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DETERMINATION OF GRANULOMETRIC COMPOSITION OF TECHNOGENIC RAW MATERIALS FOR PRODUCING COMPOSITE FUEL

Purpose. To determine the granulometric composition of technogenic raw materials for agglomeration by the adhesive-chemical method. This approach allows for determining the optimal particle size distribution for obtaining the prepared agglomerated fuel, which has the form of cylindrical rods with a diameter of 30 mm and a length of 50–200 mm.

Methodology. The granulometric composition of technogenic raw materials was determined using sieve and sedimentation analyses. 38 representative samples of carbon-containing raw materials were subjected to the investigation.

Findings. The sieve analysis results of representative samples of coal sludge and culms are presented; their graphical characteristics is given. Sieve analysis of the granulometric composition of samples of carbon-containing raw materials and sedimentation analysis of solid fuel samples with a fraction of fewer than 50 microns is carried out. It has been established that all samples with sizes of more than 5–6 mm should be subjected to further grinding.

Originality. For the first time, studies and comparative analysis of granulometric compositions of technogenic raw materials have been realized, which allows for a reasonable approach to obtaining composite fuel from carbon-containing wastes by the adhesive-chemical method, using various compositions of components.

Practical value. The results can process technogenic raw materials to get agglomerated fuel of specified parameters by the adhesive-chemical method and other processing areas, including using carbon-containing waste from various productions.

Keywords: *granulometric composition, sieve analysis, sedimentation analysis, technogenic raw materials, culms, sludge, agglomerated fuel*

Introduction. Ukraine's energy sector needs commercial coal from 19 to 21 million tons annually. At the same time, in 2020, coal production amounted to 28.82 million tons. This is less than in 2019 by 2,406.3 thousand tons or 7.7 %. The production of thermal coal decreased by 3,057.8 thousand tons or 12.3 %. Natural gas also produced less than 501.2 million m^3 (or 2.4 %) compared to 2019 and amounted to a total of 20,233.9 million m^3 [1]. Tens of billions of hryvnias are spent annually on coal imports. Because of the above mentioned, one of the promising ways in the context of sustainable development of Ukraine is to ensure energy independence [2, 3], which will certainly contribute to the development of innovative energy-saving systems [4].

Ukraine has accumulated approximately 36 billion tons of waste, more than 50 thousand tons per 1 km^2 of territory. Of this amount, about 30 % of industrial waste and about 4 % of household waste are recycled. These wastes are technogenic mineral deposits that can be considered for their efficient processing and production of composite fuel. This secondary fuel can find efficient applications for industrial utilization [5], electricity generation [6], metallurgical processes [7], as well as in solving industrial decarbonization by reducing coal production [8].

The amount of accumulation, disposal, and reuse of this waste constantly changes depending on the classification of waste into certain types and classes of hazards. In addition to environmental challenges in addressing issues of industrial waste recycling, it is possible and necessary to address energy and social aspects caused by the demand for solid fuel and the current situation in Ukraine [9]. The key difficulties in addressing the issues of industrial waste utilization are weak and inconsistent regulatory and institutional framework, lack of funding, and insufficient quality control and assessment.

Ukraine's fuel and energy sector needs to find new nontrivial ways to reduce the coal shortage. One of such ways may be to include an off-balance waste of coal beneficiation into the raw material base of solid fuels; this resource has accumulated in large quantities in sludge settling tanks and sludge accumulators of coal processing plants and coke-making plants over the past few decades.

No less acute problem in the fuel and energy sector of Ukraine is the problem of processing and use of brown coal [10], which is due to several reasons. Thus, brown coal is destroyed after extraction with the transformation into an easily destructive mass, like coal sludge. Under this condition, it is not easy to transport over long distances. High energy con-

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sumption of brown coal briquettes production and sharp fluctuations in prices on the world energy market leads to an increase in their cost, which sometimes exceeds the cost of high-calorific coal. The cost of briquettes largely depends on the distance of briquette production to consumers. It is worth giving an example of Germany, where thermal power plants that consume brown coal briquettes are located 5–10 km from their production.

From the abovementioned, we can conclude that one of the possible ways of integrated processing and use of off-balance coal resources may be their briquetting at low temperatures and pressures without primary beneficiation using if needed, low-ash brown coal as a composite as well as various additives to intensify the process of obtaining granular fuel without binders.

