

## NEW IMPLEMENTATIONS OF KOMAG JIGS FOR COKING AND STEAM COAL IN COLLABORATION WITH CARBO-ECO AND FUGOR COMPANIES

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### **Abstract:**

The basic process of minerals' mechanical preparation, including coal, is a beneficiation process which has a decisive impact on quantitative-and-qualitative parameters of commercial products. At present the products of the MBE-CMT, Allmineral and Tenova companies have big market shares as regards foreign water pulsatory jigs, as well as ITG KOMAG on the local Polish market. New implementations of jigs, developed at the KOMAG Institute of Mining Technology, for beneficiation of coking coal and steam coal in collaboration with Carbo-Eco Ltd. and Fugor Ltd. companies, were realized in 2019. Technical and technological parameters of new devices are described in the article. Supply systems of feed are presented as well as the method of collecting tailings and middlings. New design solutions, applied in modernized preparation plants, aimed at an improvement of jigs production capacity and efficiency are presented. In the case of each jig, after its activation and conducted adjusting processes, exact tests of a beneficiation efficiency were performed and their results are presented in the tabular form. Basic beneficiation accuracy indicators and parameters of products' separation as well as balances of products are given. The test results, obtained from newly activated jigs, are discussed.

**Key words:** *beneficiation process, hard coal, jig*

### **INTRODUCTION**

A beneficiation of hard coal is an integral and extremely important part of a production process of commercial assortments aimed at a quality increase of extracted mineral and at reaching qualitative-and-quantitative parameters of products required by purchasers.

An improvement of coal quality is achieved due to conducting a series of technological processes, among others, a beneficiation in pulsatory jigs [1, 15].

The solution of selected jigs, designed at the KOMAG Institute of Mining Technology, implemented in 2019 for a beneficiation of hard coal, are presented in the article. Special attention is paid to the parameters and state-of-the-art solutions of the OM fines pulsatory jigs for steam and coking coal.

### **LITERATURE REVIEW**

Pulsatory jigs are basic devices for a beneficiation of hard coal in Polish mechanical preparation plants. A elaboration of the first designs of jigs was started at KOMAG in 1955.

It was the equipment, having two air chambers situated beside the working trough, along the jig axis [20, 24, 26, 29]. The following jigs were designed:

- OBM (fines pistonless jig),
- ODM (fines double – trough pistonless jig),
- OBZ (grain pistonless jig).

The jigs were characterized by considerable dimensions and a big weight. In the seventies of the last century the jigs, having air chambers under the sieve deck, installed in bottom boxes transversely to the jig longitudinal axis [2, 26], started to be designed at KOMAG.

At present jigs for a beneficiation of different grain classes, including fines jigs – OM (Fig. 1 and 2) for the grains 20-0(0.5) mm, medium-size grain jigs – OS designed for the grains 80(50)-0(0.5) mm, and the grain jigs – OZ for grains 120-20 mm are constructed at the KOMAG Institute.



**Fig. 1** Two pulsatory jigs OM15, ZG "Sobieski"  
Source: [33].



**Fig. 2** OM24 jig, "Borynia-Zofiówka" Mine, Zofiówka Branch  
Source: [33].

Their design is modernized continuously, according to users' expectations both in the aspect of the shape geometry of bottom boxes, fixing of sieve decks, an improvement of automatic adjustment of heavy products' collection, pulsatory valves and of working air collectors [21, 22, 23].

At present the products of the MBE-CMT (Batac-Jig), All-mineral (ALLJIG) and Tenova (APIC-Jig) companies have big market shares as regards foreign water pulsatory jigs. The above mentioned jigs are used in beneficiation processes of coal and metal as feeds. In relation to the kind and parameters of the raw material to be beneficiated (mainly the scope of grain sizes), each of the producers offers appropriate types of jigs which often differ in air flow control system to pulsatory chambers, using different types of valves.

The systems of pulsatory air distribution in water jigs, due to their impact on shaping the required water pulsation curve, are subject to a continuous improvement process in parallel with a development of the drives' technology and an elaboration of new materials, to a bigger extent than the other jig assemblies. As each of the three jig producers uses different design and construction solutions of pulsatory valves, so each of them is discussed separately [3].

