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Metal extraction from ore benefication codas by means of lixiviation in a disintegrator

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Abstract:
laboratory experiments results of extraction of polymetals from ore benefication codas are given. The concept combined in time and space of chemical enrichment and mechanical activation of minerals in a disintegrator is proved. The regression analysis of a coda lixiviation options of enrichment in a disintegrator is made. Ranging of variable factors of experiment is made. The conclusion that a lixiviation of codas in a disintegrator is more preferable than a traditional agitation lixiviation is drawn. The directions of technology use in the mining problems solution are recommended.

Key terms: metal, enrichment coda, ore, mechanical activation, disintegrator, regression analysis, lixiviation, experiment, agitation lixiviation, technology, mining.

1.Introduction.

The modern mining differs in scale of mining operations, use of the potent equipment and dynamism caused by change of quality requirements as a result of reaction to the raw materials environment [1]. Environmental negative impact begins with a conclusion from economic circulation of lands in vicinities of the mountain enterprise and as much as possible amplifies in shelf-life of processing codas which are not subject to use because they contain valuable toxiferous components. The tendency of bulk dredging of ores from a subsoil counting on opportunities of their enrichment that actually does not occur is the reason of increase in quantity of sub-standard mineral raw materials in storages. Storage of mineral raw materials taken from subsoil brings complex damage to environment therefore a radical utilization is radical measure of minimizing danger. Use of codas without the complete extraction of metals is non-economic and dangerous, so the cost of not extracted metals can be comparable with the cost of the extracted metals, and products on their basis lose durability under the influence of natural lixiviation. Traditional concentrating processes do not provide the complete extraction of metals therefore utilization of enrichment codas are not effective. Modernization of concentrating processes is carried out due to combination of operations of hydrometallurgical and chemical processing with use of new technological processes [2]. In essence recent trend of enrichment is the chemical enrichment and activation of minerals combined in time and space in a disintegrator when extraction of metals in solution is accelerated at pressing-in of the lixivating solution in mineral microcracks [3]. Lixiviation in the activator increases treatment of metals in solution to standards of sanitary safety that allows to use secondary codas of processing without restrictions [4].

2.Technique.

Effectiveness of lixiviation technology in a disintegrator is estimated by comparison of its indexes with indexes of traditional technology processing of a agitation lixiviation in percolators. Criterion of an alternate technologies assessment is the size of metal extraction [5]. Experiments were carried out with mathematical scheduling by Venkena-Boksa method. Indexes of metal extraction options were compared. Results interpreted in the form of logarithmic or polynomial interpolation. Chemical composition of enrichment codas of Mizursky factory RSO-Alania, %: SiO2 – 31,4; Fe – 4,4;Ca O – 1,96;S – 1,88;Ag – 0,015;Cu – 0,18;Mn – 0,015;K2 O – 3,5; Al2 O 3 – 0,8; Ti O2 - 0,03; Zn – 0,95; Pb – 0,84.

Codas leached in DEZ-11 disintegrator on the stages differing with a place and nature of influence:
1. A agitation lixiviation in a percolator.
2. A agitation lixiviation in a percolator after activation in a disintegrator.
3. A lixiviation in a disintegrator.
4. A agitation lixiviation in a percolator after activation and a lixiviation in a disintegrator.
5. Lixiviation in a disintegrator in several stages.

Variable factors at the organization of experiments:
1. The content of sulfuric acid and Sodium chloridum, X1 and X2 , (X 1 -1 - 2, 0 - 6 and 1 - 10 g/l), (X2 - 1 - 20, 0 – 90 and 1 – 160 g/l).
2.Ratio of Zh:T, H3 (1 - 4, 0 - 7 and 1 – 10),
3. Time of a lixiviation, X4 (1 - 0,25, 0 - 0,5, 1-1 hour, except stages 3 and 5),
4. Speed of rotation of rotors of a disintegrator, X5 (1 - 50, 0 - 125, 1 – 200 Hz, except stage 1),
5. Quantity of lixiviation stages , X6 (1-3, 0-5, 1-7) (stage 5).

On the basis of the received results algorithms of regression and correlation analysis are made. The non-linear regression analysis is carried out by reduction of the equation to the linear form. The algorithm of the regression analysis is presented by the quadratic form in the form of computer program in the MATLAB language.