Literature review. Dnipro University of Technology has developed a fundamentally innovative adhesive-chemical technology for the agglomeration of industrial wastes. The technology does not require high pressures up to 150–800 kg/cm^2 and temperatures of about 200 °C, as required by conventional briquetting. Electricity costs are 2.5–3 times lower due to energy-efficient mechanoactivation processes made of composite fuel. The prime cost of processing waste, represented by technogenic deposits, reaches 150–250 UAH per 1 ton [11]. More than 250 million tons of such waste have been accumulated with different quality characteristics of all ranges of extracted coal. The issue of producing composite fuel should be solved by substantiating the technological parameters of production processes and investigating raw materials' physical and mechanical characteristics and their mineral and chemical compositions [12]. In addition, the crucial factor for the adhesive-chemical technology is establishing the particle size distribution of sludges and culms as raw materials for the process. Previously, studies on particle size characteristics of sludges and culms for adhesive-chemical technology were not considered.

Purpose. Firstly, it is necessary to carry out complex particle size distribution studies to substantiate the rational parameters of the agglomeration process of technogenic raw materials by the adhesive-chemical method. Secondly, it is necessary to establish the optimal particle size distribution to obtain finished fuel briquettes that have the form of cylindrical rods with a diameter of 30 mm and a length of 50–200 mm.

Methods. The optimal particle size distribution determines the preparation of solid fuel for agglomeration. In the case of the presence, for example, in the initial coal sludge fraction larger than 5 mm, there is a need to pass it through the screen. In the case of sludge, such fractions are technogenic waste, which may contain various objects of metal, wood, or another origin (nails, nuts, chips, etc.). The size of the coal particles, as shown by research, does not exceed 2.5 mm [13].

The influence of the particle size distribution of the finished fuel is determined by the size of the total grain collision surface, the number and size of voids in the structure of the obtained briquettes, the content of acute-angled grains, the relief of the solid surface and the presence of dust particles.

The bulk mixture of minerals is a fraction of various sizes, ranging from the maximum, measured in hundreds of millimeters, to the smallest grains of a few micrometers. Comparing the particles, their size is characterized by one size. It is usually called the diameter of the particle (grain). For cubic pieces, the length of the cube's edge is taken as a diameter; for spherical pieces – the diameter of the sphere; for an irregular shape – the average of three dimensions: the length, width, and thickness of the parallelepiped in which the particle fits. Sometimes the concept of equivalent diameter is used. It is the diameter of a conditional sphere, whose volume is equal to the volume of the irregular shape particle

$$d_e = \sqrt[3]{\frac{6G}{\pi \cdot \delta}},$$

where d_e is the equivalent particle diameter; G, δ is the mass and density of the particle, respectively.

The size of the bulk material is estimated by the quantitative ratio of the corresponding size. Numerical ratios of individual sizes of material are called particle size distribution and are determined by analyses:

- sieve analysis is a scattering of material on a standard set of sieves with a mesh size of 50 μm or more [14];
- sedimentation analysis is a division of material into sizes according to the velocities of particles in the aqueous medium (materials from 1 to 50 μm) [15];
- microscopic is measuring the particle size with a microscope (materials up to tenths of a micron) [16].

The methods of sieve analyses of different materials are identical. Their essence is careful scattering of the test substance by hand or mechanically into sizes using a set of standard sieves. The module characterizes the ratio of the sizes of a mesh of two adjacent sieves. Standard sets of sieves with a module equal to 2, $\sqrt{2}$ are used.

With the dry method for scattering small material, sieves are installed one above the other from large meshes to small ones. The sample is filled on the upper sieve, and the whole set of sieves is shaken for 10–30 minutes. The residue on each sieve is weighed to the nearest 0.01 g. The sum of the masses of all size classes is 100 %.

Sedimentation is a more accurate and detailed analysis for studying particle size distribution.

There is widespread use of sedimentation analysis in the gravitational field to determine the dispersed composition of crushed materials, lands, and soils, and others. The sedimentation analysis is performed to establish the molecular weight and homogeneity of various polymeric materials, including biopolymers, and the study on sedimentation processes in technical and biological suspensions of microparticles and nanoparticles that aggregate [17].

Spherical dispersed particles are subjected to gravity proportional to the apparent (considering Archimedes' law) mass

$$P = \frac{4}{3} r^3 \cdot \pi \cdot g \cdot \Delta\rho,$$

where g is free-fall acceleration; $\Delta\rho = \rho_2 - \rho_1$ is the difference in the densities of the particle and the medium.