The BATAc jigs have under-the-sieves working chambers positioned longitudinally, an electronic pulsation control and an electrohydraulic adjustment of the products' collection. In relation to grain sizes in the feed, the distribution systems of pulsatory air use pneumatically supplied disk valves or oscillatory (butterfly type) ones [31].

In the ALLJIG jigs rotary valves are used for supplying compressed air to the equipment with side chambers in the process of beneficiating and cleaning aggregates.

However, in the case of the jigs with under-the-sieves working chambers disk valves are used [30] for a beneficiation of coal feeds and of metal ores.

In the APIC jigs the electronic JigScan system, elaborated in 1986 by the JKMRC Company is used. It controls the flow by an adjustment of the oscillatory valves operation [19, 32, 34] on the base of measurements of air pressure in the working chamber, as well as in the retarding and outlet reservoir.

A review of pulsatory jigs' designs was conducted on the basis of information presented in advertising materials and on the producers' web-sites.

#### OPERATIONAL PRINCIPLE OF PULSATORY JIGS

A beneficiation in jigs consists in using the in-water falling speed of grains, having different densities. The material, under beneficiation, is subject to cyclic loosening in the pulsatory water environment which causes its stratification and transport on the surface of sieve deck in the direction of the zone of beneficiated products' separation. Initially prepared mixture of hard coal grains, conducted to the working box, is subject to a pulsation in the water environment on sieve decks in the following working compartments of the jig. A stratification of material is realized due to a movement of water in the working chamber [11], using e.g. compressed air. When the water moves towards the top, the material on the sieve is raised and it falls down onto the sieve deck.

Subjecting the material to numerous pulsations enables to divide it into layers, from the grains with the biggest speed of falling down, situated on the sieve deck to the grains with the smallest speed of falling down, raised to the surface of the material under beneficiation. Separated material moves continuously in the direction of the separation zone, at the end of the jig working compartment [11].

Basing on measurement and control signals of beneficiation products collecting systems, a separation of the material for the top product (concentrate), which moves over the overflow threshold, ending a single jig compartment and the bottom product (tailings) conducted through the collecting channel, situated below the sieve deck, in the system of collecting products [2], is realized.

#### IMPLEMENTATION OF STATE-OF-THE-ART JIGS OF KOMAG TYPE

An implementation of jigs for steam and coking coal, designed at the KOMAG Institute and commissioned in 2019, is presented in the examples given below.

### ZG "Sobieski" Coal Mechanical Preparation Plant – steam coal

A design of jigs for the ZG "Sobieski" Coal Mechanical Preparation Plant was elaborated at the KOMAG Institute of Mining Technology in 2018. New three-product jigs OM15L and OM15P were produced by Fugor Ltd. They replaced two worked out Allmineral jigs.

The commissioning, at a participation of KOMAG researchers, was performed by the Carbo-Eco Ltd. in two stages to ensure the Plant production continuity.

A two-stage approach consisted in a disassembly of one Allmineral jig and in its exchange for a new one of KOMAG type and then of the other one, which was operated during the exchange period. In the first half of 2019 the OM15L jig (so called "grey system") was started and in the other half of 2019 the OM15P jig (so called "green system") was started (Fig. 3).

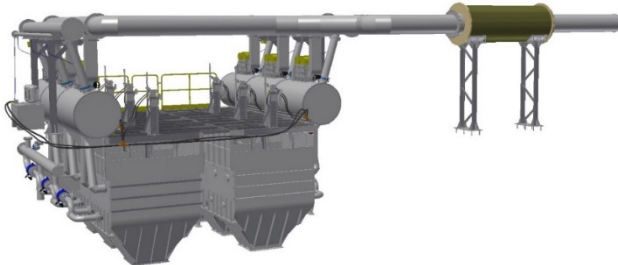


Fig. 3 ZG "Sobieski" OM15L and OM15P jigs  
Source: [25].

A modernization of the ZG "Sobieski" Mechanical Preparation Plant consisted in an adaptation of the Plant to a three-product beneficiation of assortments: Pea Coal, Jaret and Fines and a possibility of increasing the fines beneficiation node loading to 16000 t/d of gross weight.

#### Supply of feed to OM15 jigs

Raw material from the surge tank is collected with belt feeders equipped with new technological scales and directed to new vibratory screens WZL1 2.8 x 6.0 (Fig. 4) of sieve decks having the slot  $s = 2$  mm, equipped with water sprays.

