AN INTERACTIVE METHOD FOR CALCULATING THE MAXIMUM EFFICIENCY (ORGANIC YIELD) IN THE PROCESSING OF THE TAILING DUMPS IN JIU VALLEY

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ABSTRACT

The interactive method presented in the paper, allows the calculation of maximum efficiency indicators (organic yields) of the processing and operational control of the actual processing process. It also allows the correlation of the technological parameters with the economic ones in order to properly capitalize on the products obtained by processing a material (raw coal or sterile resulted from coal preparation) containing solid fuel fractions. Using the interactive system, one can pre-determine the optimal mixture of material to be processed and have different characteristics. The interactive method consists of three C programs that allow: the selection of the mixture of solid material to be processed, by tracing the abacuses and determining the theoretical weight extractions, depending on the desired quality of the concentrates; calculation of the organic processing yields; estimating the processing results, using the Fournol method, taking into account the performance of the processing equipment used and the density of separation between the products.

KEYWORDS: efficiency indicators, coal processing, interactive system, tailings dump, Fournol method

1. Introduction

Although the coal extraction and processing activities have diminished a lot in Romania as a result of restructuring the mining activity, it is still necessary to study the processing in terms of efficiency, given the large reserves of fuel mass that exist both in the underground coal deposits, as well as in the tailings dumps across the Jiu Valley.

For an operational leading of a coal processing activity, it is necessary to know the maximal technological parameters and therefore it was proposed an interactive system for substantiating and determining the maximum coal processing efficiency.

The importance of elaborating a novel scientific methodology, resides in the need of reducing the degree of energy dependence on other states in the region, due to current political and economic points of view.

The interactive system consists of a three computer programs package which allows calculating rapidly the coal processing efficiency. The proposed methodology replaces the classical method of abacuses reading in order to establish the theoretical recovery value and thus, the efficiency.

The new method uses only the same data bases of the densimetric analysis on granulometric classes, which allows the abacuses tracing [1] in order to calculate the theoretical recoveries.

The three programs elaborated in C [2], allow:
- The selection of coal collieries which feeds the coal plant in order to establish a global densimetric analysis on a mixture of coals;
- The calculus and the tracing of washing curves HR for the coals mixture and for any ash content of the feeding;
- The calculus of the maximal recoveries, taking into account not only the densimetric analysis but also the selectivity indices of the concentration installations and the separation density between products. No matter what the calculus methodology is, in the coal processing plants, it is usually applied the notion of "organic efficiency":

$$\eta = \frac{v_r}{v_t} \cdot 100 \qquad (1)$$

Briefly, the new methodology consists of the recalculation of a densimetric analysis on a coals blend, the washing curves tracing for any ash content (to determine the theoretical recovery v_t) and the calculus by the Fournol method of the possible recovery, v_r [3, 4].

2. The Interactive System Description and Program Results

For a proper assessment of the coal processing results, it is necessary to know the densimetric analysis of the rough coal.

A different washability of coals from different zones influences the selectivity indices of concentration machines. Therefore, the establishment of an average densimetric analysis from a blend of coals is an important step of the proposed interactive system. This densimetric analysis is the data base for starting the global calculus and these are carried out for different periods of time; the samples are representative in time and this is also an important aspect of our research. The selectivity of coal processing is different on granulometric classes and that's why the densimetric analysis and the calculus stages are carried out on two granulometric classes which represent the concentration installations feeding. In order to establish a global densimetric analysis for a coals mixture, it is necessary to know the coal-classes weight and their ash content. In this way it will be possible to recompose the granulometric and densimetric composition of the plant's feeding by a successive weighting average.

The SELECT program allows to do this calculus, starting from a selection matrix of the coal colliery (A) and from two matrices which include the densimetric analysis results on granulometric classes (B) and (C) - the last matrices with the same form. The general format of these matrices is presented in Tables 1, 2 and 3 [5, 6].

