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Verification of flotation agents based on residues from pyrolysis of wood

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Abstract

The paper deals with the research in 2 newly prepared flotation agents based on residues from the pyrolysis of wood which are compared with commonly applied Montanol 551 collector. They are tested on the black-coal slurry samples from the Jankowice Mine in Poland, both in the laboratory as well as in pilot conditions. With respect to a significant financial demands of the commercial flotation agents, which are used in the Czech preparation plants, the newly prepared flotation agents are based on residues from the pyrolysis of wood, which are economically very interesting products. The research results imply that compared with the Belgian collector of Montanol 551, a collector labelled KOPD 11 is its very good substitute.

Key words: flotation agents, pyrolysis of wood, flotation

Introduction

Coal is a raw material mined for purposes of numerous industries, e.g. metallurgy, power-engineering, chemistry and many other branches. At the beginning of the 21st century, the global significance of coal for the civilization is universal.

Currently, mining of black coal is stagnating despite the fact that the consumption of industrial raw materials, the natural resources of which are not renewable and depletable by the human action, is increasing. The level of slump in the coal mining is dependent on the development of both international and national conditions. Another significant factor having an influence on this is the fulfilment of the international agreement on gradual reduction of the sulphur oxides released into the atmosphere. There is a question how to deal with the issues in connection with the slump in coal mining. One possibility is as perfect preparation of the mined coal as possible, as well as maximum utilization of its combustible component (Ralston et al., 2003).

This trend represents new objectives for mineral dressing – to prepare and comprehensively use the finest coal fractions that originate from the processes of black coal preparation. The created large share of slurry fractions cannot be processed applying classical dressing methods. Those fractions then leave the preparation plant unused, they get into the circuit water of waste water treatment plants, they deteriorate the processes of sedimentation, filtration, water courses get polluted and there are losses in the valuable raw materials as the coal slurries are dewatered in the sludge beds or lagoons and they remain unutilized.

Thanks to flotation as a technological method of dressing mineral resources and secondary raw materials it is possible to deal with an uneasy task of ensuring an effective, practical and complex utilization of the material sources. Flotation belongs among the methods which permit processing of the fine, non-homogeneous black--coal slurry (Kmeť, 1992).

Materials and methods

Flotation tests were implemented in the laboratory of the Institute of Environmental Engineering at VŠB-TU Ostrava, applying a laboratory flotation machine VRF-1, a product of RD Příbram. It is a pneumo-mechanical mixing flotation machine with an own air admission.

Flotation was carried out under the conditions below:

- feed density: 150 $g \cdot l^{-1}$
- sample grain-size: < 0.5 mm
- flotation agent dose: 500 $g \cdot t^{-1}$
- agitation time of pulp and flotation agent: 1 minute
- flotation time: 5 minutes

Pilot tests were carried out on a pilot flotation machine. It is a pneumo-mechanical mixing flotation machine with an own air admission.

Flotation was carried out under the conditions below:

- feed density: 1 800 $g \cdot l^{-1}$
- sample grain-size: < 0.5 mm,
- flotation agent dose: 2 000 $g \cdot t^{-1}$
- agitation time of pulp and flotation agent: 10 minute
- flotation time: 10 minutes

Fig. 1. Pilot flotation machine.

Fractional flotation was implemented. The laboratory flotation concentrates were sampled after the 1st, 2nd, 3rd and 5th minutes. The pilot flotation concentrates were sampled after the 2nd, 4th, 6th and 10th minutes. Having terminated flotation, the flotation concentrates and tailings were filtered in a pressure filter and dried in a drier at the temperature of 105 °C. The dried samples were weighed, quartered and an ash content analysis was carried out.

In total, 3 flotation agents based on residues from the pyrolysis of wood were tested (KOPD 3, KOPD 9, KOPD 11) and they were compared with a commonly applied collector of Montanol 551. All the flotation agents were tested on the black-coal slurry samples from Jankowice in Poland.

Characteristics of the applied flotation agents

Regarding the fact that producers do not state the chemical compositions of their flotation agents, the agents underwent IR spectroscopy which was implemented in the Central Analytical Laboratories of VŠB-TU Ostrava. The following flotation agents were used to test selectivity of the individual flotation collectors:

- **Montanol 551** – The IR spectra analysis implies the following composition of carboxylic compounds, aromatic and aliphatic hydrocarbons, alkenes, alcohols, phenols, glycols, esters, ethers and alkanes.
- **KOPDs** – These are flotation agents arising from the residues from the pyrolysis of wood during production of activated coal in SLZ CHÉMIA, a. s. (KOPD 9, KOPD 11). The producer declares the composition of carboxylic acids, alcohols, aliphatic hydrocarbons and water (Kušnierová et al., 2009).