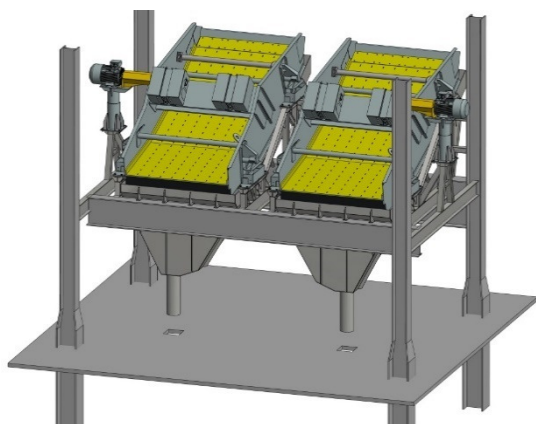


Fig. 4 An installation of desludging screens WZL1 2.8 x 6.0 before ZG "Sobieski" OM15 jigs  
Source: [25].

A separation of the feed onto two grain classes: top product 30-2 mm, which is directed for a beneficiation to new three-product jigs OM15L and OM15P and the bottom product, which together with water is directed to the tank of technological-and suspension water system, is carried out on vibratory desludging screens (WZL1).

#### Three-product beneficiation of grain class 30-2 mm in OM15 fines jig

A new beneficiation node (Fig. 3) consists of two fines jigs OM15L and OM15P (30-2 mm), of maximal capacity up to 320 t/h each. The decks of slotted sieves  $s = 5$  mm are installed in them. The working components were shortened to 2200 mm in the jigs due to too small space at the installation site, at the cost of a shorter collecting system of products.

A pulsatory motion is generated in the jig by an action of compressed air onto the water level, delivered by new Aezen blowers of absolute pressure about 0.4 bar. The jigs consist of three compartments, in two first ones tailings is separated and in the last one – middlings is separated. In the beneficiation process, in the OM15L and OM15P fines jigs, three products are obtained:

- concentrate – collected from the jig together with water through the overflow threshold of the last compartment and it is directed for dewatering to the system of stationary dewatering slotted sieves of the slot  $s = 2$  mm, on the existing PWE2 screens. It is a two-deck screen, in which the bottom deck is made of slotted sieves of the slot  $s = 2$  mm, but the top one has the sieves slot 25 mm,
- middlings – raised and dewatered by the existing bucket conveyor B-800 (Fig. 5) and next by the belt conveyor and the screen directed to the UP 1000x1000 crusher. The crusher material and the screen between-the-sieves product (6-2 mm) can be subject to a secondary beneficiation in the OM15L and OM15P jigs to regain coal grains from the middlings, so called concretions,
- tailings – raised and dewatered with use of a new bucket conveyor B-1000 (Fig. 5) of the capacity up to 250 t/h.



Fig. 5 ZG "Sobieski" bucket conveyors  
Source: [33].

### Coal Mechanical Preparation Plant "Borynia-Zofiówka" Mine, Zofiówka Branch – coking coal

A design of a jig for the Coal Mechanical Preparation Plant of the "Zofiówka" Mine was developed at the KOMAG Institute of Mining Technology in 2018. After having produced the equipment by the Fugor Ltd., in the second half of 2019, the Carbo-Eco Ltd. commissioned the modernized beneficiation system. A new beneficiation node (Fig. 6) consists of the single trough fines jig OM24 (20-2 mm), of capacity up to 640 t/h, which replaced a double trough three-compartment jig OM 24D3E.

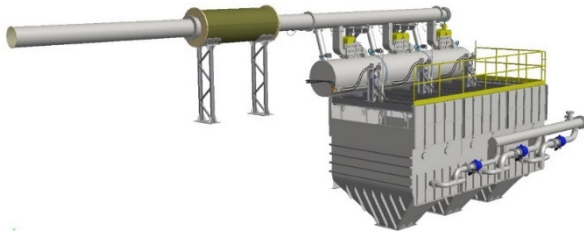


Fig. 6 OM24 fines jig, Zofiówka Mine

Source: [25].

A deck, made of perforated sieves Lv 25 x 5, was used in it. It was the first application of the Polish design jig having the working trough width of 3500 mm.