Table 1. *Matrix A*

Mines / Coal plant	P_1	P_2	P_3…	P_n
E_1	1	0	1	1
E_2	1	0	0	1
E_3	0	1	0	1
E_4…	0	1	1	0
E_n	0	1	0	0

Table 2. *The form of matrices B and C*

Densimetric fractions, t/m³											
-1.4		1.4-1.5		1.5-1.7		1.7-1.9		1.9-2.0		+2.0	
v^*	y^{**}	v	y	v	y	v	y	v	y	v	y
v_{11}	y_{11}	v_{12}	y_{12}	v_{13}	y_{13}	v_{14}	y_{14}	v_{15}	y_{15}	v_{16}	y_{16}
v_{21}	y_{21}	v_{22}	y_{22}	v_{23}	y_{23}	v_{24}	y_{24}	v_{25}	y_{25}	v_{26}	y_{26}
v_{31}	y_{31}	v_{32}	y_{32}	v_{33}	y_{33}	v_{34}	y_{34}	v_{35}	y_{35}	v_{36}	y_{36}
v_{41}	y_{41}	v_{42}	y_{42}	v_{43}	y_{43}	v_{44}	y_{44}	v_{45}	y_{45}	v_{46}	y_{46}
…	…	…	…	…	…	…	…	…	…	…	…
v_{n1}	y_{n1}	v_{n2}	y_{n2}	v_{n3}	y_{n3}	v_{n4}	y_{n4}	v_{n5}	y_{n5}	v_{n6}	y_{n6}

* - weight recovery, %   ** - ash contents, %

The HR program makes up the basis of the abacuses tracing, in order to establish the theoretical recovery. The abacuses are graphic representations of the quantity and the quality variation of the concentrate with the ash content of the rough coal (the feeding) [7].

The abacuses tracing is possible only if we consider that, in time, the washability of coal is constant; this assumption allows the HR curves tracing for any ash content in the plant feeding.

The calculus algorithm is very simple: maintaining constant the ash contents on densimetric fractions, we recalculate the weight recoveries (the quantities), by applying a correction coefficient, calculated by the relation:

$$k = \frac{v_1}{v_2} \qquad (2)$$

- v_1 represents the concentrate weight recovery (all the densimetric fractions under the density 1.9 kg/dm³) for the initial ash content of the coal plant feeding;

- v_2 is the concentrate weight recovery for an imposed ash content (the new content for what we desire to recalculate and to trace the HR curves);

The value of v_2 is calculated by the relation:

$$v_2 = \frac{b-a}{b-c} \cdot 100 \qquad (3)$$

where:

b - is the ash content of the densimetric fraction +1.9 kg/dm³;

a - represents the imposed average ash content (for the new HR curves);

c - the ash content of the concentrate (weighting average of ash contents of densimetric fractions = 1.9 kg/dm³ from the densimetric analysis).

The correction coefficient k, can be under or over unitary, depending on the imposed ash content.

Applying this calculus algorithm, we can trace un unlimited number of washability curves, in order to obtain a high accuracy of the abacuses. We can establish directly the theoretical recoveries for any ash content of the rough coal and of the concentrate, by abacuses reading.

The automatically calculated data, which is the basis for the HR curves tracing are presented in Table 3.

The computer HR curves are rendered in Figure 1 and the abacuses resulted from the HR curves interpretations are presented in Figure 2.