Results and discussion

Both pilot and laboratory flotation tests of the lower rank black-coal slurries from the Jankowice Mine in Poland were carried out and compared. The coal from the Mine of Jankowice is of a lower quality and thus the ash contents are over 10 %, which is considered to be a limit for the quality coal. The flotation results are apparent from Tables below. First, the laboratory test results are presented, being followed by the pilot test results.

Fig. 2. Flotation froth in pilot flotation machine.

As apparent from Tab. 1 the collector of Montanol 551 shows very good selective properties. In the first two minutes of flotation, over 60 % floats out. The yield in the first flotation minute is about 19 %. The flotation time is optimal and the collector makes the coal easily treatable. See in Tab. 1.

In the case of the two following flotation tests using the KOPD 9 and KOPD 11 flotation agents (see Tabs. 2 and 3) an excellent ash content was obtained in the first concentrate, which was mere 18.48 % and a considerably high yield. The agent of KOPD 9 did not provide as high yield in the first minute, but in the second minute the total yield exceeded a 50 % level. It can be said that the newly prepared flotation agents are quality substitutes of Montanol 551.

Easy treatability of Montanol 551 on the Jankowice coal sample is clear from the Tab. 4. The ash content in the first two minutes ranges from 17 % to 36.4 % of the yield. Comparing with the ash content after four minutes, ash rises to 29.6 % and the yield drops to 45.8 %. It can be said that in the case of this agent the ideal flotation time is up to 2 minutes at the top yield.

Applying the agent of KOPD 11 (see Tab. 5) an easy treatability of the coal is apparent. A large yield in the first two minutes is obtained at prominent ash content and the following fast drop in the yield in the next minutes indicates the necessity to shorten the flotation time to 1 minute, which provides a higher quality flotation concentrate at a lower yield.

In the case of the agent of KOPD 9 a difficult treatability was identified in the same coal sample, which results

Tab. 1
Results of the laboratory flotation – Montanol 511

Fraction	time	Yield	Ash cont.	Ash abundance	Σ ash abundance	Σ ash yield	Aver. ash content	Σ ash abundance	Σ ash yield	Aver. ash content
	min.	%	%	$kg \cdot 10\ t^{-1}$	$kg \cdot 10\ t^{-1}$	%	%	$kg \cdot 10\ t^{-1}$	%	%
KL1	1	35.23	35.68	19.64	700.68	700.68	35.68	19.64	3 733.29	100.00
KL2	2	34.78	35.22	27.78	978.42	1 679.10	70.90	23.68	3 032.61	64.32
KL3	3	5.24	5.31	39.23	208.17	1 887.27	76.20	24.77	2 054.19	29.10
KL4	5	2.08	2.11	43.71	92.07	1 979.34	78.31	25.28	1 846.02	23.80
OL1	5	21.42	21.69	80.86	1 753.95	3 733.29	100.00	37.33	1 753.95	21.69
P	98.75	100.00	37.33	3 733.00						

Notes: K – concentrate, O – tailings, P – feed

Tab. 2
Results of the laboratory flotation – KOPD 11

Fraction	time	Yield	Ash cont.	Ash abundance	Σ ash abundance	Σ ash yield	Aver. ash content	Σ ash abundance	Σ ash yield	Aver. ash content
	min.	%	%	$kg \cdot 10\ t^{-1}$	$kg \cdot 10\ t^{-1}$	%	%	$kg \cdot 10\ t^{-1}$	%	%
KL5	1	83.29	55.99	18.48	1 034.62	1 034.62	55.99	18.48	3 419.84	100.00
KL6	2	17.28	11.62	28.97	336.49	1 371.11	67.60	20.28	2 385.22	44.01
KL7	3	10.64	7.15	30.38	217.28	1 588.39	74.75	21.25	2 048.73	32.40
KL8	5	6.68	4.49	37.97	170.49	1 758.88	79.24	22.20	1 831.45	25.25
OL9	5	30.88	20.76	80.02	1 660.96	3 419.84	100.00	34.20	1 660.96	20.76
P	148.77	100.00	34.20	3 420.00						

