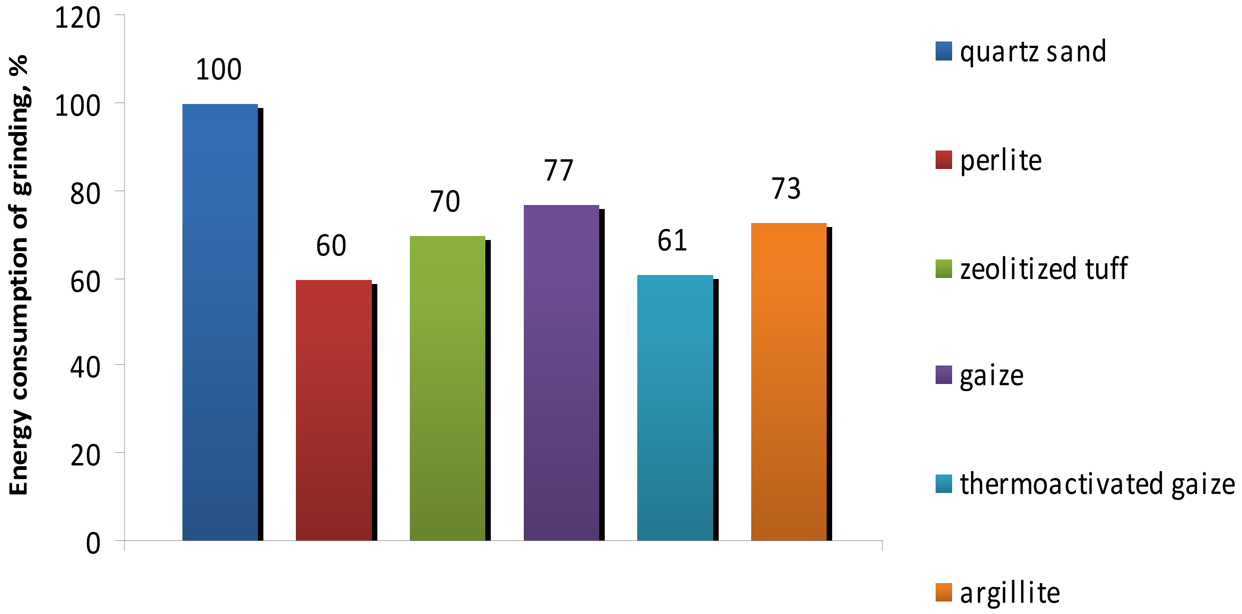

Figure 2. Energy consumption of aluminosilicates grinding versus quartz sand .

of the equipment based on the High-Technology Center, BSTU named after V.G. Shoukhov.

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