Enrichability curves analysis of several coals mixture

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S u m m a r y. The paper analyzes the shape of the curve enrichment few coals. The numerical experiment a mixture of four coal mines. A comparison of the curves with the curves of mixtures enrichability raw material prove the assertion of the immutability of species distribution functions boundary ash and coal density fractions in description of the fractional composition of multi-component mixtures of coal
K e y w o r d s : fraction composition, weight distribution function, a mixture of several coal enrichability curves.

INTRODUCTION

Traditionally [1,2,3] among specialists in coal enrichment a table view of fractional composition is used. The process of finding a table view for a given coal mixture with equity participation from a mathematical point of view, is not complicated, but it has some significant limitations, such as, for example, the inability to obtain the characteristics of the mixture, if splitting into fractions for the terms do not match.

Actual task is to obtain the characteristics of a several coals mixture given arbitrarily, since this problem is solved as in the formation of the several coals batch, as well as directly in the calculation scheme of coal preparation plant [4,5,6,7], such as the calculation of coal preparation plant unit [8,9,10,11,12], which is the union of several coal streams from other units [13,14,15].

OBJECTS AND PROBLEMS

Recent research shows perspectivity of use weight distribution functions to describe the equations of fractional composition. A model is proposed to describe the fractional composition of the raw coal in [4,5,6], and in [7,8,9] a method of fractional composition information recovery based on the proposed model.

These results are relevant for solving a large number of coal enrichment tasks [16,17,18,19], such as the calculation the batch, the evaluation indicators of enrichment and separation, and the results of others [20,21,22,23,24].

The solution of these problems on the basis of analytical description of the raw coals mixture [9] is based on the assumption of enrichment curves form immutability, which, of course, needs no proof.

THE RESULTS OF RESEARCH

As is known, the distribution function of the density and ash content of coal fractions are [1]. Then, using the concept of enrichability [1] surface, the fractional composition can be written as:

$$\Gamma(\rho)=\frac{1}{1+\left(a_0+a_1t_\rho\right)\sqrt{\dfrac{1}{t_\rho}-1}},\ t_\rho=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F(\lambda)=\frac{1}{1+\left(b_0+b_1t_\lambda\right)\sqrt{\dfrac{1}{t_\lambda}-1}},\ t_\lambda=\left(\frac{\lambda-\lambda_{01}}{\lambda_{k1}-\lambda_{01}}\right)^2$$

$$U\left(\rho_{i-1},\rho_i\right)=\frac{\Lambda\left(\Gamma_i\left(\rho_i\right)\right)-\Lambda\left(\Gamma_{i-1}\left(\rho_{i-1}\right)\right)}{\Gamma_i\left(\rho_i\right)-\Gamma_{i-1}\left(\rho_{i-1}\right)}$$

$$\Lambda(\Gamma)=\int_0^\Gamma\lambda(\Gamma)d\Gamma,$$

where: a_0, a_1, b_0, b_1 – parameters on the results of the experiment.

Obviously, to get the total number of the coals mixture characteristics, given the parameters of the fractional composition equations is sufficient to obtain an algorithm for determining the distribution function parameters, for example, the density, since the distribution function in the algorithm is the same for the ash. So, let

$$F_1(t)=\frac{1}{1+(a_{01}+a_{11}t)\sqrt{\frac{1}{t}-1}}\quad t=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F_2(t)=\frac{1}{1+(a_{21}+a_{21}t)\sqrt{\frac{1}{t}-1}}\quad t=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F_3(t)=\frac{1}{1+(a_{31}+a_{31}t)\sqrt{\frac{1}{t}-1}}\quad t=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F_3(t)=p_1F_1(t)+p_2F_2(t).$$

Obviously, because ρ_0 it ρ_k makes sense and not just the parameters of the distribution, and are physical values, namely, the minimum and maximum density of raw materials, it is obvious that the minimum density as a result of two distribution laws superposition is $\rho_{03}=\min\{\rho_{01};\rho_{02}\}$, and accordingly, the maximum density $\rho_{k3}=\max\{\rho_{k1};\rho_{k2}\}$. Then for mathematical correctness, it is necessary to determine the distribution function as follows:

$$F(t)=\begin{cases}0,\rho<\rho_0\\ \dfrac{1}{1+(a_0+a_1t)\sqrt{\frac{1}{t}-1}},\rho_0<\rho<\rho_k\\ 1,\rho>\rho_k\end{cases}.$$

One way of finding the distribution function parameters is the final realization of the changes in the table analytic representation, perform calculations in a table, and then perform the inverse transformation in analytical form. Although this approach at first glance looks like the easiest way to get the distribution function final parameters, it has several disadvantages, one of which is the time it takes to double conversion.

