Semi-industrial dewatering tests of flotation products in filter presses
Badania półtechniczne odwadniania w prasach filtracyjnych produktów węzła flotacji

M. Lenartowicz, B. Piechaczek, G. Gruszka, A. Pyc
PROREM sp. z o.o., ul. Energetyków 7, 44-330 Jastrzębie-Zdrój
e-mail: mlenartowicz@prorem.pl, bpiechaczek@prorem.pl

Abstract

This paper presents the results of semi-industrial filtration tests carried out by PROREM and Bilfinger Water Technologies on all products of coking coal flotation. The aim of the tests, carried out using a DIEMME Filtration® pilot plant, was to evaluate the possibility and efficiency of using pressure filtration for each specific flotation product. The tests confirmed that horizontal filter presses are perfectly suited for this application.

Keywords: filtration, solid-liquid separation, dewatering, filter press, flotation

Streszczenie

Artykuł przedstawia wyniki półprzemysłowych badań odwadniania wszystkich produktów flotacji węgla koksującego przeprowadzonych przez firmy PROREM i Bilfinger Water Technologies. Celem prób – wykonanych przy pomocy półprzemysłowej prasy filtracyjnej DIEMME Filtration® – była ocena możliwości i skuteczności zastosowania filtracji ciśnieniowej do odwadniania każdego z produktów pochodzących z flotacji. Wykonane próby wykazały, że poziome prasy filtracyjne idealnie sprawdzają się w tego typu zastosowaniach.

Słowa kluczowe: filtracja, rozdział frakcji, odwadnianie, prasa filtracyjna, flotacja

1. Introduction

Coal particles below 0.5 mm result from mining and their content in run-of-mine coal can reach up to 25% [2, 4, 6]. Moreover these particles are also produced during transportation and various beneficiation processes. Prep plants in Poland usually beneficiate coal particles below 0.5 mm using flotation [7, 13, 14].

Flotating coking coal -0.5 mm results in two products which need to be dewatered: flotation concentrate and flotation tailings. The concentrate can be dewatered in a two-stage process using vacuum disc filters (e.g. FTB, FTC, FTPD types) and thermal drum dryers [1, 5, 10] or in a single-step system using screen-bowl centrifuges [1, 5, 10]. The use of screen-bowl centrifuges to dewater coking coal flotation concentrate has led to the production of the so-called sediment, i.e. ultra-fine particles present in the effluent from the bowl part of the centrifuges. Sediment – being a product of centrifuges dewatering clean coking coal – can be classified as clean coal having commercial value as well. One of the ways to dewater this product is through using pressure filtration in chamber-membrane filter presses [12].

Flotation tailings – after thickening – are usually dewatered using pressure filtration in chamber filter presses [3, 9, 11].

As mentioned previously coking coal flotation concentrate is dewatered using vacuum disc filters and dryers or screen-bowl centrifuges. These both solutions have their disadvantages. In case of vacuum disc filters followed by thermal drum dryers it is the negative impact on the environment (emissions from the dryers), while in case of screen-bowl centrifuges it is the production of another product which requires dewatering [5]. An alternative in the dewatering of the concentrate is using filter presses [12].

This paper covers semi-industrial dewatering tests of flotation products in filter presses. The aim of the filtration tests was to find the optimal filter presses for the dewatering of flotation concentrate, sediment and flotation tailings.

2. Semi-industrial tests

2.1 Test equipment

The tests were carried out using equipment (fig. 1) comprising of:

Filter press feeding membrane pump: 15 bar, max. delivery: 1.5 m^3/h;

- Fibre glass feeding tank with an agitator, heater and temperature control;
- Chamber-membrane filter press (total filtration area 1.86–1.92 m^2; volume 19.5–36.9 l);
- Volumetric compressor for membrane squeezing and cake blowing.

Fig. 1. Test equipment [8]

2.2 Test products

The tests were carried out at a coal prep plant which beneficiates gas-coking coal type 34. The products tested were flotation concentrate, sediment and tailings. The feed to the filter press was collected from the respective production lines during normal operation of the plant.

3. Test results

3.1 Flotation concentrate

Table 1 shows the characteristics of the tested flotation concentrate [8]. The tests were carried out using chamber-membrane plates with the chamber thickness 50 mm. Table 2 shows the results of the tests [8].

