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IMPACT OF QUANTITATIVE AND QUALITATIVE DIFFERENTIATION OF FEED ON EFFECTIVENESS OF JIG BENEFICIATION PROCESS

1. Introduction

Preparation of feed for beneficiation machines used in a processing of hard coal is associated with proper blending of the material and regularity of its feeding to jigs, to their consecutive operational compartments.

Industrial experience shows many cases of incorrectness in feed preparation, what causes unwanted fluctuations in parameters of beneficiation products. Qualitatively irregular feeding to jigs is caused by lack of sufficiently effective solutions enabling realization of feeding across the width of operational trough, which, depending on a jig type, can be from 2 to 7 m [1, 4].

Dividers of feed stream from belt conveyors and classifying screens as well as from feeders used for that purpose enables even quantitative distribution. However, it does not ensure averaging as regards grains granulation and density. Use of new solutions in a node, where the feed is prepared and sent to a jig as well as adaptation of a jig to qualitatively irregular feeding can be the solution of this problem.

Industrial and laboratory tests are carried out to develop some changes in beneficiation technology and to implement new solutions increasing effectiveness of jig beneficiation of qualitatively unstable coal feed [2–4].

Results of laboratory tests of qualitative and quantitative impact of differentiation of feed on effectiveness of its separation in a pulsatory jig are given in the paper [4].

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2. Test stand

The experimental laboratory jig was developed for carrying out tests (Fig. 1). The stand was equipped with water recirculation system and it enabled overflow beneficiation with separation into two final products.

Fig. 1. Test stand for the laboratory jig [5]

Two separate, tandem pulsatory chambers, supplied with compressed air by two independent electronically controlled inlet disc valves and manually controlled throttle valves, which are installed between air surge chamber and the systems of disc valves, are used to induce water pulsatory flow in a jig operational chamber of dimensions 750 × 250 mm. Control of air outflow from air-and-water pulsatory chambers is realized by adjustment of inlet disc valves.

Intensity of air flow to the surge chamber is controlled by a valve installed between the surge chamber and blower. Manometer and electronic pressure converter are used to measure changes of pressure of operational air in a jig surge chamber.

The jig has a feed container of volume of about 0.06 m^3 and a system for products receive. Light product continuously flows over the operational chamber to the surface of fixed screen, while heavy product is periodically unloaded to the lock of a volume of 0.03 m^3 by manual control of block of discharge opening and after filling the lock it is discharged out of the lock. The lock of heavy product has two knife gate dampers, alternate opening of which enables periodical discharge of the product, maintaining constant level of water in operational chamber of a jig. Separate measuring and control systems in the recirculation hydraulic supply system are used to control intensity of lower water inflow to two pulsatory chambers and upper water inflow to the chute.

Control of parameters of water pulsatory movement is realized by change of settings in electronic system for control of operation of pneumatic cylinders of disc valves in their systems.

3. Testing method

The tests consisted in determination of relationship between quantitative-and-qualitative irregularity of coal feeding to the pulsatory jig and effectiveness of feed separation.

Raw coal of grain size 16–3 mm, in which the shares of size fractions of < 1.5, 1.5 — 1.8 and > 1.8 g/cm^3 density were respectively equal to 55.5, 8.9 and 35.6%, was the feed in the tests. The share of grain size 16–8 mm in the feed was equal to 34% and its gravimetric composition differed from the composition, which is characteristic for grains of size 8–3 mm what is shown in Table 1.

TABLE 1
Gravimetric composition of experimental feed [4]

Fraction density, [g/cm^3]	**Grain class, mm**		
	16–3	**16–8**	**8–3**
< 1.5	55.5	64.4	50.9
1.5–1.8	8.9	13.4	6.6
> 1.8	35.6	22.2	42.5
Total	100.0	100.0	100.0

In each test different method of feed distribution across the width of jig inlet was used, keeping other process parameters constant at the level which was set during the initial tests.

Qualitative and quantitative irregularity of the material at jig inlet was generated separately to:

- differentiate feed qualitatively as regards granulometric and gravimetric parameters, at quantitatively stable distribution on the surface of feeding chute,
- differentiate feed quantitatively across the width of the chute at its stable quality.

Differentiation of feed quality parameters was obtained by separation of grain size class 16–3 mm on a screen with meshes of diameter 8 mm. It enabled feeding the operational chamber with grains of class 16–8 mm and 8–3 mm separately on the left and on the right side with the same output.

