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Stability analysis of the model describing the fractional composition of coal

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Summary. The paper analyzes the stability analysis of the model describing the fractional composition of coal. The numerical experiment was made in the neiborhood of each parameter optimum value. The analysis showed that in the neighborhood 0.05 of the parameters optimal values of the fractional composition describing model does not exceed the error of obtaining experimental data.

Key words: fraction composition, weight distribution function, stability analysis.

INTRODUCTION

Raw materials information recovery [1-4], in particular the problem of the fractional composition information recovery [10,12,14], is one of the main objectives of coal preparation, as it directly affects the quality of all processes of coal preparation plant. In practice, the solution of the fractional composition recovery is an inevitable compromise between the price of the fractional analysis and accuracy, that is, the number of bundles. Therefore, the actual task of modern coal preparation is the problem of finding such a description of the information about the fractional composition of coal [18,19], which would allow much detail as possible to calculate output and the ash content of an arbitrary number of narrow fractions of the minimum volume sampling.

One solution to this problem is using a model for the description of coal fractional composition, based on the use of the boundary density weight distribution functions and of the boundary ash content in conjunction with the concept of enrichabilitysurface. This model allows us to obtain an analytical solution that takes into account the physical limitations imposed on the description of the fractional composition of coal. Due to the fact that this model has a stochastic nature, as well as the method of identifying the model parameters, one of the most promising areas for further research is to analyze the influence of errors in the determination of the model parameters on its stability [5-7, 9, 15].

OBJECTS AND PROBLEMS

The purpose of this paper to analyze the experimental data to assess the impact of changes in the parameters straightening weight distribution functions of the boundary density and ash content on the stability of the model describing the fractional composition of coal [20-24].

The model parameters describing the fractional composition can be divided into physical (minimum and maximum boundary density), real (minimum and maximum ash content of the boundary) and the parameters of straightening, determined by the probability of paper [22]. The method of probability paper [8,11,13] is based on finding such a transformation of the distribution function, which turns it into a straight line. Then the question of finding the parameters of the distribution function is to find the coefficients of the line [16,17].

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: $\Gamma(\rho)=\frac{1}{1+\left(a_0+a_1t_\rho\right)\sqrt{1/t_\rho-1}}$, $t_\rho=\left(\frac{\rho-\rho_0}{\rho_1-\rho_0}\right)^2$

$$F(\lambda)=\frac{1}{1+\left(b_0+b_1t_\lambda\right)\sqrt{1/t_\lambda-1}},\ t_\lambda=\left(\frac{\lambda-\lambda_0}{\lambda_1-\lambda_0}\right)^2$$

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

$\Lambda(\Gamma)=\int_0^\Gamma\lambda(\Gamma)d\Gamma$, where: a_0,a_1,b_0,b_1 – parameters on the results of the experiment, ρ_0,ρ_1 – minimum and maximum boundary density, λ_0,λ_1.

The model description shows that the modification of parameters b_0,b_1 influences the calculation of the average ash and does not affect the calculation of output values of narrow fractions.

Consider the experimental data on the fractional composition of the raw coal machine classes of mine "Almaznaya" (class 100 mm), by the identification of the model parameters and compare the experimental and theoretical results (table 1):

$a_0=0,09537594$, $a_1=0,28370233$,

$b_0=0,26466792$, $b_1=0,64594815$,

$\rho_0=1,58175342$, $\rho_1=2,00826073$,

$\lambda_0=0,03893242$, $\lambda_1=0,93534468$,

$\beta_{ke}=45,402$, $\beta_k=45,402$

Table 1. Comparison of theoretical and experimental data describing the fractional composition of coal (мine «Almaznaya»)

γ_e, %	γ_t, %	$\lvert\Delta\gamma\rvert$	A_e^d, %	A_t^d,%	$\lvert\Delta A^d\rvert$
30,87	30,8693	0,0007	8,6	8,6	0
46,96	46,96	0	47,5	47,4991	0,0009
22,17	22,1707	0,0007	92,2	92,1992	0,0008

The comparison results (Table 1) shows that the relative error in determining outputs and the average ash content of narrow fractions does not exceed obtain experimental data error.