Tab. 1 Flotation concentrate characteristics [8]

pH	7.5
Slurry specific weight (kg/dm^3)	1.116
Concentration (g/l)	390
Mass content [%]	35.2

Tab. 2 Test results [8]

Test no.			1	2	3
general information	filtration area	m^2	0.008	0.008	0.008
	filtration temperature	°C	ambient	ambient	ambient
feeding	feeding pressure	bar	6	6	6
cake washing	washing solution		0	0	0
	washing temperature	°C	0	0	0
	washing pressure	bar	0	0	0
cake blowing	blowing pressure	bar	7	7	7
membrane squeezing	squeezing pressure	bar	13	13	13
cake characteristics	filtrate quality		opalescent	opalescent	opalescent
	cake quality		compact	compact	compact
	cake dryness	% (105°C)	78.9	79.5	74.5
	cake moisture	% (105°C)	21.1	20.5	25.5

Three filtration tests were carried out on flotation concentrate using chamber-membrane filter presses. The constant parameters were: feeding pressure, cake blowing pressure and membrane squeezing pressure. The variables were cake blowing time and air consumption. The tests were compared through the analysis of the cake moisture content. The obtained cake residual moisture results varied from 20.5% to 25.5%.

3.2 Sediment

Table 3 shows the characteristics of the tested sediment [8]. The tests were carried out using chamber-membrane plates with the chamber thickness 50 mm (tests 1, 2) and chamber plates with the chamber thickness 35 mm (test 3). Table 4 shows the results of the tests [8].

Tab. 3 Sediment characteristics [8]

pH	7.3
Slurry specific weight (kg/dm^3)	1.044
Concentration (g/l)	104
Mass content [%]	10.0

Tab. 4 Test results [8]

Test no.			1	2	3
general information	filtration area	m^2	0.008	0.008	0.016
	filtration temperature	°C	ambient	ambient	ambient
feeding	feeding pressure	bar	6	6	13
cake washing	washing solution		0	0	0
	washing temperature	°C	0	0	0
	washing pressure	bar	0	0	0
cake blowing	blowing pressure	bar	7	7	0
membrane squeezing	squeezing pressure	bar	13	13	0
cake characteristics	filtrate quality		opalescent	opalescent	opalescent
	cake quality		compact	compact	compact
	cake dryness	% (105°C)	69.6	74.8	68.8
	cake moisture	% (105°C)	30.4	25.2	31.2

In order to analyse the filter cake residual moisture three tests were performed. In case of tests 1 and 2 where chamber-membrane filter plates were used the constant parameters were: feeding pressure, cake blowing pressure and membrane squeezing pressure, while cake blowing time and air consumption varied. The obtained cake residual moisture results varied from 25.2% to 30.4%.

In order to evaluate what level of cake residual moisture can be achieved using chamber plates test 3 was executed. The filter press was fed at 13 bar. The obtained residual moisture was 31.2%. Comparing this value with the best one obtained during tests with chamber-membrane plates the cake residual moisture increased by 6 percentage points (from 25.2 to 31.2%).

3.3 Flotation tailings

Table 5 shows the characteristics of the tested flotation tailings [8]. The tests were carried out using chamber plates with the chamber thickness 25 mm (tests 1, 2) and chamber-membrane plates with the chamber thickness 40 mm (test 3). Table 6 shows the results of the tests [8].

Tab. 5 Flotation tailings characteristics [8]

pH	–
Slurry specific weight (kg/dm^3)	1.260
Concentration (g/l)	500
Mass content [%]	39.7

In order to analyse the filter cake residual moisture three tests were performed. The obtained cake residual moisture results ranged from 21% to 22.5% and depended on the filtration process parameters set. In case of tests 1 and 2 – in which chamber plates were used – increasing the feeding pressure from 10 bar to 14 bar resulted in the drop of cake residual moisture by 0.5 percentage point (from 22.5 to 22%).

In order to evaluate what level of cake residual moisture can be achieved using chamber-membrane plates test 3 was executed. For this test the feeding pressure was 7 bar and the membrane squeezing pressure was 15 bar. The obtained cake residual moisture was 21%. Comparing this value with the best one obtained during tests with chamber plates the cake residual moisture decreased by 1 percentage point (from 22 to 21%).

Tab. 6 Test results [8]

Test no.			1	2	3
general information	filtration area	m^2	0.016	0.016	0.008
	filtration temperature	°C	ambient	ambient	ambient
feeding	feeding pressure	bar	10	14	7
cake washing	washing solution		0	0	0
	washing temperature	°C	0	0	0
	washing pressure	bar	0	0	0
cake blowing	blowing pressure	bar	0	0	0
membrane squeezing	squeezing pressure	bar	0	0	15
cake characteristics	filtrate quality		limpid	limpid	opalescent
	cake quality		compact	compact	compact
	cake dryness	% (105°C)	77.5	78	79
	cake moisture	% (105°C)	22.5	22	21

4. Summary

The article presented the results of completed semi-industrial tests of dewatering in pressure filter presses of flotation products, i.e. flotation concentrate, sediment and tailings.