Raw fines (20-2 mm), obtained in the result of the initial classification on the PZ2275 screens (4 devices), is the feed for all the jig systems. Total feed load of worked out jigs reached 5000 t/d, at about 20 h/d of their operation. A new jig enables to increase the load up to 12000 t/d. Tailings from the jig is dewatered in the B-1000 bucket conveyor and middlings, after its dewatering in the B-800 bucket conveyor (Fig. 5), is connected on the belt conveyor and subject to additional dewatering on the WP 1.5 x 2.5 screen. The dewatered, above mentioned product is used for generating energy mixes.

The concentrate product is directed to a common trough, from which it is directed to two dewatering systems, consisting of five OSO 2400 sieves and of one OSO 3200 sieve as well as of six sieve centrifuges (2 devices of WOW 1.3, 2 devices of HSG 1200, 2 devices of HES 1300).

An innovative solution of the jig feeding boxes, with an overflow trough and the spray improving a uniform distribution of the material before the jig and a better use of the working bed (Fig. 7) was applied in the modernized beneficiation system.

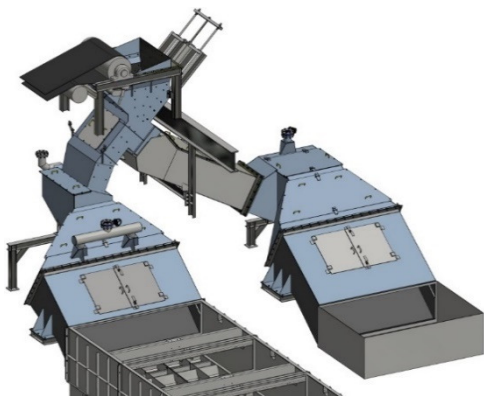


Fig. 7 System of feed supply to OM24 jig

Source: [23].

### METHODS

To obtain the material for laboratory analyses some raw coal samples (feed) and beneficiation products samples, separately for both types of coal, were taken.

#### ZG "Sobieski" – steam coal

The feed samples were taken from the outlets of the WZL1 screens directing the material to the working troughs of jigs. Due to lack of access to overflow thresholds of the jigs, the concentrate product was sampled on the collecting chutes of the classification products of the PWP2 2.5 x 5.25 screens, however middlings and tailings were taken from the discharge of bucket conveyors. Due to the fact that both middlings as well as tailings are collected (dewatered) from both jigs by common bucket conveyors, combined middlings and tailings were taken for tests.

The material from coal dumps was the feed for jigs during a process of taking samples. During a collection of samples periodic, short-lasting stops of the feed occurred.

#### Borynia-Zofiówka Mine, Zofiówka Branch – coking coal

The feed was taken from the belt conveyor supplying the feed to the chute installed on the jig inlet. To concentrate product was collected along the whole length of the third compartment overflow threshold.

Middlings was sampled directly from the bucket conveyor, however tailings was taken from the belt conveyor collecting the material dewatered in the bucket conveyor. During the sampling process, the feed was supplied in a stable way and there were no significant fluctuations in loading the jig with the material [14].

#### Laboratory analyses

The taken samples were quartered and they were transported to the laboratory back-up facilities of the Division of Preparation Systems in which they were subject to the following analyses [16, 17].

Laboratory tests were realized according to the requirements of the PN-EN ISO/IEC 17025:2005 Standard using the measuring apparatus ensuring the coherence of measurements. The supervised measuring equipment such as scales HR 120, WPT15H, B200, chamber stove PM-6/1100A and calorimeter LECO AC 350 were used in the tests.

Calculations and a determination of basic separation process parameters (separation density, probable dissipation and imperfection) were made in accordance to the Standard PN-G-07020:1997.

The ash content, according to PN-ISO 1171:2002 Standard was determined in the obtained density fractions of the feed and of the beneficiation products.

Heat of combustion was determined for feeds and beneficiation products and also calorific values were calculated according to the Standard PN-ISO 1928:2002.

A feed grain size analysis was conducted on the sieve mesh 20; 16; 10; 6; 3 and 0.5 mm, obtaining grain classes > 20; 20-16; 16-10; 10-6; 6-3; 3-0.5 and 0.5-0 mm.