Under the action of the force P, the particles begin to move rapidly. However, they are affected by the resistance force of the medium F, proportional to their velocity U, radius r, and viscosity η of the medium (Stokes law)

$$F = 6\pi \cdot U \cdot \eta \cdot r.$$

As the velocity of the particle increases, the moment comes when the force of resistance of the medium F balances the force of gravity P acting on the particle. After this moment, the particle moves with a constant sedimentation rate U

$$U = \frac{g \cdot V \cdot \Delta\rho}{6\pi \cdot \eta \cdot r}; \; V = \frac{4}{3} \pi \cdot r^3,$$

where V is the volume of a spherical particle of radius r.

For sedimentation analysis, it is necessary to calculate the particle sedimentation time (t_{dpp}, s)

$$t_{dpp} = \frac{0.1835}{d^2(\delta)},$$

where δ is material density, g/cm^3; d is diameter of particles of the material, μm.

The equation can determine the calculation of the density δ

$$\delta = \frac{(A-B)\gamma_p}{(C-B)-(D-A)},$$

where A is the weight of the dry flask with the material, g; B is the weight of the dry flask, g; γ_p is the density of water at the test temperature, g/cm^3; C is the weight of the flask with water, g; D is the weight of the flask with water and material, g.

To determine the bulk (volumetric) mass using a calibrated vessel with a volume of A and weight of P_o. The vessel is filled with the material to the edges and then shaken by tapping the bottom against the table. Excess material is removed with a ruler or a glass stick.

The bulk density of the material Δ is to be equal to

$$\Delta = \frac{P_1 - P_0}{A},$$

where P_1 is the weight of the vessel with the material, g; P is weight of the vessel, g.

Results. Graphic representation is called the characteristic of quantities. Table 1 presents the results of the sieve analyses of six most representative samples of coal sludge and culms.

Table 1

Results of the sieve analysis

Size, mm	*A* sludge		*L* culm		*C* sludge		*F* sludge		*G* sludge		*LF** culm	
	Yield of sizes, %											
	γ	∑γ	γ	∑γ	γ	∑γ	γ	∑γ	γ	∑γ	γ	∑γ**
−10.0+2.5	–	–	16.21	16.21	–	–	–	–	–	–	19.43	19.43
−2.5+1.0	–	–	23.04	35.25	–12.14	–	–	–	12.67	12.67	19.53	38.96
−1.0+0.315	–	–	27.23	62.48	39.23	12.14	16.19	16.19	50.85	63.52	25.26	64.22
−0.315+0.05	42.56	42.56	27.76	90.24	48.63	51.37	42.78	58.97	24.44	87.96	22.90	87.12
−0.05+0	57.44	100	5.76	100		100	41.03	100	12.04	100	12.88	100
Total	100		100		100		100		100		100	

Note: * – *A*, *L*, *C*, *F*, *G*, *LF* – coal ranks: anthracite, lean, coking, fat, gaseous, long-flame, respectively [18]; ** – γ, ∑γ – partial and total yield of the size in percent, respectively