Let (speaking about the fractional composition description model):

$\varepsilon_1=\max\limits_{1\le i\le n}\left|\gamma_{i\,\mathrm{e}}-\gamma_{i\,\mathrm{t}}\right|$ – estimation of an absolute error of output value determination,

$\varepsilon_2=\max\limits_{1\le i\le n}\left|\frac{\gamma_{i\,\mathrm{e}}-\gamma_{i\,\mathrm{t}}}{\gamma_{i\,\mathrm{e}}}\right|$ – estimation of an relative error of output value determination,

$\varepsilon_3=\sum\limits_{i=1}^{n}\left(\gamma_{i\,\mathrm{e}}-\gamma_{i\,\mathrm{t}}\right)^2$ – the sum of the narrow fractions outputs squared deviations,

$\varepsilon_4=\sum\limits_{i=1}^{n}\left(\frac{\gamma_{i\,\mathrm{e}}-\gamma_{i\,\mathrm{t}}}{\gamma_{i\,\mathrm{e}}}\right)^2$ – the sum of the narrow fractions outputs relative squared deviations,

where: γ_{ie},γ_{it} – accordingly the output of the i narrow fraction by experimental and theoretical data,

$\varepsilon_5=\max\limits_{1\le i\le n}\left|A_{ie}^{\mathrm{d}}-A_{it}^{\mathrm{d}}\right|$ – estimation of an absolute error of an average ash content determination,

$\varepsilon_6=\max\limits_{1\le i\le n}\left|\frac{A_{ie}^{\mathrm{d}}-A_{it}^{\mathrm{d}}}{A_{ie}^{\mathrm{d}}}\right|$ – estimation of an relative error of an average ash content determination,

$\varepsilon_7=\sum\limits_{i=1}^{n}\left(A_{i\,\mathrm{e}}^{\mathrm{d}}-A_{i\,\mathrm{t}}^{\mathrm{d}}\right)^2$ – the sum of the narrow fractions ash content squared deviations,

$\varepsilon_8=\sum\limits_{i=1}^{n}\left(\frac{A_{i\,\mathrm{e}}^{\mathrm{d}}-A_{i\,\mathrm{t}}^{\mathrm{d}}}{A_{i\,\mathrm{e}}^{\mathrm{d}}}\right)^2$ – the sum of the narrow fractions ash content relative squared deviations,

where: $A_{i\,\mathrm{e}}^{\mathrm{d}},A_{i\,\mathrm{t}}^{\mathrm{d}}$ – accordingly the average ash content of the i narrow fraction by experimental and theoretical data.

Let's do the numerical experiment in a neighborhood of the parameter ρ_0 optimal value. Results analysis showed that estimation of an absolute error of output value determination (fig.1) and the sum relative squared deviations (fig. 3) close to $1,5816$, estimation of an relative error (fig. 2) in the interval $[1,58064649;1,5816651]$, the sum of relative squared deviations in the interval $[1,57623253;1,58641859]$ is not more that 0,05. The behavior of the model in determining the average ash content (figures 5-8) has a similar character.

Let's do the numerical experiment in a neighborhood of the parameter ρ_1 optimal value. Results analysis showed that estimation of all types of calculated errors related to the output values (figures 9-12) in interval $[2,007017;2,009007]$ are close to 0. The behavior of the model in determining the average ash content (figures 14-16) is almost the same excluding (figure 13) the estimation of the absolute error (which is not more than 0,05 in the neighborhood of the optimum value).

