University of Belgrade
Technical Faculty in Bor

Chamber of Commerce
and Industry of Serbia

XV International Mineral Processing & Recycling Conference

IMPRC
INTERNATIONAL MINERAL PROCESSING & RECYCLING CONFERENCE

Proceedings

Editors:
Jovica Sokolović
Milan Trumić

17-19 May 2023 | Belgrade SERBIA

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XV International Mineral Processing & Recycling Conference

PUBLISHER:
University of Belgrade, Technical Faculty in Bor

FOR THE PUBLISHER:
Dean: Prof. Dr Dejan Tanikić

EDITORS:
Prof. Dr Jovica Sokolović
Prof. Dr Milan Trumić

PROCEEDINGS COVER DESIGN:
Vojislav Jotović

PRINTED BY:
Grafomed - Trade Bor d.o.o., Bor, Serbia
Printed: 200 copies

PUBLICATION YEAR:
2023

==========

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

622.7(082)
502.131.1:628.477.6(082)
628.477.6(082)

INTERNATIONAL Mineral Processing and Recycling Conference (15 ; 2023 ; Belgrade)
Proceedings / XV International Mineral Processing and Recycling Conference, IMPRC, 17-19 May 2023, Belgrade, Serbia ; editors Jovica Sokolović, Milan Trumić. - Belgrade : University, Technical Faculty in Bor, 2023 (Bor : Grafomed Trade). - XII, 634 str. : ilustr. ; 25 cm

Na vrhu nasl. str.: Chamber of Commerce and Industry of Serbia. - Tiraž 200. - Bibliografija uz većinu radova.

ISBN 978-86-6305-133-1

а) Руде -- Припрема -- Зборници б) Отпадне материје -- Одрживи развој -- Зборници в) Отпадне материје -- Рециклажа -- Зборници

COBISS.SR-ID 114566153

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Conference is financially supported by Republic of Serbia, Ministry of Science, Technological Development and Innovation

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XV International Mineral Processing and Recycling Conference
17-19 May 2023, Belgrade, Serbia

COMPARISON OF THE RESULTS OF SEPARATION OF DIFFERENT COALS IN THE ANTHRACITE MINE "VRSKA CUKA"

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ABSTRACT – This paper presents the comparative results of the study of the efficiency of the separation of coal in the anthracite mine "Vrska Cuka". Industrial and laboratory tests of the possibility of gravity separation were carried out with the aim of verifying the sharpness of the separation in the process of coal separation, as well as assessing its impact on the technological indicators of the process. Parallel research was carried out on two different samples of raw coal: from the anthracite mine "Vrska Cuka" and the lignite mine "Lubnica". The Ecart probable values are Ep=97.5 kg/m^3 and 40 kg/m^3, respectively. Such results only confirm the fact that grain size affects the value of Ep, that is, that coarser-grained products are separated better, more efficiently than finer-grained products.

Keywords: Vrska Cuka, Lubnica, Gravity Separation, Coal.

INTRODUCTION

Anthracite mine "Vrska Cuka" Avramica is located about 10 km from Zajecar in eastern Serbia. The mine has a modern separation that was completed in 1994. The industrial plant comprises of a complex technological process for gravity and flotation concentration of raw coal. Size fractions over 0.5 mm are treated by dense-medium processes, whereas flotation has been proposed for sizes finer than 0.5 mm [1].

The gravitational concentration of coal is carried out in the two-part separator "BSRI - 1200" with a spiral and electromagnetic valve for separating the sink fraction. In this device for separation, two different size fractions of anthracite coal can be treated at the same time, namely: (- 30 + 5) and (- 5 + 0.5) mm [1,2]. In the separation plant, lignite with different characteristics from the Lubnica mine is washed, too. The aim of this study is to perform a comparative analysis of the results of separation of different coals. Research was carried out on two different samples of raw coal: from the anthracite mine "Vrska Cuka" and the lignite mine "Lubnica".

