Interactive system for substantiating and determining the maximum efficiency coal processing, regardless of the technology applied

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Abstract: - For an operative control of a macro system and for establishing scientifically proved likely maximal indicators, an interactive system has been worked out. It enables us to determine the criteria of technical efficiency in accordance with the economic one, imposed by market economy laws. The proposed interactive system gives us the possibility of finding the optimum combination of several raw coal grades of various, dressing, which supply the processing plants in the Jiu Valley, the only coal basin of Romania where coking and semi-coking coal is being mined. The system structure combines 3 programs enabling: selecting the blend of row coal coming from several mines, determining the theoretical weight extractions, function of the terminal product quality and the calculation of probable results by the Fournol method for establishing the maximum achievable weight extraction by taking into account the equipment flaws and the products separation densities.

Key-Words: - coal dressing, weight extraction, interactive system, abacuses

1 Introduction

Although the coal processing activity was diminished a lot in Romania, however it is necessary to approach this activity especially in connection with his efficiency, taking into account the coal quality worsening.

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 necessity to elaborate a scientific methodology starts from two reasons: the new demands of the coal marketing and the performances of the new coal technologies, which must to replace the old technologies from the coal processing plants.

The interactive system consists of a three computer, programs package which allows to calculate rapidly, the coal processing efficiency. The proposed methodology replaces the classical method of efficiency calculation, which involves usually the abacuses using.

The new method has the same data basis in order to establish the theoretical recoveries - the densimetric analysis on granulometric classes, which allows the abacuses tracing.

The three programs elaborated in C, allows:

- The selecting 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 indicies 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”:

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

Briefly, the new methodology consist 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.

2 The interactive system description

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 proceeded from different zones influences the selectivity indicies of concentration machines. Therefore, the establishing of an average densimetric analysis from a bled of coals is an important step of the proposed interactive system. These 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 classes weight and their ash content. So will be possible to recompose by a successive weighting average the granulometric and densimetric composition of the plant's feeding.

The SELECT program allows to do this calculus, starting from a selection matrix of the coal colliery (A) and from a two matrices which include the densimetric analysis results on granulometric classes (B) and (C) – the last matrices with the same form. the general presentation of these matrices are presented in tables 1,2 and 3.

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

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).

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.

Table 2 – The form of matrices B and C

-1.4		1.4-1.5		...		1.9-2.0		+2.0	
v^*	y^{**}	V	y	...	...	v	y	v	y
v_{11}	y_{11}	v_{12}	y_{12}	...	...	v_{15}	y_{15}	v_{16}	y_{16}
v_{21}	y_{21}	v_{22}	y_{22}	...	...	v_{25}	y_{25}	v_{26}	y_{26}
v_{31}	y_{31}	v_{32}	y_{32}	...	...	v_{35}	y_{35}	v_{36}	y_{36}
v_{41}	y_{41}	v_{42}	y_{42}	...	...	v_{45}	y_{45}	v_{46}	y_{46}
…	…	…	…	...	...	…	…	…	…
v_{n1}	y_{n1}	v_{n2}	y_{n2}	...	...	v_{n5}	y_{n5}	v_{n6}	y_{n6}

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:

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

- v_1 represents the concentrate weight recovery (all the densimetric fractions under the density 1,9 kg/dm^3) 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:

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

where:

b – is the ash content of the densimetric fraction +1,9 kg/dm^3;

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/dm^3 from the densimetric analysis).

The correction coefficient k can be under or over unitary, function by 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. By abacuses reading, for any ash content of the rough coal and of the concentrate we can establish directly the theoretical recoveries.

The data automatically calculated which are 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.