Table 3. *The computer data for the HR curves*

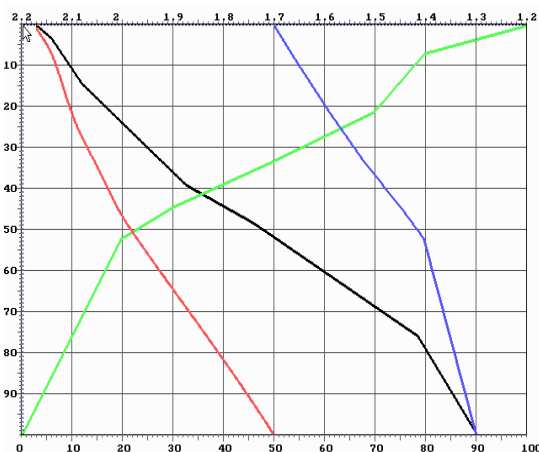| δ	v (%)	y (%)	+v/2 (%)	Σv (%)	v·y	Σv·y	Σv·y/Σv	100−Σv	100a−Σvy	100a−Σvy /100a−Σv
								100.00	5000.00	50.00
-1,4	7.47	6.12	3.73	7.47	45.71	45.71	6.11	92.53	4954.28	53.54
1,4-1,5	14.25	12.10	14.59	21.72	172.42	218.14	10.04	78.28	4781.85	61.08
1,5-1,7	11.98	22.90	27.71	33.70	274.34	492.48	14.61	66.30	4507.51	67.98
1,7-1,9	11.27	32.80	39.33	44.97	369.65	862.13	19.17	55.03	4137.86	75.19
1,9-2,0	7.39	46.10	48.66	52.36	340.67	1202.81	22.97	47.64	3797.18	79.70
+2,0	47.64	78.50	76.18	100.00	3739.74	4942.55	50.00	0.00	0.00	

Fig. 1. *The washability curves HR*
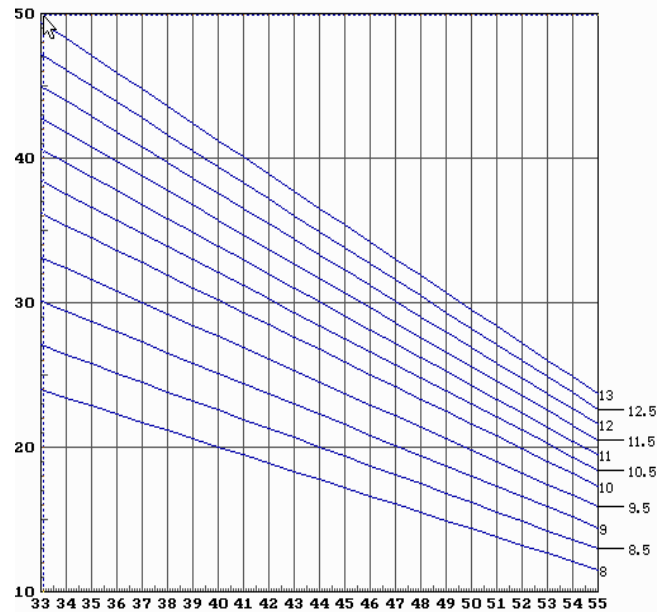
Fig. 2. *The abacuses of the theoretical recovery variation with the ash content from the rough coal and from the concentrate*

To establish the probable recovery, we used the mathematical method of Fournol, starting from the densimetric analysis, the concentration machine imperfection and the separation density. The results obtained by using the FOURNOL program are presented in Table 4.

Table 4. *The computer results from the Fournol method*

dm	Brut			x	n		ci=vi*n	ki=viyi*n	vi-ci	vi*yi-ki
	vi(%)	yi(%)	vi*yi							
1.35	1.96	6.12	12.00	2.6108	0.9954		1.9526	11.9502	0.0088	0.0542
1.45	8.17	12.10	98.87	1.6642	0.9519		7.7788	94.1240	0.3926	4.7506
1.60	9.58	22.90	219.41	0.5806	0.7194		6.8930	157.8511	2.6884	61.5653
1.80	9.57	32.80	314.11	-0.5029	0.3075		2.9449	96.5943	6.6316	217.5168
1.95	6.30	46.10	290.72	-1.1502	0.1250		0.7888	36.3672	5.5175	254.3604
2.10	55.28	78.50	4339.96	-1.7024	0.0442		2.4487	192.2259	52.8374	4147.7382
			5275.09				22.8071	589.1130	68.0765	4685.9858
								25.8302		68.8340

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The comparative results between the coal efficiencies planned, realized in the processing plants over time, and calculated by the interactive system, are presented in Table 5.