The above mentioned analysis was conducted according to the PN-ISO 1953:1999 Standard.

The feed and products of separation in heavy media of density 1.3; 1.4; 1.5; 1.6; 1.7; 1.8 and 2.0 g/cm<sup>3</sup>, giving density fractions < 1.3; 1.3-1.4; 1.4-1.5; 1.5-1.6; 1.6-1.7; 1.7-1.8; 1.8-2.0 and > 2.0 g/cm<sup>3</sup>, were subject to density analyses in the grain class 0.5 mm.

Density analyses were made in accordance with the PN-G-04559:1997 Standard. The ash content and the calorific value were given in an analytical state. An analytical moisture on the level of 3% was accepted for calculating the calorific values in the case of all the samples under analysis.

**RESULTS AND DISCUSSION**

**OM15L and OM15P fines jigs, ZG “Sobieski” – steam coal**

In Tables from 1 to 4 the results of the feed beneficiation process in the jigs OM15L and OM15P [18] are listed. The results of feed grain analyses are given in Table 1. In Table 2 and 3 the results of density-ash analyses of the feed and of the beneficiation products are presented. The balance of beneficiation products in a form of their percentage and mass shares is given in Table 4. The outputs of basic fractions of the feed and beneficiation products for the OM15L and OM15P jigs are presented in Fig. 8 and 9.

**Table 1**  
*Grain size composition of feed – OM15L and OM15P jigs*

Grain class	OM15L Feed		OM15P Feed	
	Output, %	Output, %	Output, %	Output, %
mm				
> 20	17.78		18.77	
20-16	9.37		9.96	
16-10	22.47	74.41	24.64	89.11
10-6	20.98		21.99	
6-3	13.81		13.75	
3-0.5	13.63	15.59	10.03	
0.5-0	1.96		0.86	10.89
Total	100.00	100.00	100.00	100.00

Source: [18].

**Table 2**  
*Density-ash composition of feed and products – OM15L jig*

Frac-tion density	Feed		Concentrate		Middlings		Tailings	
	Output, %	Ash, %	Output, %	Ash, %	Output, %	Ash, %	Output, %	Ash, %
g/cm <sup>3</sup>								
< 1.5	52.53	10.14	96.54	9.87	17.42	25.02	0.92	22.51
1.5-1.8	5.03	40.78	3.18	36.06	47.61	41.19	3.96	45.05
> 1.8	42.44	86.03	0.28	61.67	34.97	67.92	95.12	86.64
Total	100.00		100.00		100.00		100.00	
Average		43.89		10.85		47.72		84.40
Calorific value, MJ/kg	15.14		25.69		13.29		2.24	

Source: [18].

**Table 3**  
*Density-ash composition of feed and products – OM15P jig*

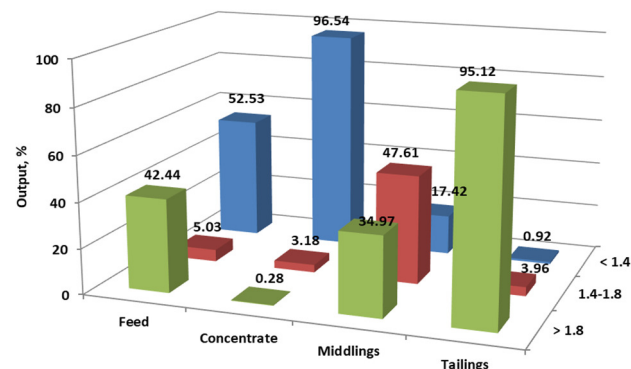
Frac-tion density	Feed		Concentrate		Middlings		Tailings	
	Output, %	Ash, %	Output, %	Ash, %	Output, %	Ash, %	Output, %	Ash, %
g/cm <sup>3</sup>								
< 1.5	53.87	9.10	96.39	8.81	17.42	25.02	0.92	22.51
1.5-1.8	5.28	40.30	3.37	35.21	47.61	41.19	3.96	45.05
> 1.8	40.85	85.94	0.24	63.17	34.97	67.31	95.12	86.64
Total	100.00		100.00		100.00		100.00	
Average		42.14		9.83		47.72		84.40
Calorific value, MJ/kg	15.30		25.09		13.29		2.24	

Source: [18].