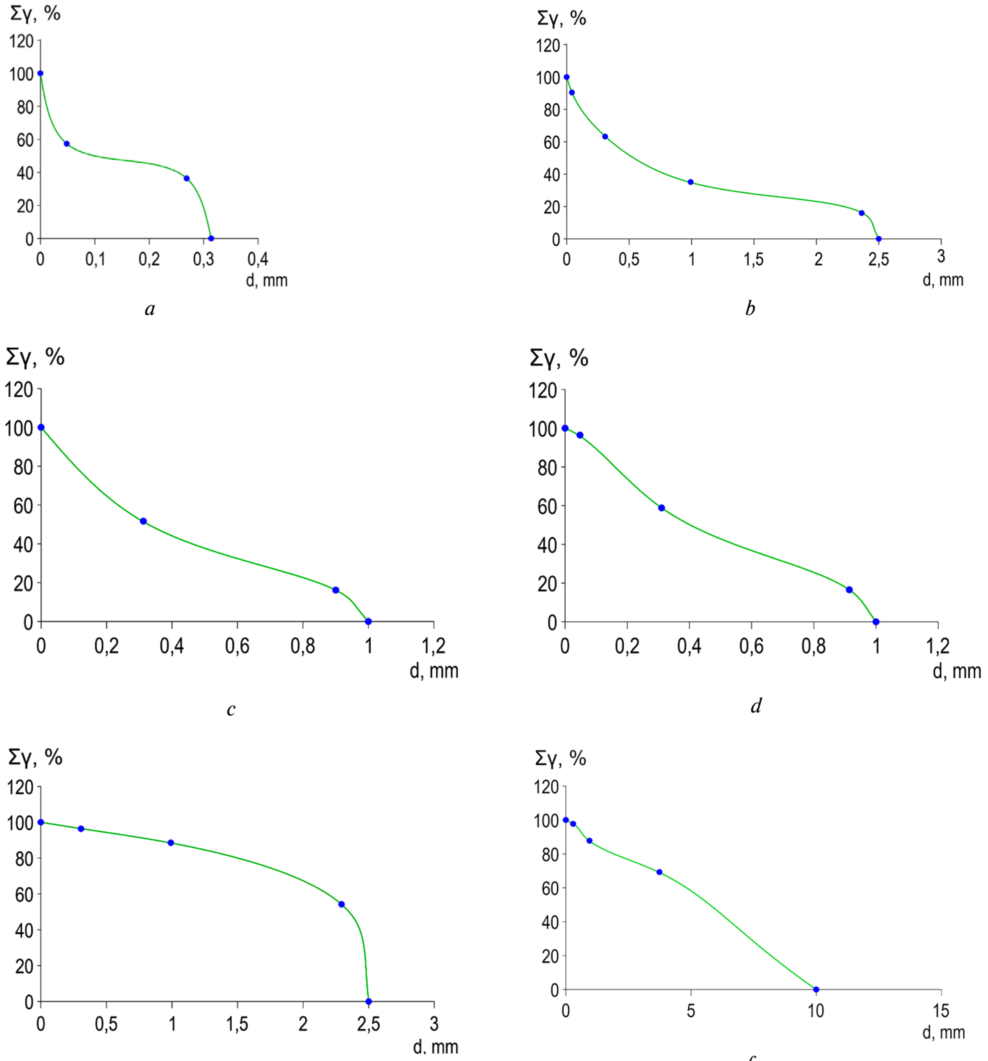

Fig. Granulometric characteristics of sludges and culms:
a – A sludge; b – L culm; c – C sludge; d – F sludge; e – G sludge; f – LF culm

Additionally, Figure gives the graphical characteristics of the particle size distribution.

The size characteristics for other samples are obtained by an identical method of graphical representation based on data from the determination of particle size distribution.

When plotting on the x-axis on a linear scale, put the size of the mesh of the sieves *d* in millimeters, and on the y-axis is the total yield of the size classes larger than the size of the mesh of the sieves in percentage.

Using a curve of the total characteristic, it is possible to determine a theoretical yield of size at screening of material with the set size.

When performing sieve analysis with the definition of a large number of sizes and obtaining the total size characteris-

Table 2

Results of the study on the particle size distribution of carbon-containing raw materials by sieve analysis