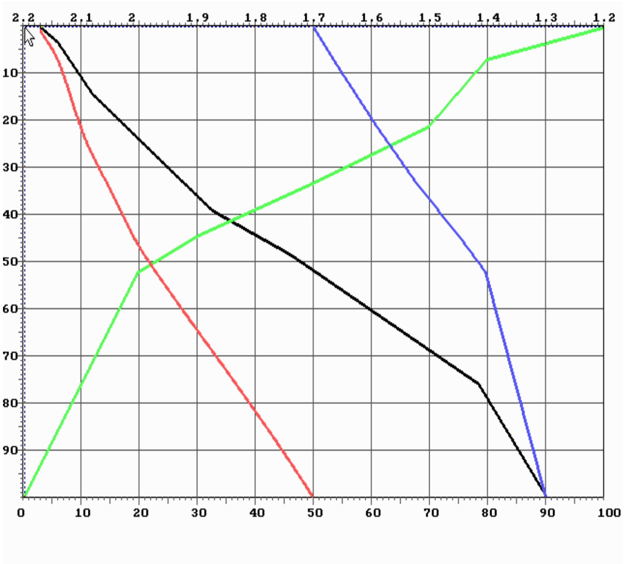

Fig.1 The washability curves HR

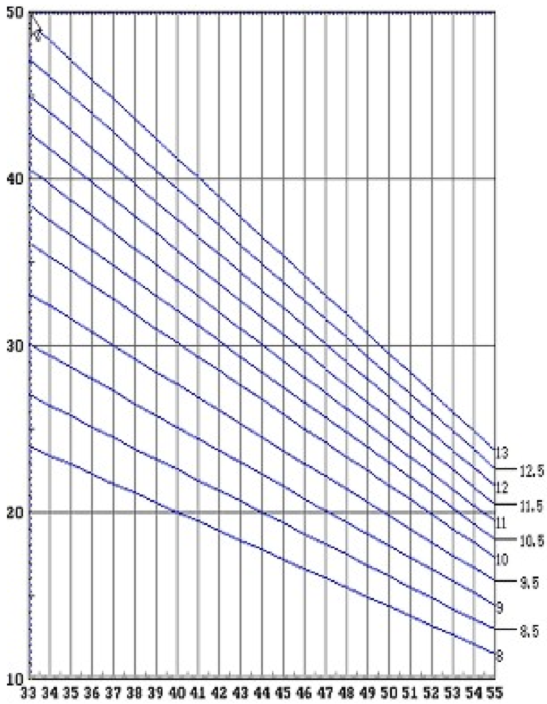

Fig.2 The abacuses of the theoretical recovery variation with the ash content from the rough coal and from the concentrate

Table 3 – The computer data for the HR curves

δ	DATE ANALIZE v (%)	y (%)	Σv +v/2 (%)	Σv (%)	'c' v·y	Σv·y	Σv·y/Σv	'b' 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	

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Table 4 The computer results from the Fournol method

dm	Brut vi(%)	yi(%)	vi*yi	x	n	ci=vi*n	ki=viyi*n	vi-ci	vi*yi-ki
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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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.

3 Comparative study of coal recovery in a coal plant using the interactive system

In order to verify the viability of the proposed interactive system it was made up a comparative study, using the real data, base from the most important coal plant from the Jiu Valley.

The evolution of the quantities, qualities and the efficiencies of coal processing on a ten years period of time is rendered in the tables 5 and 6.

The main characteristics of the rough coal are presented in table 7, inclusively the granulometric classes rates.

Taking into account that the main parameters which point out the efficiency of the coal processing are the global and the coking coal recoveries, in figure 3 are presented the variation of both parameters, depending on the feeding quality (the variation in time of the ash contents from coal plant feeding).

Table 5 – The quantitative-qualitative parameters evolution for the coking coal

	Quantity (tones)	Coking coal recovery (%)	Ash con-tent (%)	Efficiency %	
				P plan	R real
1	245741	21,7	11,1	70,0	59,1
2	242835	21,3	11,0	70,0	54,9
3	258677	23,6	11,3	70,0	48,7
4	260373	23,9	11,7	70,0	46,2
5	185188	20,4	12,1	70,0	45,5
6	150622	19,7	12,7	70,0	42,7
7	127059	18,9	13,3	70,0	29,2
8	92019	17,3	14,7	70,0	28,3
9	79549	15,0	15,2	70,0	23,4
10	56237	11,4	16,6	70,0	17,9

A short analysis of the coal plant realizations point out few technological interpretation such as:

If the quantities decreasing is explicable by the political economical reasons imposed by the market lows, his quality decreasing and the efficiency coal processing decreasing is less justifiable.