Table 5. The comparative results of the coal processing efficiencies

Coking coal efficiency, %			Global efficiency, %		
Planned	Real	IS calculus	Planned	Real	IS calculus
70	59.1	60.2	85	87.7	87.0
70	54.9	58.3	85	86.5	86.9
70	48.7	56.8	85	87.9	85.7
70	46.2	57.0	85	84.0	85.1
70	45.5	55.4	85	83.8	84.3
70	42.7	48.3	85	81.7	84.5
70	29.2	49.2	85	79.3	83.9
70	28.3	48.7	85	78.4	84.0
70	23.4	50.2	85	72.8	83.5
70	17.9	49.6	85	74.5	83.6

The data interpretation emphasizes some aspects e.g.:

- the differences between the classical and the new methodology of calculating the coal processing efficiency are acceptable, on the conditions of using the abacuses tracing;

- for the global efficiency, the planned and the calculated values by the proposed system are very closed, but it's obviously that the planned values must be modified in time, depending on the feeding quality.

3. Conclusions

The interactive system for substantiating and determining the maximum coal efficiency allows:

The interactive method for calculating the maximum efficiency (organic processing yields) of a solid raw material containing a mass of fuel in the form of coal, allows:

- the efficiency calculus by eliminating the classic method where the theoretical recovery (the weight concentrate extraction) is determined by reading on the abacuses;

- the establishment of maximal efficiencies values possible to achieve for any coals blend (with the same or with different washability) in correlation with the market demands;

- the calculus of the optimal values of the separation efficiencies on granulometric classes in order to obtain an automatic adjustment of the concentration machines (especially of the jigging machines); for the jigging process we have a rapid method to establish the efficiency criterion which include the separation between the three concentration products (the coking coal, the energetic coal and the gangue).

The main advantages of the interactive system application are:

• Replacing the old calculus method, where the subjectivism may introduce some errors in the calculus results;

• Offering the possibility to establish the optimum coals blend for the coal plant feeding, in correlation with the market demands and taking into account the washability and the coking properties of the rough coal;

• Allowing to use the selectivity indices of the concentration installations from practice in the efficiency indices;

• Assuring the data bases to elaborate and to assess a complex technical study depending on the concentrates quality, making up a scientific bases so useful for a profitable coal processing activity.

References

[1]. **Popescu F.**, *Programarea şi utilizarea calculatoarelor*, Editura Sigma Plus, Deva, 2002.

[2]. **Popescu F.**, *Aplicaţii industriale ale tehnicii de calcul*, Editura AGIR, Bucureşti, 2009.

[3]. **Bădulescu C.**, *Procesarea diferitelor tipuri de deşeuri industrial*, Editura Universitas, Petrosani, 2021.

[4]. **Bădulescu C.**, *Solubilization Processing of Ashes Power Plant*, Mining Revue, vol. 27, no. 1, p. 45-51, https://doi.org/10.2478/minrv-2021-0006, 2021.

[5]. **Garaliu A., Ciocan V., Sârbu R., Zăvoianu C.**, *Implementarea unui nou sistem de apreciere a rezultatelor maximale posibil de realizat la uzinele de preparare a cărbunilor din Valea Jiului*, 7th BMPC, Vatra Dornei - România, p. 350-356, 28-30 mai 2007.

[6]. **Krausz S.**, *et al.*, *Study concerning the coal processing efficiency increasing for the processing plants in the Jiu Valley*, Petroşani, Petroşani, 1999.

[7]. **Mihăilescu L.**, *et al.*, *Modern Methods in the Coal Processing Efficiency Calculus*, Postgraudate coursebook, University of Petroşani, Romania.