**Table 4**  
*Balance of beneficiation products – OM15L and OM15P jigs*

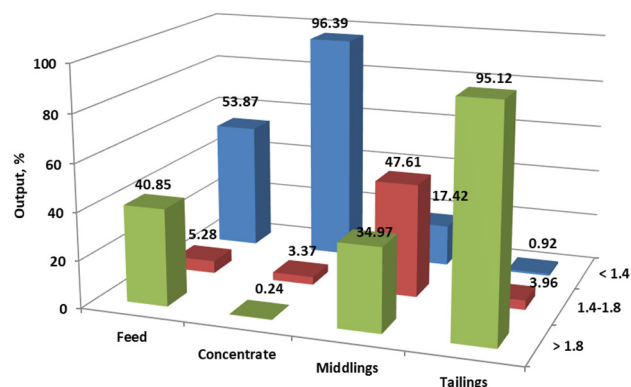
Product	Feed		Concentrate		Middlings		Tailings	
	OM15L	OM15P	OM15L	OM15P	OM15L	OM15P	OM15L	OM15P
Share, %	100.00	100.00	53.38	54.81	3.42	3.77	43.20	41.42
Share, t/h	300.0	300.0	160.1	164.4	10.2	11.3	129.6	124.3
Ash, %	43.89	42.14	10.85	9.83	47.72	47.72	84.40	84.40

Source: [18].



**Fig. 8** Output of basic fractions of feed and beneficiation products – OM15L jig

Source: [18].



**Fig. 9** Output of basic fractions of feed and beneficiation products – OM15P jig

Source: [18].

The average values of the imperfection coefficient, determined on the basis of separation curves of jigs, were for the OM15L jig  $I = 0.174$  and for the OM15P jig  $I = 0.169$ .

### Feed

A grain analysis in the OM15L (and OM15P) jigs showed a significant share of the class  $> 20$  mm, being respectively: 17.78% (18.77%). The biggest grains reached the size of about 40 mm. A share of class 3-0 mm was on the level 15.59% (18.77%) at only 1.96% (0.86%) share of class  $< 0.5$  mm. A density analysis, in accepted basic fractions, showed that the share of the tailings fraction ( $> 1.8$  g/cm<sup>3</sup>), in the grain class  $> 0.5$  mm was 42.44% (40.85%), of parting fraction (1.5-1.8 g/cm<sup>3</sup>) – 5.03% (5.28%) and of concentrate fraction ( $< 1.5$  g/cm<sup>3</sup>) – 52.53% (53.87%). The ash content in the grain class  $> 0.5$  was significant and it was 43.89% (42.14%). The density fraction  $< 1.5$  g/cm<sup>3</sup> contained 10.14% (9.10%) of ash, however the fraction  $> 1.8$  g/cm<sup>3</sup> (tailings fraction) – 86.03% (85.94%). The feed calorific value was 15.14 MJ/kg (15.30 MJ/kg).

### Concentrate

The conducted density ash analyses showed that the concentrate product contained 96.54% (96.39%) of the fraction  $< 1.5$  g/cm<sup>3</sup> of the ash content equal to 9.87% (8.81%). A share of tailings fractions ( $> 1.8$  g/cm<sup>3</sup>) in the product under analysis was 0.28% (0.24%) at the ash content equal to 61.67% (63.17%). The output of the concentrate product was 53.38% (54.81%), at the average ash content in the product under analysis, was 10.85% (9.83%). The calorific value of the concentrate product was 25.69 MJ/kg (25.09 MJ/kg).

### Middlings

The results of analyses showed that middlings contained 47.61% of the fraction 1.5-1.8 g/cm<sup>3</sup> of the ash content equal to 41.19%. Shares of concentrate fractions ( $< 1.5$  g/cm<sup>3</sup>)

and of tailings fractions ( $> 1.8$  g/cm<sup>3</sup>), in the product under analysis, were respectively 17.42% and 34.97%. The output of middlings was 3.42% at the average ash content, in the product under analysis, was 47.72%. The calorific value of middlings was 13.29 MJ/kg.