3. Main part

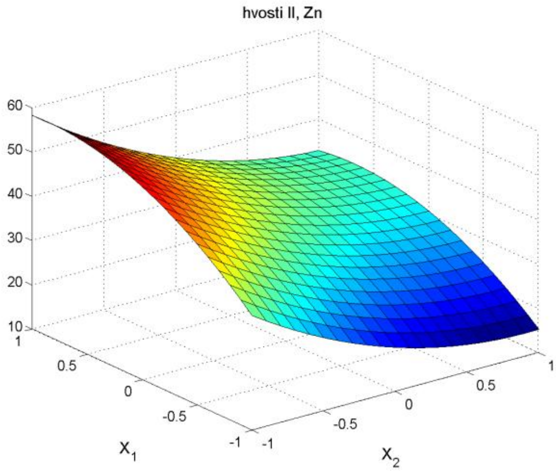
3.1. Parameters of traditional lixiviation

Agitation lixiviation of enrichment codas in a percolator is characterized by tab. 1 and fig. 1. It allows to extract part of metals, but duration of process makes it economically inefficient [6].

Table 1 - Parameters of agitation lixiviation

Regression equation	Indexes of significance
ε_{Zn}=39,35 +6,76X_1-18,88X_2 -0,62X_4 – 11,6X_1^2+7,19X_2^2+2,03X_4^2 – -2,84X_1X_2 -1,39X_1X_3 -0,89X_1X_4 - 2,04X_2X_3+1,00X_2X_4 -2,45X_3X_4	R^2=0,9393; S_{ad}=46,93; F=68,59
ε_{Pb}=42,43 +16,8X_2+2,68X_3 +0,93X_4 – 3,89X_1^2 -19,31X_2^2+2,36X_4^2 + +2,12X_1X_2 -0,9X_1X_4 +1,73X_2X_3+1.04X_3X_4	R^2=0,8888; S_{ad}=71,17; F=30,19

The dimensionless variables:
Extraction variation boundaries, %: Zincum 10,95 - 67,79, lead 0,48 - 58,33.



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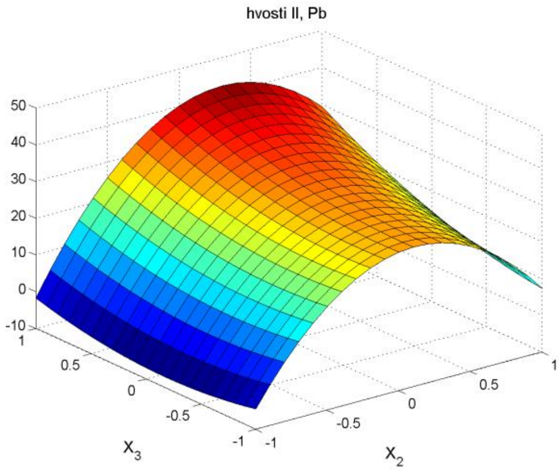

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Figure 1 – Agitation lixiviation results:a) Zincum; b) lead

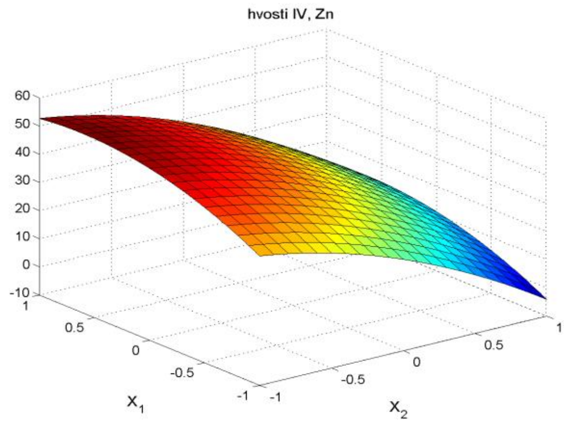
3.2. Lixiviation parameters with activation

In order to establish the role of disintegrator codas are leached on traditional technology after activation in a disintegrator (tab. 2, Fig. 2):

Table 2-Parameters of agitation lixiviation after disintegrator

Regression equation	Indexes of significance
ε_{Zn}=36,37 +9,96X_1-11,56X_2 +1,07X_3– 6,53X_1^2+5,63X_2^2-1,00X_3^2- 3,95X_4^2- – 1,21X_1X_2 -5,79X_1X_3 -4,16X_2X_3 -0,74X_2X_4 - 1,15X_3X_4	R2=0,9688; S ad =24,88; F=102,17
ε_{Pb}=29,91 +1,1X_1+10,63X_2+ 6,15X_3 +2,09X_4–2,41X_1^2-26,29X_2^2+ +3,84X_3^2+ +9,25X_4^2 +1,21X_1X_2 - 0,72X_1X_3+3,21X_1X_4+4,81X_2X_3+ +1,08X_2X_4-1,00X_3X_4	R^2=0,8789; S_{ad}=86,00; F=10,52