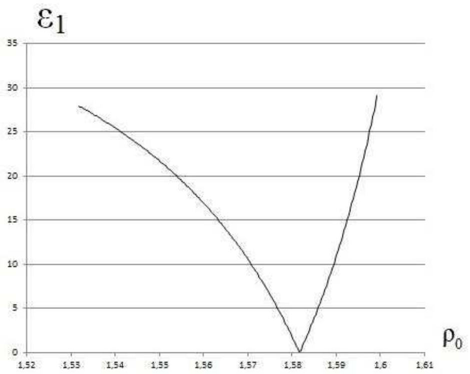

Fig. 1. A plot of $\varepsilon_1(\rho_0)$

Fig. 2. A plot of $\varepsilon_2(\rho_0)$

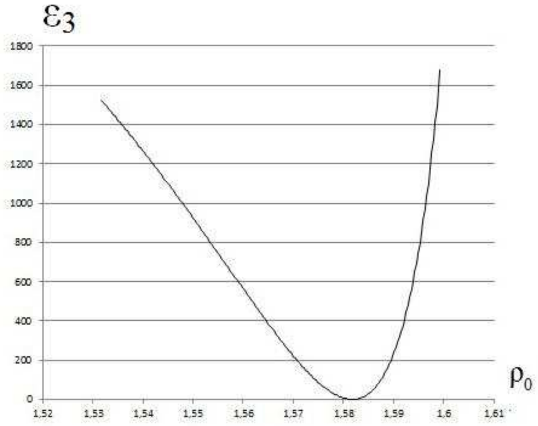

Fig. 3. A plot of $\varepsilon_3(\rho_0)$

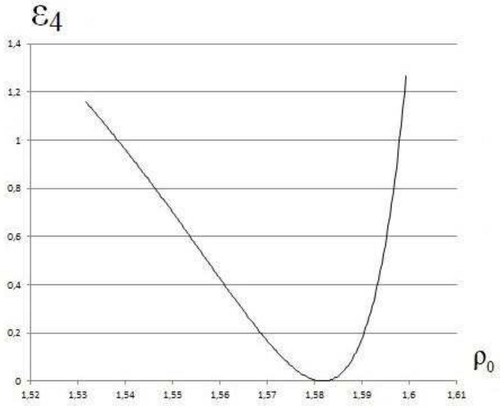

Fig. 4. A plot of $\varepsilon_4(\rho_0)$

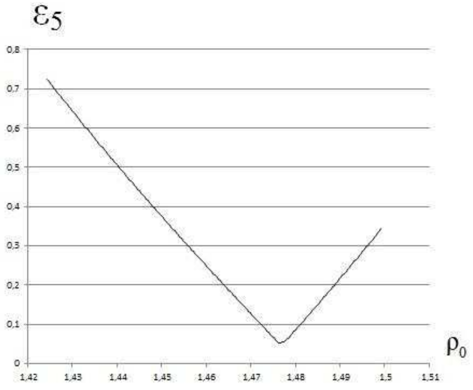

Fig. 5. A plot of $\varepsilon_5(\rho_0)$

Fig. 6. A plot of $\varepsilon_6(\rho_0)$

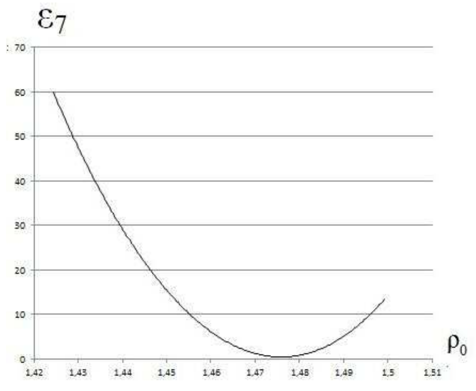

Fig. 7. A plot of $\varepsilon_7(\rho_0)$

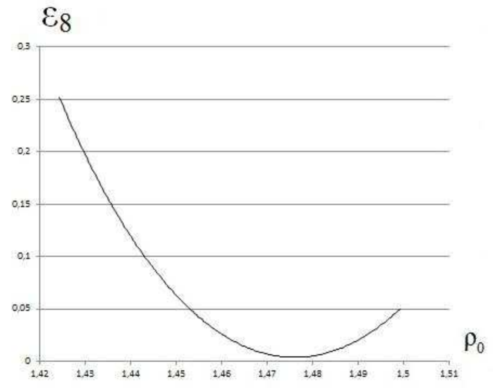