EXPERIMENTAL

The samples for experimental tests were collected from separation process in the anthracite mine "Vrska Cuka". As in the separation of the "Vrska Cuka" anthracite mine, different coal assortments from the "Lubnica" mine are washed, the samples from the "Lubnica" mine were collected in the same way and from the same sampling points from the coal separation plant [3].

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The particle size analysis by size fractions and the float-sink analysis by density fractions were perfomed in order to characterize the raw coal. The laboratory float-sink analysis were performed on the raw coal and all products (float and sink prodcuts) of coal separation. The analysis was performed using an inorganic heavy liquid (solutions of $ZnCl_2$ of density ranging from from 1300 to 1850 kg/m^3). All obtained size fractions and density fractions were analyzed on the ash content.

RESULTS AND DISCUSSION

Particle size analysis

The particle size analysis and ash content in size fractions of raw coal from the "Vrska Cuka" and "Lubnica" are given in Table 1.

Table 1 Particle size distribution of raw coal [3]

Particle size d (mm)	Vrska Cuka		Lubnica	
	Mass %	Ash %	Mass %	Ash %
+30	0.00	0.00	1.63	67.24
-30+15	10.66	40.01	61.58	39.41
-15+10	29.09	41.71	28.80	32.75
-10+5	21.38	41.12	2.96	38.87
-5+0	38.87	33.49	5.03	52.42
∑	100.00		100.00	

The results of the analysis of the particle size distribution of the raw coal sample from the "Lubnica" mine show that this sample is significantly coarser-grained compared to the raw coal from the "Vrska Cuka" anthracite mine, and that in this sample there are dominant participation of coarse size classes, even particles with a size above 30 mm.

Float-Sink analyses

The results of float-sink analysis of a raw coal from anthracite mine "Vrska Cuka" as well as products of separation (separation coal as float fraction and tailing as sink fraction) are shown in Table 2 [3].

Table 2 Float-sink analysis of a raw coal and products of separation of coal from anthracite mine "Vrska Cuka"

Specific gravity kg/m^3	Raw coal (feed) (%)		Separated coal (float) (%)		Tailing (sink) (%)	
	Mass %	Ash %	Mass %	Ash %	Mass %	Ash %
-1300	6.19	6.79	4.78	3.38	0.38	3.82
-1400	27.37	9.83	40.50	3.77	11.37	4.48
-1500	8.57	18.20	17.63	13.00	4.31	14.64
-1600	7.64	34.00	9.58	24.16	3.40	25.47
-1700	8.85	40.29	5.07	29.13	3.81	32.15
-1850	10.86	53.64	2.95	41.32	3.77	40.62
+1850	30.51	68.82	19.49	80.07	72.96	80.91
∑	100.00		100.00		100.00	

By separation of raw anthracite coal, it can be noticed that depending on the quality, in the range of separation densities between 1400 and 1800 kg/m^3, the mass yield of the float coal is from 34% to 65%. For instance, the separation of raw coal on the density 1600 kg/m^3, it can be achieved mass yield of coal, Im = 49.78% with average ash content, p = 14.60%.

Based on the results, it can be seen that the fractions below 1500 kg/m^3 have a significant mass share of about 63% with an ash content of 8.68% in the separated coal product.

The fraction above 1850 kg/m^3, with the largest mass share in tailings (sinking product) which is 72.96% and with an ash content of 80.91%.The results of float-sink analysis of a raw coal from lignite mine "Lubnica" as well as products of separation by the density fractions are shown in Table 3 [3].

Table 3 Float-sink analysis of a raw coal and products of separation of coal from lignite mine "Lubnica"

Specific gravity kg/m^3	Raw coal (feed) (%)		Separated coal (float) (%)		Tailing (sink) (%)	
	Mass %	Ash %	Mass %	Ash %	Mass %	Ash %
-1300	23.95	10.75	51.66	8.78	0.77	13.23
-1400	11.90	20.01	32.25	19.40	2.73	23.27
-1500	29.96	40.76	11.78	41.01	4.72	41.39
-1600	11.48	54.83	3.41	55.59	20.96	57.40
-1700	4.25	57.87	0.82	56.54	23.52	64.05
-1850	12.20	63.43	0.08	52.74	30.93	73.99
+1850	6.26	73.51	0.00	0.00	16.37	82.02
∑	100.00		100.00		100.00	

The float-sink analysis of the raw lignite coal shows a low degree of separability for the tested raw material, the mass yield at a density of 1400 kg/m^3 is 35.80%. The ash content at this density is about 14%.