Let us introduce the auxiliary function

$$\varphi(\theta)=\left\|F_3(\theta,t)-\left(p_1F_1(t)+p_2F_2(t)\right)\right\|,$$

where: θ – vector of the desired function unknown parameters.

Then, the problem reduces to solving a standard problem of finding the minimum of the function.

The proposed approach can be used for finding the parameters of the law as a distribution by density, and by ash content. Moreover, a similar approach can be applied in the case of equations size distribution. In addition, the proposed approach allows as well to find the parameters composition of n functions.

To solve the problems we will use the information about fraction composition of four different coal mines. Fractional composition of the raw coals from the coal mines is given in tables 1-4.

Thus, the proposed algorithm for finding the parameters of the several coals fractional composition equations allows for all calculations.

Table 1. Fractional composition of the coal mine number one "Almaznaya"

ρ, t/m3	γ_{teor},%	A^d_{teor},%	γ_{exp},%	A^d_{exp},%
<1.6	30,8698	8,5999	30,87	8,6
1,6-1,8	46,9603	47,5004	46,96	47,5
>1,8	22,1699	92,1991	22,17	92,2

where: ρ – density of narrow fractions γ_{exp} – experimental output value narrow faction A^d_{exp} – experimental value of the average ash content of narrow fraction, γ_{teor} – output value narrow fraction, obtained by simulation, A^d_{teor} – the average ash content of narrow fraction, obtained by simulation.

Weight distribution function of raw materials fractional composition from coal mine "Almaznaya" have forms (fig. 1, fig. 2)

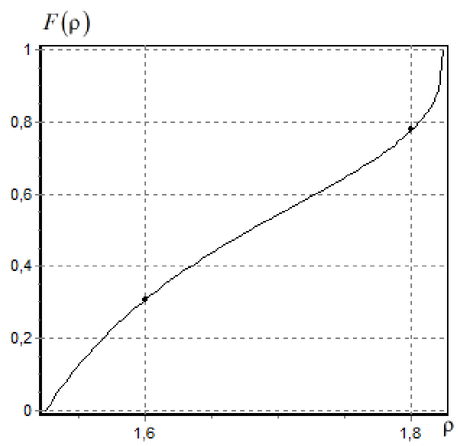

Fig. 1. The distribution function by the coal fractions boundary density

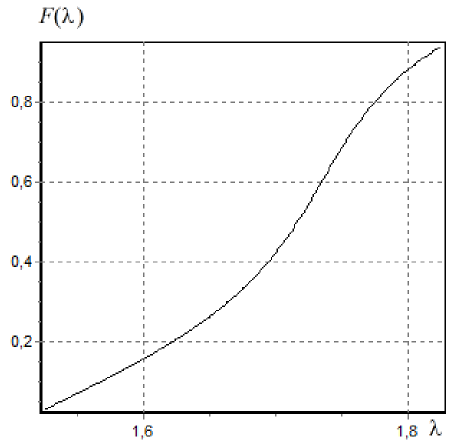

Fig. 2. The distribution function by the coal fractions boundary ash content

Table 2. Fractional composition of the coal mine number two "Zarechnaya"

ρ, t/m3	γ_{teor} ,%	A^d_{teor} ,%	γ_{exp} ,%	A^d_{exp} ,%
<1.6	75,3231	2,6104	75,3131	18,8
1,6-1,8	14,9195	5,6987	14,9195	33,1
>1,8	9,7574	20,1238	9,7674	46,7

Weight distribution function of raw materials fractional composition from coal mine "Zarechnaya" have forms (fig. 3, fig. 4) follows:

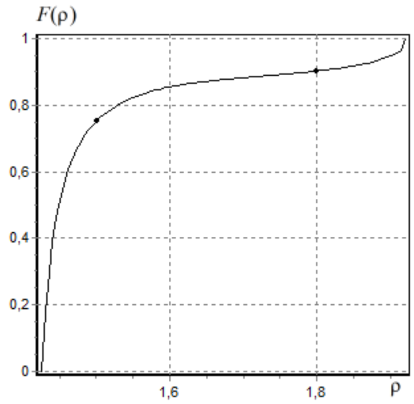

Fig. 3. The distribution function by the coal fractions boundary density

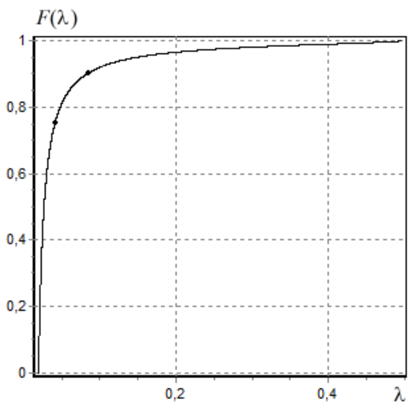

Fig. 4. The distribution function by the coal fractions boundary ash content

Table 3. Fractional composition of coal mine number 3 "Velikomostovskaya"