The dimensionless variables: Extraction variation boundaries, %: Zincum 4,63 - 66,11, lead 0,81 - 45,00



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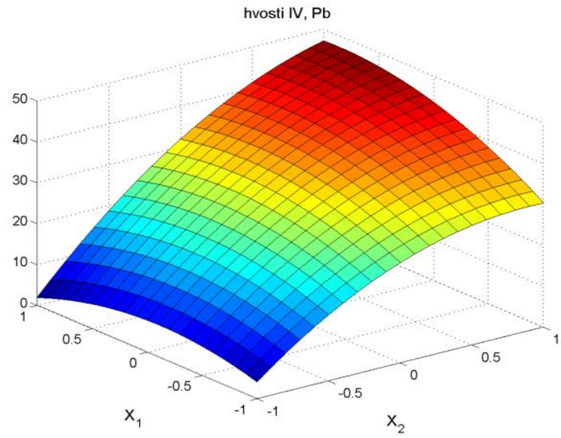

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Figure 2 – Parameters of activated codas lixiviation: a) Zincum; b) lead

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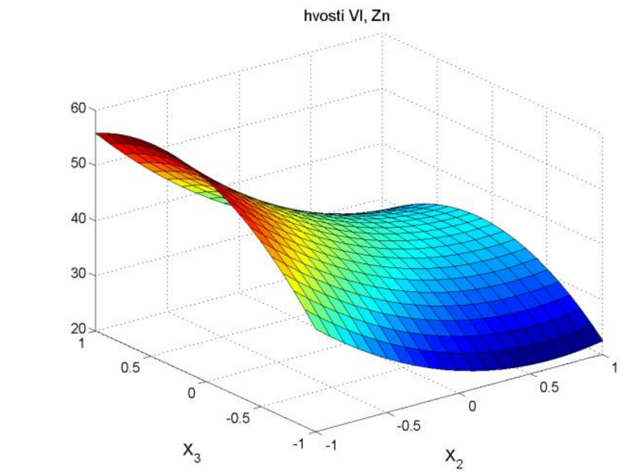
At the following stage parameters of mineral lixiviation in the course of activation in disintegrator are investigated. (tab. 3, Fig. 3):

Table 3 - Lixiviation parameters in disintegrator

Regression equation	Indexes of significance
εZn=32,15 +11,4X1-14,04X2 +0,68X3+1,85X4 - 2,90X1^2 +9,25X2^2 –2,53X4^2 --0,39X1X2-1,95X1X3+1,32X1X4 +1,47X2X3+4,84X2X4+ 3,61X3X4	R^2=0,8277; S_{ad}=143,62; F=18,06
ε_{Pb}=39,44 -1,17X_1+16,76 X_2+1,28X_3 - 0,55X_4 – 5,64X_1^2 -14,81X_2^2-0,86X_3^2- 4,09X_1X_3-1,42X_1X_4 -0,42X_2X_3-1,00X_2X_4- 0,82X_3X_4	R^2=0,9483; S_{ad}=35,09; F=44,58

The dimensionless variables: Extraction variation boundaries, %: Zincum 6,32 - 78,74, lead 0,33 - 47,50.



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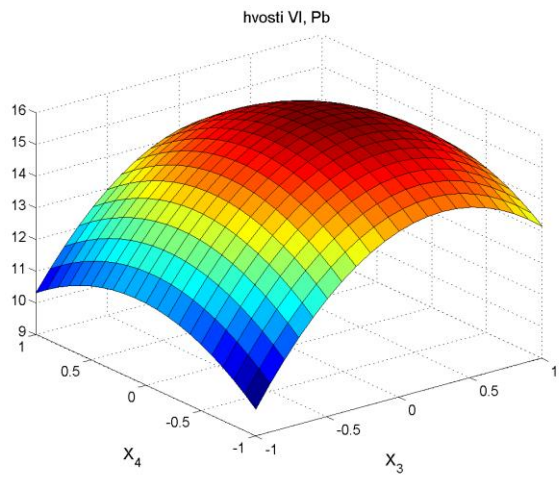