The results of float-sink analysis of the sample of separated coal show that the fraction -1300 kg/m^3, which amounts to 51.66%, is dominant in this product. The ash content in this fraction is about 9%.

Determination of separation efficiency

The partition or distribution curve is useful in assessing the efficiency or sharpness of the coal separation [5]. The partition curve or Tromp curve (introduced by Tromp in 1937) is obtained by plotting the partition coefficient against the mean of its density range [6].

The separation density or cut point (ρ_{50}) and the probable error of separation (E_P) can both be calculated from the partition curve [5].

The probable error of separation (E_P) is defined as half the difference between the S.G. where 75% is recovered in the sinks and the S.G. at which 25% is recovered in the sinks [5].

The mass yield was calculated using the Grumbrecht method. Figure 1 and Table 4 show the results.

Table 4 Calculation of mass yield of Grumbrecht methods – Vrska Cuka

Specific gravity	Feed raw coal (%)	Separation coal (float) (%)	Tailing (sink) (%)				
kg/m³	U	K	J	U - J	K - J	(U – J) (K – J)	(K – J)²
-1300	6.19	4.78	0.38	5.81	4.40	25.58	19.36
-1400	27.37	40.50	11.37	16.00	29.13	466.16	848.56
-1500	8.57	17.63	4.31	4.26	13.32	56.79	177.42
-1600	7.64	9.58	3.40	4.24	6.18	26.19	38.19
-1700	8.85	5.07	3.81	5.04	1.26	6.36	1.59
-1850	10.86	2.95	3.77	7.09	-0.82	-5.81	0.67
+1850	30.51	19.49	72.96	-42.45	-53.47	2269.85	2859.04
∑	100.00	100.00	100.00			2845.12	3925.47

$$Im = \frac{2845.12}{3925.47} \cdot 100 = 72.48\% \quad (1)$$

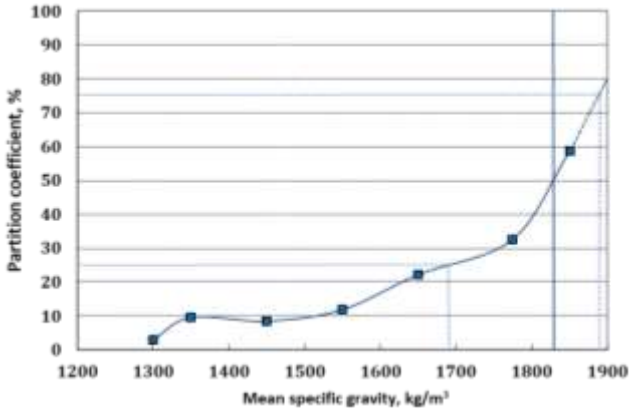

Figure 1 Partition curve for gravity separation of raw coal from the anthracite mine "Vrska Cuka" [3]

From the partition curve, the separation density or ρ_{50} is 1835 kg/m^3. The probable error of separation or the Ecart probable (Ep) is expressed as:

$$E_p = \frac{\rho_{75} - \rho_{25}}{2} = \frac{1890 - 1695}{2} = 97.5\ kg/m^3 \quad (2)$$

Table 5 compares theoretical and practical data for the gravity separation of raw coal from the "Vrska Cuka" anthracite mine.

Table 5 Compared theoretic and industrial values for gravity separation of raw coal

	Theoretic values	Industrial values
Mass yield (wt. %)	68.40	72.48
Average ash (%)	23.51	24.60
ρ_p (kg/m³)	1835	1835
E_p (kg/m³)	0	97.5

The results of the calculation of mass yield of Grumbrecht methods as well as partition curve for gravity separation of raw coal from the lignite mine "Lubnica" are shown in Table 6 and Figure 2.