### Tailings

The results of conducted analyses showed that total losses of concentrate fraction ( $< 1.5$  g/cm<sup>3</sup>) in tailings were 0.92%, whereas the total share of combustible materials ( $< 1.8$  g/cm<sup>3</sup>) in the above product was equal to 86.64%. The output of tailings was on the level 43.20% at the ash content of 84.40%. The tailings calorific value was 2.24 MJ/kg.

### OM24 fines jig, Borynia-Zofiówka Mine, Zofiówka Branch – coking coal

In Tables from 5 to 7 the results of the feed beneficiation process in the OM24 jig [14, 16] are listed. Results of grain size analyses of the feed are presented in Table 5.

**Table 5**  
**Grain size composition of feed – OM24 jig**

Grain class mm	Feed	
	Output, %	Output, %
$> 20$	3.62	
20-16	6.32	
16-10	12.24	44.31
10-6	11.98	
6-3	10.15	
3-0.5	35.19	55.69
0.5-0	20.50	
Suma	100.00	100.00

Source: [17].

In Table 6 the results of density-ash analyses of the feed and beneficiation products are given. The balance of beneficiation products, in a form of their percentage and mass shares, is shown in Table 7. The outputs of basic functions of the feed and of beneficiation products for the OM24 jig are presented in Fig. 10.

**Table 6**  
**Density-ash composition of feed and products – OM24 jig**

Frac- tion density	Feed		Concen- trate		Middlings		Tailings	
	Output, %	Ash, %	Output, %	Ash, %	Output, %	Ash, %	Output, %	Ash, %
g/cm <sup>3</sup>								
$< 1.4$	56.54	4.37	88.57	4.20	20.52	6.62	1.23	5.57
1.4-1.8	10.61	27.77	10.84	24.02	17.61	32.61	4.04	36.84
$> 1.8$	32.85	82.89	0.59	59.29	61.87	77.59	94.73	86.22
Total	100.00		100.00		100.00		100.00	
Average		32.65		6.67		55.10		83.24
Calorific value, MJ/kg		22.21		32.14		13.17		3.80

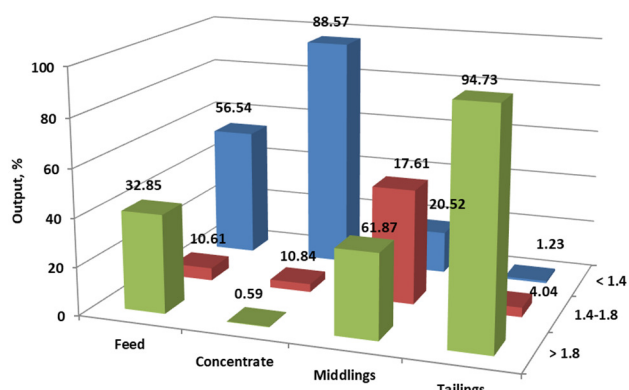
Source: [17].

**Table 7**  
**Balance of beneficiation products – OM24 jig**

Product	Feed	Concentrate	Middlings	Tailings
Share, %	100.00	59.19	18.73	22.08
Share, t/h	580.0	343.3	108.6	128.1
Ash, %	32.65	6.67	55.10	83.24

Source: [17].

The imperfection coefficient, determined on the basis of the jig average technological efficiency (on the basis of the concentrate separation curves and the sum of "heavy" products), was equal to  $I = 0.150$ , at the separation density  $\Delta = 1.579$  g/cm<sup>3</sup> and probable dissipation equal to  $E_p = 0.087$  g/cm<sup>3</sup>.



**Fig. 10 Output of basic fractions of feed and beneficiation products – OM24 jig**

Source: [17].

### Feed

The grain analysis showed an insignificant share of class > 20 mm which was 3.62%. The share of class 3-0 mm was high and it was on the level of about 55% (including class < 0.5 mm – 20.50%). The density analysis, in accepted basic fractions, demonstrated that the share of the tailings fraction (> 1.8 g/cm<sup>3</sup>) in the grain class > 0.5 mm was 32.85%, of the parting fraction (1.4-1.8 g/cm<sup>3</sup>) – 10.61% and of the concentrate fraction (< 1.4 g/cm<sup>3</sup>) – 56.54%. The ash content in the grain class > 0.5 mm was on the level of 32.65%. The density fraction < 1.4 g/cm<sup>3</sup> contained 4.37% of ash, whereas the fraction > 1.8 g/cm<sup>3</sup> (tailings) – 82.89%. The feed calorific value was 22.21 MJ/kg.