ρ, t/m3	γ_{teor} ,%	A^d_{teor} ,%	γ_{exp} ,%	A^d_{exp} ,%
<1.6	71,3231	2,6104	71,3231	18,8
1,6-1,8	19,6595	5,6987	19,6595	2,89
>1,8	9,7523	20,1238	9,7523	1,89

Weight distribution function of raw materials fractional composition from coal mine "Velikomostovskaya" have forms (fig. 5, fig. 6) follows:

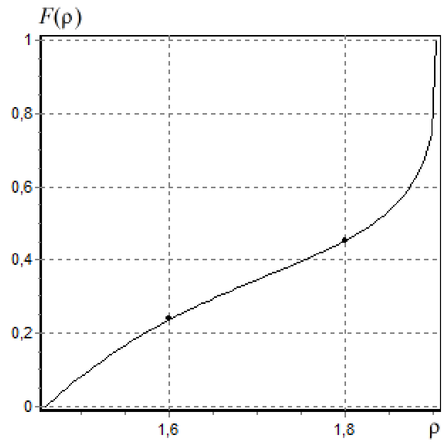

Fig. 5. The distribution function by the coal fractions boundary density

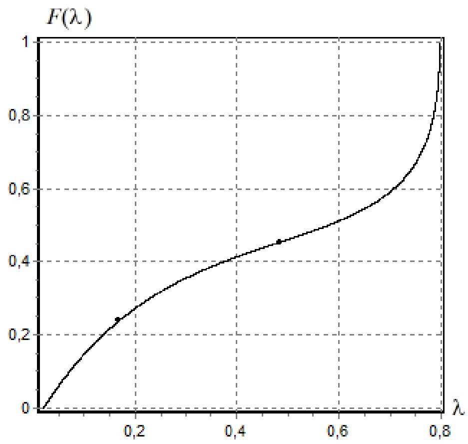

Fig. 6. The distribution function by the coal fractions boundary ash content

Table 4. Fractional composition of coal mine № 4 "Novodonetskaya"

$\rho_{m/м^3}$	γ_{teor} %	A^d_{teor} %	γ_{exp} %	A^d_{exp} %
<1.6	34,2574	9,4483	34,6	7,5
1,6-1,8	8,5149	25,126	8,6	26,7
>1,8	57,2277	83,2856	57,8	83,3

Weight distribution function of raw materials fractional composition from coal mine "Novodonetskaya" have forms (fig. 7, fig. 8) follows:

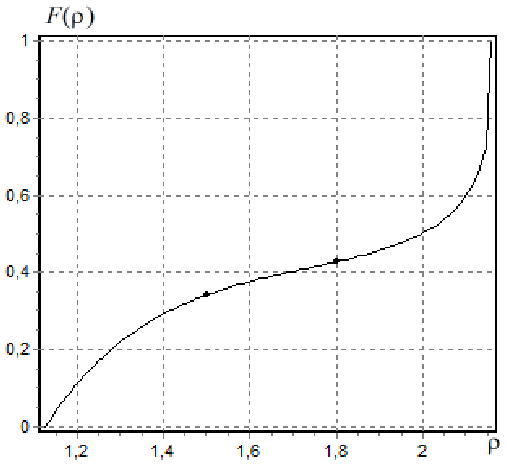

Fig. 7. The distribution function by the coal fractions boundary density

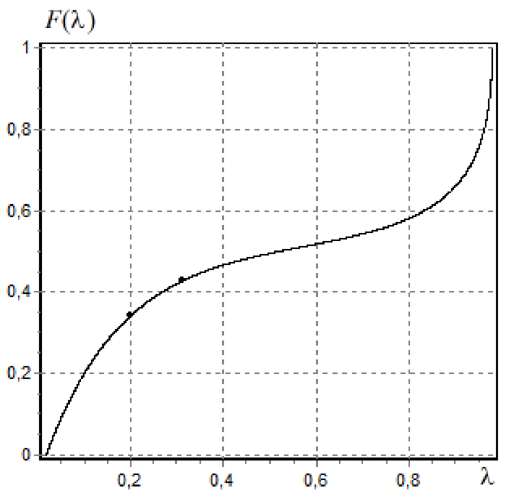

Fig. 8. The distribution function by the coal fractions boundary ash content

Fractional composition of the mixture for numerical experiments we find as a linear combination with the corresponding outputs

$$\gamma = q_1\gamma_1 + q_2\gamma_2 + q_3\gamma_3 + q_4\gamma_4,$$

where: $q_i, i = 1,2,3,4$, the batch components equity participation, and similarly for the average ash content.