Table 6 – The quantitative-qualitative parameters evolution for the processed coal (washed coal)

	Quantity (tones)	Coking coal recovery (%)	Ash con-tent (%)	Efficiency %	
				P plan	R real
1	704130	64,4	30,4	85,0	87,7
2	703862	67,9	31,6	85,0	86,5
3	691649	70,4	30,6	85,0	87,9
4	719263	74,9	32,2	85,0	84,0
5	578713	75,5	32,1	85,0	83,8
6	537938	73,8	33,2	85,0	81,7
7	498270	72,1	34,9	85,0	79,3
8	462409	70,6	39,6	85,0	78,4
9	434695	67,9	41,9	85,0	72,8
10	336750	65,6	44,5	85,0	74,5

Table 7 – The quantitative-qualitative parameters of the rough coal (the coal plant feeding)

Quantity (tones)	Ash cont. %	Granulometric classes, %		Classes ashes, %	
		0-14	14-80	0-14	14-80
1093370	46,9	62,0	38,0	40,7	57,0
1036624	47,0	64,7	35,3	41,6	56,9
982456	47,3	59,5	40,5	38,7	47,6
960298	41,6	64,3	35,7	36,3	51,1
766507	42,9	65,4	34,6	38,1	52,0
728913	43,7	67,2	32,8	35,6	60,3
691082	43,1	60,4	39,6	34,1	56,8
654970	41,6	64,2	35,8	35,2	53,1
640199	43,6	60,9	39,1	38,4	51,7
511004	41,8	64,1	39,9	37,3	61,5

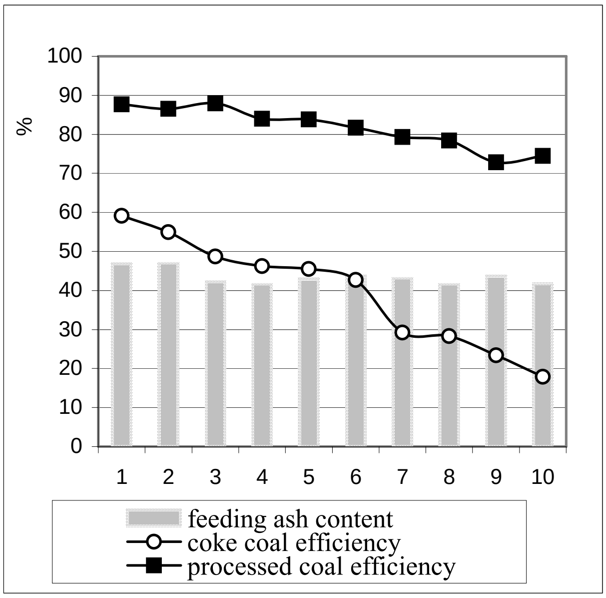

Fig.3 The variation of the ash content from feeding and of the processing efficencies in time

The planned efficiencies for the coal plant are constants in time; obviously, this aspect reflects a total unsuitable way to establish the planned parameters, without a correlation between the rough coal parameters and the processing installations possibilities.

The weights on granulometric classes of the rough coal are relatively constants in time and this aspect, don't imposes modifications in the technological flow or the concentration machines replacing.

In figure 3, we can observe that the rough coal quality is almost constantly in time and therefore, a constant decreasing of the coal processing efficiency id unacceptable; this is a clear proof of an uncorrelation existence between the feeding quality and the concentrates quality, respectively the coal processing efficiency.

The comparative results between the coal efficiencies planned, realized and calculated by the interactive system, are presented in table 8.

Table 8 – 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

4 Conclusions

The interactive system for substantiating and determining the maximum coal efficiency 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 establishing of maximal efficiencies values possible to achieve for any coals blend (with the same or with different washabilities) in correlation with the market demands;
- the calculus of the optimal values of the separation efficiencies on granulometric classes in order to 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 criterions which includes 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:

- Replace the old calculus method, where the subjectivism may introduce some errors in the calculus results;
- Offers 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;
- Allows, to use in the efficiency calculus, the selectivity indicies of the concentration installations from practice;
- Assures the data bases to elaborate and to assess a complex technical study function of the concentrates quality, making up a scientific bases, so useful for a profitable coal processing activity.

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