No.	Sample*	Size range, mm				
		−10.0+2.5	−2.5+1.0	−1.0+0.315	−0.315+0.05	−0.05+0
		Yield of sizes and total yield γ and $\sum\gamma$, respectively, %				
1	B_1	–	7.65; 7.65	49.87; 57.52	28.41; 85.93	14.07; 100
2	B_2	–	–	13.34; 13.34	66.32; 79.66	20.34; 100
3	B_3	–	–	36.05; 36.05	60.12; 96.17	3.83; 100
4	Peat$_1$	8.23; 8.23	23.8; 32.03	31.31; 63.34	20.37; 83.71	16.29; 100
5	Peat$_2$	17.25; 17.25	25.22; 42.47	35.24; 77.71	11.50; 79.21	20.79; 100
6	A_1 culm	9.21; 9.21	33.11; 42.32	24.23; 66.55	26.76; 93.31	6.69; 100
7	A_2 sludge	–	–	–	41.56; 41.56	58.44; 100
8	A_3 sludge	–	–	5.87; 5.87	61.45; 67.32	32.68; 100
9	A_4 sludge	–	–	–	43.12; 43.12	56.88; 100
10	A_5 sludge	–	–	–	53.35; 53.35	46.65; 100
11	A_6 culm	5.3; 5.3	29.83; 35.13	28.2; 63.33	27.70; 90.03	9.97; 100
12	A_7 culm	12.82; 12.82	36.80; 49.62	27.5; 77.12	20.40; 97.52	2.48; 100
13	L_1 culm	15.21; 15.21	22.04; 37.25	27.23; 64.48	27.76; 92.24	7.76; 100
14	L_2 culm	3.25; 3.25	29.23; 32.48	37.75; 70.23	11.76; 81.99	18.01; 100
15	L_3 sludge	–	–	–	58.45; 58.45	41.55; 100
16	L_4 sludge	–	–	17.34; 17.34	61.48; 78.82	21.18; 100
17	L_5 sludge	–	–	17.65; 17.65	63.71; 81.31	18.69; 100
18	C_1 sludge	–	–	14.83; 14.83	51.20; 66.03	33.97; 100
19	C_2 sludge	–	–	5.46; 5.46	47.30; 52.76	47.24; 100
20	C_3 sludge	–	–	7.14; 7.14	57.23; 64.37	35.63; 100
21	C_4 sludge	–	–	9.40; 9.4	61.30; 70.7	29.30; 100
22	C_5 culm	5.52; 5.52	31.21; 36.73	26.87; 63.6	20.60; 84.2	15.80; 100
23	F_1 culm	12.46; 12.46	43.23; 55.69	23.38; 79.07	16.47; 95.54	4.46; 100
24	F_2 sludge	–	3.8; 3.8	37.12; 40.92	47.71; 88.63	11.37; 100
25	F_3 sludge	–	–	41.30; 41.3	35.70; 77.0	23.0; 100
26	F_4 sludge	–	6.55; 6.55	39.34; 45.89	48.12; 94.01	5.99; 100
27	F_5 sludge	–	5.98; 5.98	45.34; 51.32	35.50; 86.82	13.18; 100
28	G_1 sludge	–	13.67; 13.67	49.85; 63.52	25.44; 88.96	11.04; 100
29	G_2 sludge	–	15.85; 15.85	46.37; 62.22	15.35; 77.57	22.43; 100
30	G_3 culm	21.06; 21.06	18.61; 39.67	27.30; 66.97	21.11; 88.08	11.92; 100
31	G_4 culm	22.70; 22.7	24.90; 47.6	31.50; 79.1	11.50; 90.6	9.4; 100
32	G_5 culm	18.54; 18.54	31.53; 40.96	26.26; 67.22	21.90; 89.12	10.88; 100
33	LF_1 culm	24.47; 24.47	20.20; 44.67	16.60; 61.27	30.50; 91.77	8.23; 100
34	LF_2 sludge	–	6.30; 6.3	47.60; 53.9	19.60; 73.5	26.5; 100
35	LF_3 sludge	–	7.30; 7.3	40.10; 47.4	34.50; 81.9	18.1; 100
36	LF_4 sludge	–	2.90; 2.9	27.10; 30.0	59.70; 89.7	10.3; 100
37	LF_5 culm	19.89; 19.89	28.32; 48.21	18.12; 66.33	23.58; 89.91	10.09; 100
38	LF_6 culm	31.45; 31.45	21.37; 52.82	17.62; 70.44	16.87; 87.77	12.23; 100

Note * – *B, A, L, C, F, G, LF*, and Peat – brown, anthracite, lean, coking, fat, gaseous, and long-flame coals, respectively tics in a wide range, the segments on the x-axis in the area of small classes have a small range. This makes us develop large graphs that complicate the use of the obtained characteristics. Therefore, the total characteristics are made in a coordinate system with semilogarithmic or logarithmic scales. In the first case, these are not linear dimensions of the holes of the sieves *d* that are plotted on the x-axis, but *lgd*. The y-axis is left on a linear scale. In the second case, they change the scale of the ordinate, taking not the total yield $\sum\gamma$, but lg $\sum\gamma$. Advantages of semilogarithmic scale are as follows: in the area of small grains, the distances between adjacent values of sieve holes on the x-axis increase, and large ones decrease. This allows calculating the yield of small sizes using graphs correctly.