The numerical experiment number 1 with equity participation: $q_1 = 0.3$, $q_2 = 0.4$, $q_3 = 0.4$, $q_4 = 0.5$ (table 5, fig. 9, fig. 10).

Table 5. Fractional composition. Numerical experiment number one

$\rho_{m/м^3}$	γ_{teor} %	$A^d{}_{teor}$ %	$\gamma_{\exp}$ %	$A^d{}_{\exp}$ %
<1.6	26,64	9,39244	26,64	9,39
1,6-1,8	30,2811	23,53323	30,28	23,53
>1,8	43,0707	48,48292	43,07	48,47

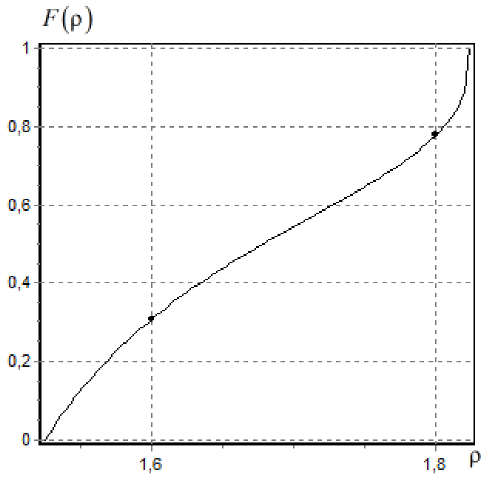

Fig. 9. The distribution function by the coal fractions boundary density

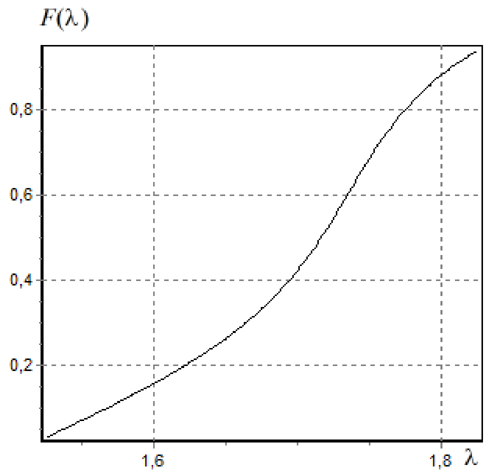

Fig. 10. The distribution function by the coal fractions boundary ash content

The numerical experiment number 2 with equity participation: $q_1 = 0.1$, $q_2 = 0.3$, $q_3 = 0.5$, $q_4 = 0.2$ (table 6, fig. 11, fig. 12).

Table 6. Fractional composition. Numerical experiment number two

$\rho_{m/м^3}$	γ_{teor} %	$A^d{}_{teor}$ %	$\gamma_{\exp}$ %	$A^d{}_{\exp}$ %
<1.6	70,19694	4,83797	63,82	5,95
1,6-1,8	18,33461	14,3342	16,67	15,1
>1,8	21,46845	41,97607	19,52	44,62

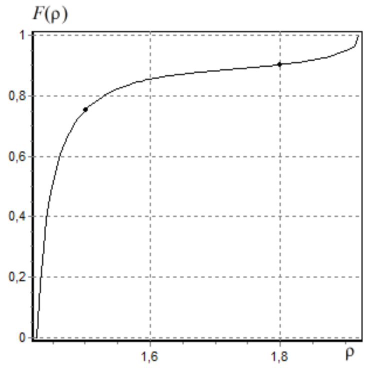

Fig. 11. The distribution function by the coal fractions boundary density

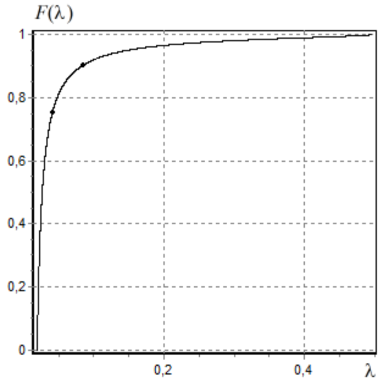

Fig. 12. The distribution function by the coal fractions boundary ash content

The numerical experiment number 3 with equity participation: $q_1 = 0.2$, $q_2 = 0.2$, $q_3 = 0.6$, $q_4 = 0.1$ (table 7, fig. 13, fig. 14).