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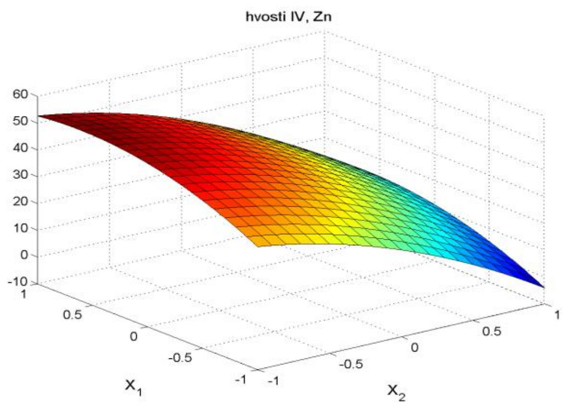
Figure 3 – Lixiviation parameters in disintegrator: a) Zincum; b) lead

Agitation lixiviation in a percolator after activation and leaching in disintegrator is characterized by tab. 4.

Table 4 - lixiviation parameters after lixiviation in disintegrator

Regression equation	Indexes of significance
εZn=36,37 +9,96X1-11,56X2 +1,07X3–6,53X1^2 +5,63X2^2 - 1,00X3^2 - 3,95X4^2 - –1,21X1X2 -5,79X1X3 -4,16X2X3 - 0,74X2X4 -1,15X3X4	R^2=0,9688; S_{ad}=24,88; F=102,17
ε_{Pb}=29,91 +1,1X_1+10,63X_2+ 6,15X_3 +2,09X_4–2,41X_1^2-26,29X_2^2+ +3,84X_3^2+ +9,25X_4^2 +1,21X_1X_2 - 0,72X_1X_3+3,21X_1X_4+4,81X_2X_3+ +1,08X_2X_4 -1,00X_3X_4	R^2=0,8789; S_{ad}=86,00; F=10,52

Dimensionless variables: Borders of extraction variation, %: Zincum 16,00 - 52,88, lead 0,30 - 21,25



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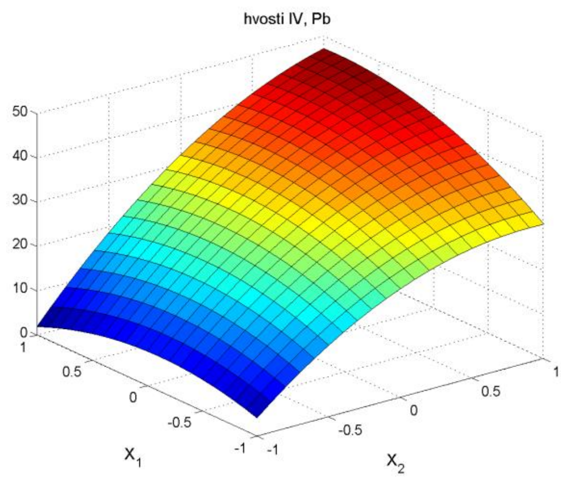

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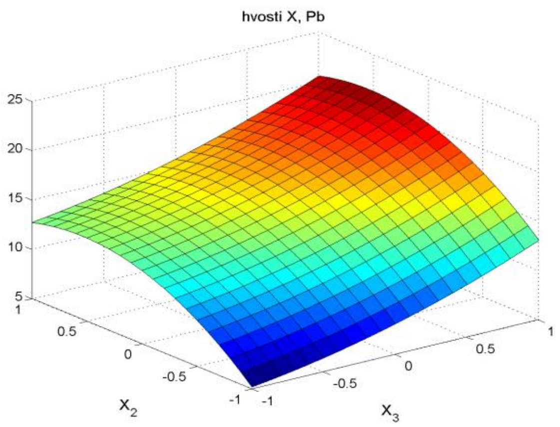
Figure 4 – extraction parameters after lixiviation in disintegrator: a) Zincum; b) lead

Combination of mechanical and chemical impact on codas significantly increases extraction of metals. To deliver the technology in comparable conditions in temporary aspect, the option with lixiviation in disintegrator at several stages is investigated (tab. 5, fig. 5).