Quantitative irregularity of feed was obtained by one-side feeding the operational chamber of the jig.

The beneficiation test, in which quantitative and qualitative distribution of feed was regular across the width of the chute, was carried out to compare the results obtained at stable feeding conditions.

All three above mentioned tests were carried out at the same load intensity.

4. Tests results

Assessment of quality of feed separation was made on the basis of yield of products and results of analyses of their gravimetric composition in heavy liquids of density1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 2.0 and 2.2 g/cm^3. Separation numbers were determined on the basis of analyses. Separation density ρ_{50}, Ecart Probable E_p and imperfection I, were determined for each test of jig beneficiation at different feeding methods.

Separation numbers for analyzed grain size classes 16–3 mm, 16–8 mm and 8–3 mm are given in Tables 2–4. Graphical presentation of tests results is showed in Figure 2–4.

TABLE 2
Separation numbers — Grain size 16–3 mm [4]

Fraction density, [g/cm^3]	Test 1	Test 2	Test 3
< 1.3	0.03	0.00	0.00
1.3–1.4	0.09	0.00	0.00
1.4–1.5	0.17	0.26	0.00
1.5–1.6	0.46	1.59	0.76
1.6–1.7	4.27	14.14	3.35
1.7–1.8	34.81	33.47	37.83
1.8–2.0	79.82	64.65	74.77
2.0–2.2	88.29	82.30	86.11
> 2.2	95.18	98.33	94.45

TABLE 3

Separation numbers — Grain size 16–8 mm [4]

Fraction density, [g/cm^3]	**Test 1**	**Test 2**	**Test 3**
< 1.3	0.03	0.00	0.00
1.3–1.4	0.09	0.00	0.00
1.4–1.5	0.17	0.26	0.00
1.5–1.6	0.46	1.59	0.76
1.6–1.7	4.27	14.14	3.35
1.7–1.8	34.81	33.47	37.83
1.8–2.0	79.82	64.65	74.77
2.0–2.2	88.29	82.30	86.11
> 2.2	95.18	98.33	94.45

TABLE 4

Separation numbers — Grain size 8–3 mm [4]

Fraction density, [g/cm^3]	**Test 1**	**Test 2**	**Test 3**
< 1.3	0.03	0.00	0.00
1.3–1.4	0.09	0.00	0.00
1.4–1.5	0.17	0.26	0.00
1.5–1.6	0.46	1.59	0.76
1.6–1.7	4.27	14.14	3.35
1.7–1.8	34.81	33.47	37.83
1.8–2.0	79.82	64.65	74.77
2.0–2.2	88.29	82.30	86.11
> 2.2	95.18	98.33	94.45

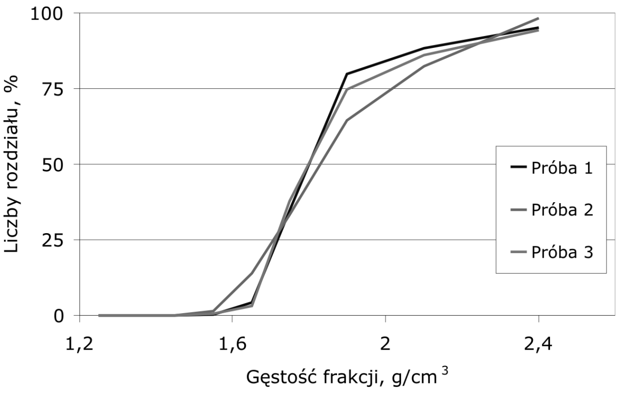

Fig. 2. Separation curves — Grain size 16–3 mm [4]

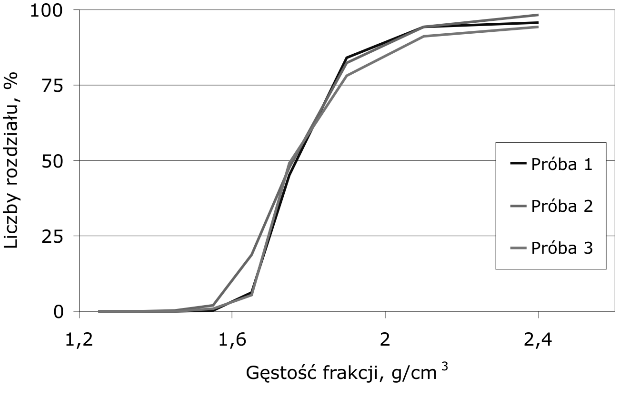

Fig. 3. Separation curves — Grain size 16–8 mm [4]