Table 7. Fractional composition. Numerical experiment number three

$\rho_{m/м^3}$	γ_{teor} %	$A^d{}_{teor}$ %	γ_{exp} %	$A^d{}_{exp}$ %
<1.6	69,8581	3,5552	69,86	3,55
1,6-1,8	12,1791	8,2113	12,18	8,22
>1,8	17,9626	28,4523	17,96	28,45

Weight distribution functions have forms as follows:

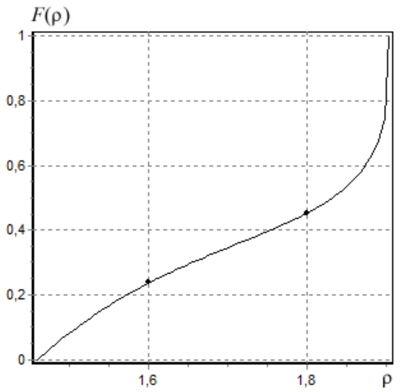

Fig. 13. The distribution function by the coal fractions boundary density

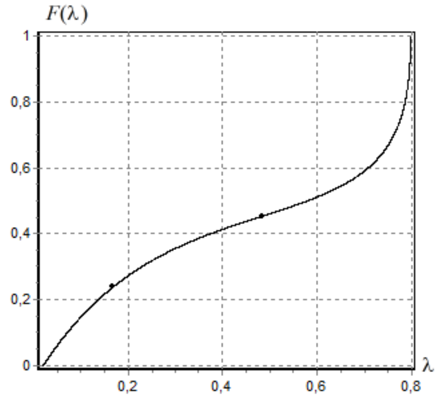

Fig. 14. The distribution function by the coal fractions boundary ash content

The numerical experiment number 4 with equity participation: $q_1 = 0.2$, $q_2 = 0.1$, $q_3 = 0.5$, $q_4 = 0.3$ (table 8, fig. 15, fig. 16).

Table 8. Fractional composition. Numerical experiment number four

$\rho_{m/м^3}$	γ_{teor} %	$A^d{}_{teor}$ %	γ_{exp} %	$A^d{}_{exp}$ %
<1.6	61,64504	6,12071	60,44	6,39
1,6-1,8	20,89823	20,4571	20,49	20,75
>1,8	19,45673	55,4997	19,08	56,25

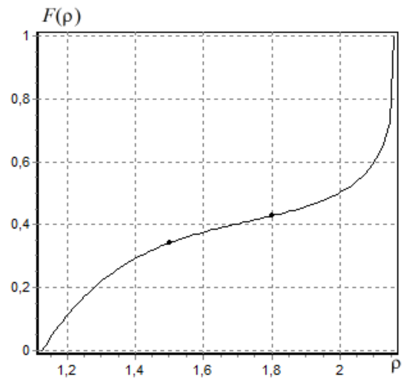

Fig. 15. The distribution function by the coal fractions boundary density

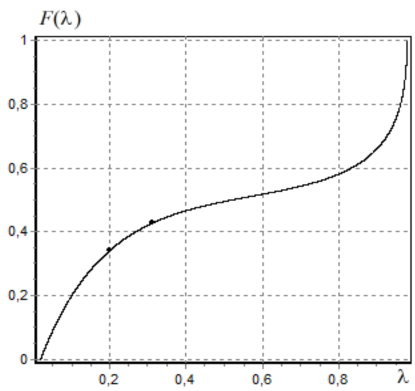

Fig. 16. The distribution function by the coal fractions boundary ash content

CONCLUSIONS

Thus, our numerical simulation shows that the weight distribution function boundary density and average ash mixture of raw coal has the same form as the weight distribution function boundary density and average ash coals involved in the formation of the charge, do not change their appearance. This result confirms the correctness of the method of fractional recovery of not only for modeling information about the raw material, but also on batch of several coal and problems of the forecast results of the division in batch of enrichment devices.

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АНАЛИЗ ВИДА КРИВЫХ ОБОГАТИМОСТИ СМЕСИ НЕСКОЛЬКИХ УГЛЕЙ

Олег Грачев

Аннотация. В работе приведен анализ вида кривых обогащения смеси нескольких углей. Проведен численный эксперимент создания смеси углей четырех шахт. Сравнение полученных кривых обогатимости смеси с кривыми обогатимости исходного сырья доказывают утверждение о неизменности вида функций, распределения граничных зольностей угля по фракциям при описании фракционного состава многокомпонентных угольных смесей
Ключевые слова: фракционный состав, весовые функции распределения, смесь нескольких углей, кривые обогатимости.