Table 5 - Lixiviation parameters in disintegrator at several stages

Regression equation	Indexes of significance
$-\varepsilon_{Zn}$=38,15 +10,66X_1-15,17X_2 +2,42X_3-1,37X_4-6,10X_1^2-+3,92X_2^2–2,99X_3^2--1,68X_4-4,85X_1X_2-4,62X_1X_3+2,1X_1X_4-3,56X_2X_3+1,95X_2X_4+1,6X_3X_4	R^2=0,9206; S_{ad}=73,40; F=30,72
ε_{Pb}=40,94 +16,12X_2+4,13X_3+0,66X_4 – 6,36X_1^2 -17,44X_2^2+3,58X_3^2-- 1,36X_4^2+4,04X_1X_2 -1,32X_1X_3+2,47X_2X_3- 2,00X_2X_4-0,72X_3X_4	R^2=0,9535; S_{ad}=29,69; F=55,26

The dimensionless variables:
Extraction variation boundaries, %:
Zincum 1,05 - 70,53, lead 1,19 - 48,81.



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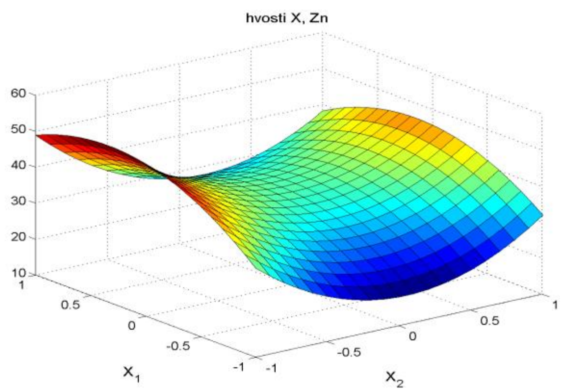

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Figure 5 – Lixiviation parameters in disintegrator at several stages: a) Zincum; b) lead

Single-pass activation of codas in disintegrator with the subsequent lixiviation out of it increases extraction of metals from enrichment codas – on lead – by 1,36 times, on Zincum – by 1,13 times. Extraction of metals to background value is provided with a multiple lixiviation in disintegrator. Extraction of metals in solution almost equally both at a multiple lixiviation in disintegrator, and at a agitation lixiviation or a agitation lixiviation of the codas activated in disintegrator together with the lixivating solutions. At identical extraction duration agitation lixiviation is two times longer lixiviation in disintegrator. The greatest impact on extraction of metals in solution has the content in the lixivating solution of Sodium chloridum. Further, in decreasing order of influence extent, follow: the content of sulfuric acid, rotation frequency of disintegrator rotors and number of lixiviation cycles in disintegrator and Zh:T ratio (tab. 6).

Table 6 - Experiment factors ranging

Metal	Number Series	Explanatory variables extent of influence			
		Max	second by influence	third by influence	min
Zincum	1	X_2	X_1	X_3	X_4
	2	X_2	X_1	X_3	X_4
	3	X_2	X_1	X_4	X_3
	4	X_2	X	X_3	X_4
	5	X_2	X_1	X_3	X_4
Lead	1	X_3	X_1	X_2	X_4
	2	X_4	X_1	X_2	X_3
	3	X_2	X_1	X_3	X_4
	4	X_2	X_1	X_3	X_4
	5	X_3	X_1	X_2	X_4

The received regression equations adequately describe the experimental data with a significance level of 0,05 since design values of Fischer coefficient exceed their table values for each equation of regression. From mechanochemical lixiviation adjustable parameters lixiviation time has the greatest impact on process. The technology of codas enrichment mechanochemical lixiviation for complex ores in a disintegrator provides extraction of metals in the range from 50 to 80% of the initial contents in codas that significantly exceeds extraction when using traditional technologies [7]. Decrease in the residual contents to norms of maximum concentration limit allows use of codas for product manufacture without restrictions with receiving complex economic and ecological effect [8]. The technology of a mechanochemical lixiviation of codas enrichment can be used for the solution of the adjoining problems of mineral expansion and technical base of mining in Russia and radical improvement of environmental ecosystems [9]. Mechanochemical lixiviation of metals is carried out experimentally and at utilization of ore codas of ferrous metals and coals, and results of various type raw materials processing have convergence [10].

Conclusion.
The concept of metal extraction from ore benefication codas by the combined combined chemical enrichment and mechanical activation of minerals in disintegrator is confirmed by results of representative experiment with the regression analysis of options of enrichment codas lixiviation, ranging of experiment variable factors and justification of optimum options of zinc and lead extraction.

Summary.
On the basis of the pilot study carried out it is possible to claim that mechanochemical activation of codas lixiviation process in disintegrator is more preferable than a traditional agitation lixiviation. The technology is recommended for use in the solution of economic and environmental problems of metal production.

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