Despite their apparent difference, the total size characteristics can be described analytically. The Rosin-Rammler equation is often used

Table 3

Results of the study on the particle size distribution of solid fuel fractions samples less than 50 μm by sedimentation analysis

No.	Sample*	Diameter of the particles d, μm			Density, δ, g/cm^3	Particle sedimentation time *t*, s			Volumetric mass Δ, %		
		1	2	3		1	2	3	1	2	3
1	B1	40	30	10	1.29	88.91	158.1	1,422.5	30	67	3
2	B2	50	30	10	1.37	53.58	148.8	1,339.4	29	48	23
3	B3	50	35	15	1.33	55.19	112.7	613.7	37	36	27
4	Peat 1	45	25	10	0.75	120.8	391.5	2,446.7	41	50	9
5	Peat 2	45	25	10	0.92	98.5	319.1	1,994.6	38	55	7
6	A_1 culm	50	30	20	1.55	47.4	131.5	296.0	70	8	22
7	A_2 sludge	50	35	20	1.67	44.0	89.7	274.7	39	43	18
8	A_3 sludge	50	35	20	1.63	45.0	91.9	281.4	30	35	35
9	A_4 sludge	50	40	20	1.69	43.4	67.9	271.4	38	36	26
10	A_5 sludge	50	30	20	1.52	48.3	134.1	301.8	41	30	29
11	A_6 culm	50	30	20	1.50	48.9	135.9	305.8	45	26	29
12	A_7 culm	50	40	20	1.32	55.6	86.9	347,5	27	34	39
13	L_1 culm	45	25	15	1.27	71.4	231.2	642.2	43	45	12
14	L_2 culm	50	35	20	2.13	34.5	70.3	215.4	29	27	44
15	L_3 sludge	50	35	20	2.05	35.8	73.1	223.8	72	8	20
16	L_4 sludge	45	30	20	2.15	42.1	94.8	213.4	35	40	25
17	L_5 sludge	45	30	20	2.08	43.6	98.0	220.6	18	54	28
18	C_1 sludge	50	40	30	2.09	35.1	54.9	97.6	46	13	41
19	C_2 sludge	50	25	15	2.02	36.3	145.3	403.7	38	50	12
20	C_3 sludge	50	30	10	1.95	37.6	104.6	941.0	35	22	43
21	C_4 sludge	50	30	15	1.89	38.8	107.9	431.5	42	35	23
22	C_5 culm	50	25	15	1.98	37.1	148.3	411.9	39	30	21
23	F_1 culm	50	30	15	1.69	43.4	120.6	482.6	43	21	36
24	F_2 sludge	50	30	20	1.75	41.9	116.5	262.1	46	25	29
25	F_3 sludge	50	30	20	1.70	43.2	120.0	269.9	49	33	18
26	F_4 sludge	50	30	20	1.65	44.5	123.6	278.0	38	25	37
27	F_5 sludge	50	30	20	1.69	43.4	120.6	271.4	40	5	55
28	G_1 sludge	50	30	20	1.60	45.9	127.4	286.7	33	20	47
29	G_2 sludge	50	30	20	1.55	47.4	131.5	296.0	35	15	50
30	G_3 culm	50	25	15	1.56	47.1	188.2	522.8	31	34	35
31	G_4 culm	50	30	20	1.50	48.9	135.9	305.8	18	18	64
32	G_5 culm	50	30	20	1.58	46.5	129.0	290.3	15	71	14
33	LF_1 culm	50	40	20	1.54	47.7	74.5	297.9	45	31	24
34	LF_2 sludge	50	30	20	1.55	47.4	131.5	296.0	70	8	22
35	LF_3 sludge	50	35	20	1.67	44.0	89.7	274.7	39	43	18
36	LF_4 sludge	50	35	20	1.63	45.0	91.9	281.4	30	35	35
37	LF_5 culm	50	40	20	1.69	43.4	67.9	271.4	38	36	26
38	LF_6 culm	50	30	20	1.52	48.3	134.1	301.8	41	30	29

Note * – *B, A, L, C, F, G, LF*, and Peat – brown, anthracite, lean, coking, fat, gaseous, and long-flame coals, respectively

$$R = 100e^{-bd^n},$$

where R is the total yield of the size greater than d (residue on the sieve), %; b, n are parameters that depend on the properties of the material and dimension; d is the size of the sieve mesh.

The theoretical principle of selecting a mixture of particles of different sizes is to create a structural composition corresponding to the highest bulk density. In such a structure, the mass and volume ratio of grains can be quite fully characterized by an empirical equation

$$P = 100\sqrt{d/D},$$

where P is the proportion of grains (% by weight) passing through a sieve with a mesh diameter of d; d is the diameter of any grain of the mixture from 0 to D; D is the maximum diameter of the grain in the mixture.