Table 6 Calculation of mass yield of Grumbrecht methods – Lubnica

Specific gravity	Feed raw coal (%)	Separation coal (float) (%)	Tailing (sink) (%)				
kg/m³	U	K	J	U - J	K - J	(U – J) (K – J)	(K – J)²
-1300	23.95	51.66	0.77	23.18	50.89	1179.58	2589.79
-1400	11.90	32.25	2.73	9.17	29.52	270.71	871.43
-1500	29.96	11.78	4.72	25.24	7.06	178.23	49.84
-1600	11.48	3.41	20.96	-9.48	-17.55	166.40	308.00
-1700	4.25	0.82	23.52	-19.27	-22.70	437.45	515.29
-1850	12.20	0.08	30.93	-18.73	-30.85	577.94	951.72
+1850	6.26	0.00	16.37	-10.11	-16.37	165.46	267.98
∑	100.00	100.00	100.00			2975.76	5554.06

$$Im = \frac{2975.76}{5554.06} \cdot 100 = 53.58\% \quad (3)$$

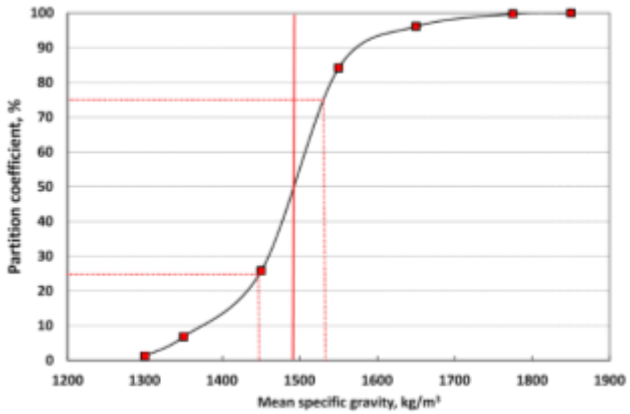

Figure 2 Partition curve for gravity separation of raw coal from the lignite mine "Lubnica" [3]

From the partition curve, the separation density or ρ_{50} is 1490 kg/m^3. The probable error of separation or the Ecart probable (Ep) is expressed as:

$$E_p = \frac{\rho_{75} - \rho_{25}}{2} = \frac{1530 - 1450}{2} = 40\ kg/m^3 \quad (4)$$

Table 7 compares theoretical and practical data for the gravity separation of raw coal from the "Lubnica" lignite mine.

Table 7 Compared theoretic and industrial values for gravity separation of raw coal

	Theoretic values	Industrial values
Mass yield (wt. %)	62.81	53.58
Average ash (%)	25.39	18.02
ρ_p (kg/m^3)	1490	1490
E_p (kg/m^3)	0	40

CONCLUSION

In this paper are shown results of the parallel research conducted on two different samples of raw coal: from the anthracite mine "Vrska Cuka" and the lignite mine "Lubnica". The achieved results in the process of separation of coal from the "Vrska Cuka" anthracite mine are as follows: mass yield is 72.48%, while the average ash content in the separated coal is 24.60%. It was determined that the separation density is ρ_p=1835 kg/m^3. The probable error of separation or the Ecart probable (Ep) value is Ep=97.5 kg/m^3, confirming that the technological process of coal separation works with a reduced sharpness of separation.

Based on the results obtained in the lignite coal separation process, it can be concluded that the separation efficiency was better. The Ecart probable (Ep) is 40 kg/m^3. At a density of 1490 kg/m^3, the mass yield is 53.58% with an ash content of 18.02% in the separated coal. Such results only confirm the fact that grain size affects the value of Ep, that is, that coarser-grained lignite coal are separated better, more efficiently and with significantly greater precision than finer-grained anthracite coal.

ACKNOWLEDGEMENT

"The research presented in this paper was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-47/2023-01/200131".

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ISBN-978-86-6305-133-1