The tests were performed using a semi-industrial scale filter press allowing to carry out the tests in the actual working conditions on site. Both chamber and chamber-membrane plates were used in the tests.

All the tests and their efficiency were evaluated on the grounds of the final cake residual moisture obtained.

The aim of the semi-industrial tests was the evaluation of the possibility to utilise filter presses for the dewatering of flotation concentrate and sediment as well as sizing of the optimal filter presses and process parameters for the flotation tailings dewatering process.

Results obtained in the tests have confirmed that filter presses can be successfully used to dewater flotation concentrate.

The lowest filter cake residual moisture in case of coking coal flotation concentrate was achieved when using chamber-membrane filter plates with the following process parameters: feeding pressure 6 bar, cake blowing pressure 7 bar, membrane squeezing pressure 13 bar, squeezing and blowing time 6 minutes.

The tests have also confirmed that filter presses can be applied in the dewatering of sediment in which particles sub-25 μm constitute over 90% [8].

The best results were achieved when the product was dewatered using chamber-membrane plates and the following process parameters (test 2): feeding pressure 6 bar, cake blowing pressure 7 bar, membrane squeezing pressure 13 bar as well as double amount of blowing air and membrane squeezing time compared with test 1.

In case of flotation tailings dewatering it is typical to dewater it using pressure filter presses equipped with chamber plates. For comparative reasons the tests saw the application of both chamber and chamber-membrane plates. The lowest filter cake residual moisture value was obtained with chamber-membrane plates and the following test parameters: feeding pressure 7 bar, membrane squeezing pressure 15 bar.

Application of chamber-membrane filter presses to dewater flotation tailings can be justified when it is needed to increase the productivity of the tailings dewatering station (shorter filtration cycle time).

References

1. Aleksa H.: Stan i kierunki rozwoju technologii odwadniania koncentratów węglowych. Przegląd Górniczy nr 9, 2005. pp. 44–51.
2. Blaschke Z.: Wzbogacanie węgla kamiennego w Polsce. Inżynieria Mineralna, styczeń–czerwiec 2001.
3. Concha F.A.: Solid-Liquid Separation in the Mining Industry. Springer International Publishing Switzerland 2014.
4. Dubiński J., Turek M., Aleksa H.: Postęp w technologii i technice przeróbki mechanicznej węgla w polskich kopalniach. Innowacyjne Systemy Przeróbcze Surowców Mineralnych. CMG KOMAG KOMEKO 2006.
5. Giemza H., Gruszka G., Hycnar J. J., Józefiak T., Kiermaszek K., Pyc A.: Innowacyjne kierunki optymalizacji obiegów wodnych dla wydzielania i wykorzystania „sedymentów" w ZMPW Jastrzębskiej Spółki Węglowej SA KOMEKO 2008. pp.171–182.
6. Janik J., Janik K., Janik T.: Nowa technologia urabiania węgla. Zeszyty Naukowe Politechniki Śląskiej. Górnictwo z. 246, Gliwice 2000.
7. Lenartowicz M.: Aktywność flotacyjna węgla w korytowej pneumomechanicznej maszynie flotacyjnej w funkcji napięcia powierzchniowego zwilżania. Praca doktorska. Katowice, GIG 2007.
8. PROREM sp. z o.o. own materials.
9. Nowak Z.: Gospodarka wodno-mułowa w zakładach przeróbki mechanicznej węgla. Wydawnictwo Śląsk, Katowice 1982.
10. Pawlica M., Korcz Ł., Niemirowski J., Szeja W.: Filtracja wirowa zawiesiny zrzutowej po odwodnieniu flotokoncentratu na wirówkach BIRD'a. Karbo 2007, nr 1 pp. 57–62.
11. Piechaczek B., Lenartowicz M., Gruszka G., Pyc A., Kaczmarczyk H.: Zwiększenie wydajności stacji odwadniania odpadów flotacyjnych poprzez zastosowanie nowoczesnej prasy filtracyjnej. Innowacyjne i przyjazne dla środowiska techniki i technologie przeróbki surowców mineralnych. Bezpieczeństwo-Jakość-Efektywność, Instytut Techniki Górniczej KOMAG, Gliwice 2014 pp. 219–231.
12. Pyc A., Giemza H., Gruszka G., Lenartowicz M.: Odwadnianie flotokoncentratu węgla koksowego w prasach filtracyjnych komorowo–membranowych. Gór. Geol. 2011 nr 2 pp. 181–188.
13. Sablik J.: Flotacja węgli kamiennych. Główny Instytut Górnictwa. Katowice 1998.
14. Sablik J., Lenartowicz M.: Energetyczne właściwości powierzchniowe ziaren w produktach przemysłowej flotacji węgla. Prace Naukowe CMG KOMAG – Monografie, Gliwice 2007.