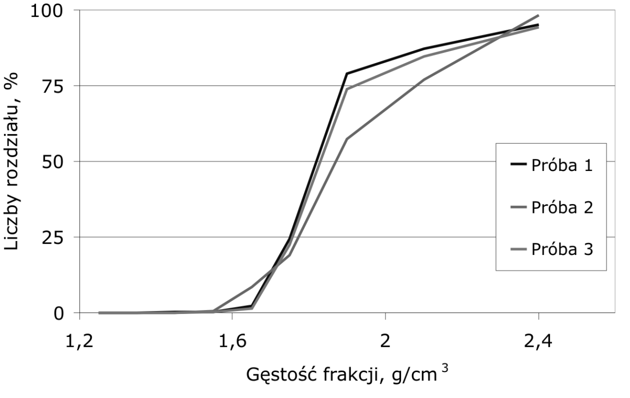

Fig. 4. Separation curves — Grain size 8–3 mm [4]

Basic parameters of separation process (indicators of beneficiation effectiveness) were determined on the basis of obtained separation numbers. Separation density ρ_{50}, Ecart Probable E_p and imperfection I, were calculated for each test and the results are presented in Table 5.

TABLE 5

Basic parameters of the process of feed separation [4]

Parameter	**Test 1**		
	16–3	**16–8**	**8–3**
Separation density ρ_{50}	1.801	1.773	1.819
Ecart Probable E_p	0.082	0.074	0.072
Imperfection I	0.102	0.095	0.088
Parameter	**Test 2**		
	16–3	**16–8**	**8–3**
Separation density ρ_{50}	1.832	1.761	1.885
Ecart Probable E_p	0.132	0.095	0.128
Imperfection I	0.159	0.125	0.145
Parameter	**Test 3**		
	16–3	**16–8**	**8–3**
Separation density ρ_{50}	1.810	1.778	1.836
Ecart Probable E_p	0.100	0.088	0.088
Imperfection I	0.124	0.113	0.106

Analysis of the results of separation of grain size class 16–3 mm showed that in the test 1 (proper feeding) the lowest separation density ρ_{50} = 1.801 g/cm^3 and the most advantageous (the lowest) Ecart Probable E_p = 0.082 and imperfection I = 0.102 were obtained.

In the test 2 (feeding at the half width of the inlet) the highest separation density ρ_{50} = 1.832 g/cm^3 and the least advantageous technological indicators E_p = 0.132, I = 0.159 were obtained.

In the test 3 (qualitative differences of feed across the width of the inlet), in comparison to the test 1, higher separation density ρ_{50} = 1.810 g/cm^3 and worse technological indicators E_p = 0.100, I = 0.124 were obtained.

Comparison of separation density of grain size classes 16–8 mm and 8–3 mm indicated that in the test 1 the values of separation density were smallest and respectively equal to 1.773 and 1.819 g/cm^3 as well as their difference was the smallest and equal to 0.046 g/cm^3.

The most disadvantageous separation was in the test 2, in which the values of separation density for analyzed grain classes were respectively equal to 1.761 and 1.885 g/cm^3 and a difference between them was the highest and equal to 0.124 g/cm^3.

In the test 3 a difference between the values of separation density of classes 16–8 and 8–3 mm was higher than in the test 1 and equal to 0.058 g/cm^3 and these values were respectively equal to 1.778 and 1.836 g/cm^3.

The laboratory tests confirmed the results of industrial tests, in which an impact of improper feeding the operational trough of the jig was analyzed [2, 4].

5. Summary

Decrease (worsening) of parameters of feed separation shows that irregular feeding of the pulsatory jig across the width of operational trough causes significant decrease of effectiveness of beneficiation process.

Assessment of impact of irregularity of feeding of the jig on effectiveness of beneficiation, which was made on the basis of obtained tests results, showed that quantitative irregularity of feeding across the width of the inlet at qualitatively stable feed decreases effectiveness of separation more than at differentiation in quality parameters.

Assurance of the quantitatively and qualitatively homogenous feeding across the width of pulsatory jig inlet is a condition to obtain high effectiveness of beneficiation of coal feed.

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