Notes: K – concentrate, O – tailings, P – feed

Tab. 3
Results of the laboratory flotation – KOPD 9

Fraction	time	Yield	Ash cont.	Ash abundance	Σ ash abundance	Σ ash yield	Aver. ash content	Σ ash abundance	Σ ash yield	Aver. ash content
	min.	%	%	$kg \cdot 10\ t^{-1}$	$kg \cdot 10\ t^{-1}$	%	%	$kg \cdot 10\ t^{-1}$	%	%
KL9	1	52.10	36.03	21.22	764.51	764.51	36.03	21.22	3 798.67	100.00
KL10	2	31.53	21.80	21.59	470.74	1 235.25	57.83	21.36	3 034.16	63.97
KL11	3	11.46	7.92	26.95	213.57	1 448.82	65.76	22.03	2 563.42	42.17
KL12	5	7.12	4.92	36.71	180.74	1 629.56	70.68	23.06	2 349.85	34.24
OL3	5	42.40	29.32	73.98	2 169.11	3 798.67	100.00	37.99	2 169.11	29.32
P	144.61	100.00	37.99	3 799.00						

Notes: K – concentrate, O – tailings, P – feed

Tab. 4
Results of the pilot flotation – Montanol 511

Fraction	time	Yield	Ash cont.	Ash abundance	Σ ash abundance	Σ ash yield	Aver. ash content	Σ ash abundance	Σ ash yield	Aver. ash content
	min.	%	%	$kg \cdot 10\ t^{-1}$	$kg \cdot 10\ t^{-1}$	%	%	$kg \cdot 10\ t^{-1}$	%	%
KP1	< 2	36.4	17.0	617.3	617.3	36.4	17.0	3 343.1	100.0	33.4
KP2	2 – 4	45.8	29.6	1 357.1	1 974.4	82.2	24.0	2 725.7	63.6	42.9
KP3	4 – 6	3.7	66.2	244.9	2 219.3	85.9	25.8	1 368.7	17.8	76.9
KP4	6 – 10	1.6	74.6	119.3	2 338.6	87.6	26.7	1 123.8	14.1	79.7
OP1	> 10	12.4	81.0	1 004.5	3 343.1	100.0	33.4	1 004.5	12.4	81.0
P	100.0	3 343.1								

Notes: K – concentrate, O – tailings, P – feed

Tab. 5
Results of the pilot flotation – KOPD 11

Fraction	time	Yield	Ash cont.	Ash abundance	Σ ash abundance	Σ ash yield	Aver. ash content	Σ ash abundance	Σ ash yield	Aver. ash content
	min.	%	%	kg · 10 t^{-1}	kg · 10 t^{-1}	%	%	kg · 10 t^{-1}	%	%
KP5	< 2	51.0	20.8	1 060.8	1 060.8	51.0	20.8	3 763.3	100.0	37.6
KP6	2 – 4	18.5	33.1	612.4	1 673.2	69.5	24.1	2 702.5	49.0	55.2
KP7	4 – 6	5.5	41.1	226.1	1 899.3	75.0	25.3	2 090.1	30.5	68.5
KP8	6 – 10	3.0	59.6	178.8	2 078.1	78.0	26.6	1 864.0	25.0	74.6
OP2	> 10	22.0	76.6	1 685.2	3 763.3	100.0	376.3	1 685.2	22.0	76.6
P	100.0	3 763.3								

Notes: K – concentrate, O – tailings, P – feed

Tab. 6
Results of the pilot flotation – KOPD 9

Fraction	time	Yield	Ash cont.	Ash abundance	Σ ash abundance	Σ ash yield	Aver. ash content	Σ ash abundance	Σ ash yield	Aver. ash content
	min.	%	%	kg · 10 t^{-1}	kg · 10 t^{-1}	%	%	kg · 10 t^{-1}	%	%
KP9	< 2	28.9	14.9	430.6	430.6	28.9	14.9	3 941.7	100.0	39.4
KP10	2 – 4	13.0	20.7	269.1	699.7	41.9	16.7	3 511.1	71.1	49.4
KP11	4 – 6	7.3	29.6	216.1	915.8	49.2	18.6	3 242.0	58.1	55.8
KP12	6 – 10	7.3	39.1	285.4	1 201.2	56.5	21.3	3 025.9	50.8	59.6
OP3	> 10	43.5	63.0	2 740.5	3 941.7	100.0	39.4	2 740.5	43.5	63.0
P	100.0	3 941.7								

Notes: K – concentrate, O – tailings, P – feed

in a low recovery with a high ash content in all the sampling periods. See in Tab. 6.

Conclusion

It is apparent from the flotation experiments that all the examined agents may be used in the flotation of the black coal. The application of the flotation agents prior to their introduction into the preparation process requires further testing in the pilot flotation machines in the practice. The tests partially differ from those carried out in the laboratory conditions. Another argument to support further efforts to make use of KOPD flotation agents is a high price of the collector of Montanol 551, which may become one reason why the flotation agents of KOPD 9 and KOPD 11 could be used in the Czech preparation plants. Despite clearly higher costs when compared with other preparation methods, flotation still remains the highest quality option how to separate fine fractions.

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