Using this equation, it is possible to determine the relationship between R and d, the optimal upper size limit, the number of grains in any size, the specific surface area, and others. Knowing the values of these parameters, it is possible to choose the particle size distribution that provides the densest arrangement of grains in the mixture.

The specific surface area of the grains in the mixture determines the thin layer distribution and the structure of the binders, as well as the proportion of adsorption contacts. The higher the number of grains is, the more there are active centers – surface elements in which atoms with unoccupied valences are concentrated.

The density of the arrangement is closely related to the grain size. Small grains are more ribbed than large ones, and the heat of their wetting is about 4 times higher. The high content of large grains (more than 6 mm) has a negative effect on the strength of briquettes. During agglomeration, these particles are easily cracked. New surfaces uncoated with binder appear. The presence of dust particles leads to an increase in the specific surface area and, consequently, to an increase in the consumption of binders, which contributes to the compaction of briquettes due to the active filling of cavities.

The density of the briquettes is significantly affected by the hollowness of the structure. It is not important how tightly the solid grains are in the briquettes, and there are always pores between them. The number and size of cavities affect the strength of briquettes [19, 20]. In briquettes of fine-grained particles, the pores are small, and they are mostly filled with binder substances. Defects in the form of cavities are few, and the strength of the briquettes is high. Briquettes with a predominance of large grains have many defects, and layers of binder to fill the voids are insufficient. Therefore, these briquettes have low strength. To increase the strength, it is recommended to introduce into the briquette mixture dust particles that easily penetrate the cavity. Irregularities and roughness of the material positively affect the mechanical fixation of the binder, increasing the strength of briquettes.

The results of studies on 38 most representative samples carried out using sieve and sedimentation methods are listed in Tables 2 and 3, respectively.

It should be noted that the strength of briquettes is lower for a more homogeneous sieve composition. The homogeneous mixture does not ensure the arrangement's proper density. The grains are located with a significant number of cavities in the frame. The pressure during briquetting is unevenly distributed in the volume of the system. As a result, the briquettes are easily deformed.

Conclusions. According to the results of determining the particle size distribution of samples of carbonaceous raw materials, a feature for preparing solid fuels for the agglomeration process was established. The particles with sizes greater than 5-6 mm should be crushed further. In case of the inexpediency of further grinding, they should be processed (mixed) with special activating or increasing adhesive properties substances. Considering the particle size distribution of carbonaceous technogenic waste, it is possible to approach the process of composite fuel production with a more reasonable approach using different compositions of certain components.

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Встановлення гранулометричного складу техногенної сировини для отримання композиційного палива

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Мета. Визначення гранулометричного складу техногенної сировини для процесу згрудкування адгезійно-хімічним методом. Це дозволить встановити оптимальний гранулометричний склад для отримання готового згрудкованного палива, що має вигляд циліндричних стрижнів діаметром 30 мм і довжиною 50–200 мм.

Методика. Визначення гранулометричного складу техногенної сировини за допомогою ситового й седиментаційного аналізів. Досліджувалися 38 представницьких проб вуглецевмісних матеріалів.

Результати. Представлені результати ситового аналізу представницьких проб вугільних шламів і штибів, наведена їх графічна характеристика. Виконаний ситовий аналіз гранулометричного складу проб вуглецевмісної сировини та седиментаційний аналіз проб твердого палива фракції менше 50 мк. Установлено, що всі проби із класом крупності більше 5–6 мм повинні бути направлені на подальше подрібнення.

Наукова новизна. Уперше виконані дослідження й порівняльний аналіз гранулометричних складів техногенної сировини, що дозволяє обґрунтовано підійти до процесу виробництва композиційного палива з вуглецевмісних відходів адгезійно-хімічним методом, використовуючи різноманітні склади компонентів.

Практична значимість. Отримані результати можуть бути використані для направленої переробки техногенної сировини як з метою отримання згрудкованного палива заданих параметрів адгезійно-хімічним методом, так і для інших напрямів переробки, у тому числі для утилізації вуглецевмісних відходів різних виробництв.

Ключові слова: *гранулометричний склад, ситовий аналіз, седиментаційний аналіз, техногенна сировина, штиб, шлам, згрудковане паливо*

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