### Concentrate

The conducted density ash analyses showed that the concentrate product contained 88.57% of the fraction < 1.4 g/cm<sup>3</sup> of the ash content equal to 4.20%. A share of tailings fractions (> 1.8 g/cm<sup>3</sup>) in the product under analysis was 0.59% at the ash content equal to 59.29%. The output of the concentrate product was 59.19%, at the average ash content in the product under analysis, was 6.67. The calorific value of the concentrate product was 32.14%.

### Middlings

The conducted analyses demonstrated that middlings contained only 17.61% of the fraction 1.4-1.8 g/cm<sup>3</sup> of the ash content equal to 32.61%. The shares of concentrate fractions (< 1.4 g/cm<sup>3</sup>) and of tailings fractions (> 1.8 g/cm<sup>3</sup>) in the product under analysis were respectively 20.52% and 61.87%. The output of middlings was 18.73% at average and significant ash content was on the level of 55.10%. The calorific value of middlings was 13.17 MJ/kg.

### Tailings

The results of conducted analyses showed that total losses of concentrate fraction (< 1.4 g/cm<sup>3</sup>) in tailings were 1.23%, whereas the total share of combustible materials (< 1.8 g/cm<sup>3</sup>) in the above product was equal to 5.27%. The ash content in the tailings fraction (> 1.8 g/cm<sup>3</sup>) was 86.22%. The output of tailings was on the level of 22.08%,

at the ash content of 83.24%. The tailings product calorific value was 3.80 MJ/kg.

### CONCLUSIONS

The research work, conducted at the KOMAG Institute in collaboration with other research and development organizations [5, 27], producers but mainly with end users of the research results [4], enabled a generation of innovative technological and constructional jigs [11]. A design development of KOMAG type pulsatory jigs concerned all the subassemblies which resulted in a productivity increase, an improvement of beneficiation accuracy indicators and a reduction of technological water consumption [12, 13]. It was also possible to obtain a reduction of jigs installation surface which enabled to reduce their weight.

An improvement of the coal concentrate quality, at required technological parameters, was achieved among others due to: a modernization of the feed supply system to the jigs, and also a modernization of the working air supply system, an automatic media control and a modification of the heavy product collection system assembly. Additionally an introduction of the authors' jig control system KOGA [6, 7, 8, 9, 10, 18, 28] enabled an increased supervision of the beneficiation process.

### Conclusions from tests of the OM15L and OM15P fines jigs

Conducted technological tests demonstrated a correct operation of the OM15L and P jigs in conditions of continuous operation at the ZG "Sobieski" Preparation Plant. An assessment of a three-product beneficiation of coal fines in the grain class 20(40)-0 mm in the OM15L and OM15P jigs, consisting in taking samples and analysing the quality of obtained products, showed advantageous separation accuracy indicators.

The results of conducted analyses pointed out that the total losses of the concentrate fraction (< 1.5 g/cm<sup>3</sup>) in tailings did not exceed 1%.

During the sampling process, an amount of the material directed for a beneficiation was maximum 320 t/h in the case of a single jig.

The OM15L and OM15P fines jigs, although the supplied feed was very non-homogeneous and separated in an unstable way (short breaks in feed supply to jigs occurred), obtained similar results, imperfection for OM15L on the level of  $I = 0.174$  and for OM15P –  $I = 0.169$ .

### Conclusions from tests of OM24 fines jig – coking coal

The conducted technological tests confirmed a correct operation of the OM24 jig in the conditions of a continuous operation of the Preparation Plant of the "Borynia-Zofiówka" Mine, Zofiówka Branch. The feed, subject to beneficiation in the jig under testing, was characterized by a big share of small grains (< 3 mm) on the level of 55.69%. The assessment of the three-product beneficiation of fines in the grain class 20(30)-0 mm in the OM24 jig, consisting in sampling and analysing the quality of obtained

products, showed advantageous separation accuracy indicators. The imperfection coefficient was equal to  $I = 0.150$ .

During a realization of the tests an amount of the material directed to a beneficiation, being on average 580 t/h, was supplied in a stable way and there were no significant fluctuations in loading the jig with the above mentioned material.

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