Fig. 8. A plot of $\varepsilon_8(\rho_0)$

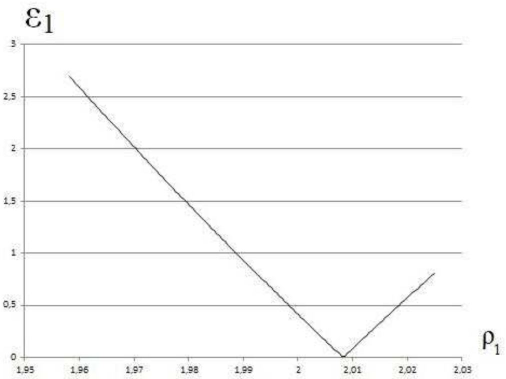

Fig. 9. A plot of $\varepsilon_1(\rho_1)$

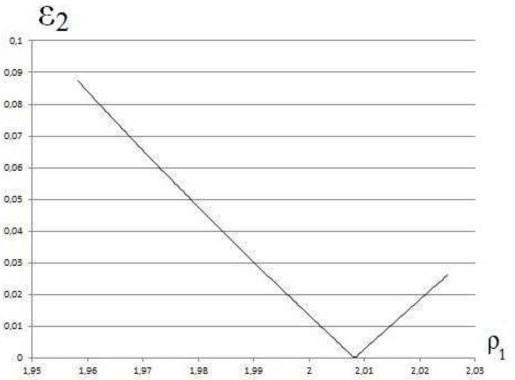

Fig. 10. A plot of $\varepsilon_2(\rho_1)$

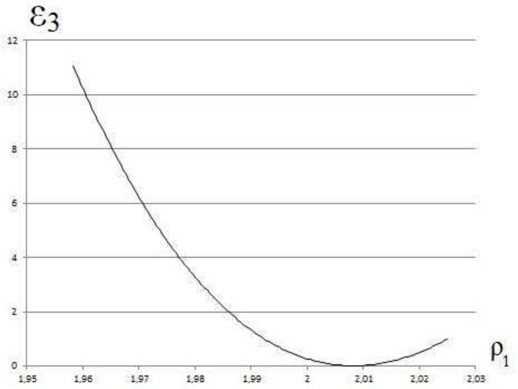

Fig. 11. A plot of $\varepsilon_3(\rho_1)$

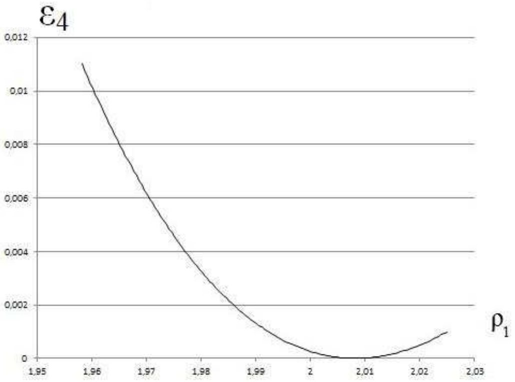

Fig. 12. A plot of $\varepsilon_4(\rho_1)$

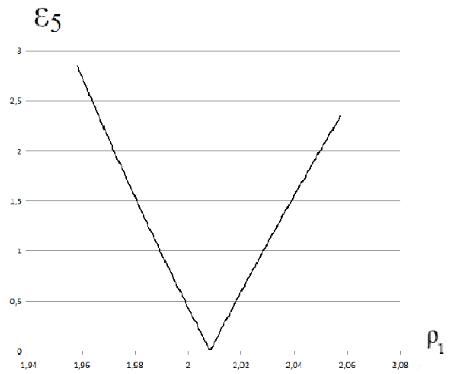

Fig. 13. A plot of $\varepsilon_5(\rho_1)$

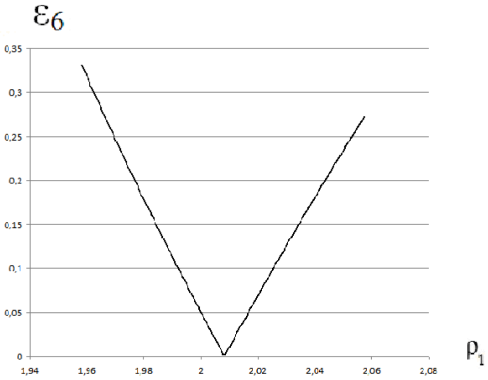

Fig. 14. A plot of $\varepsilon_6(\rho_0)$

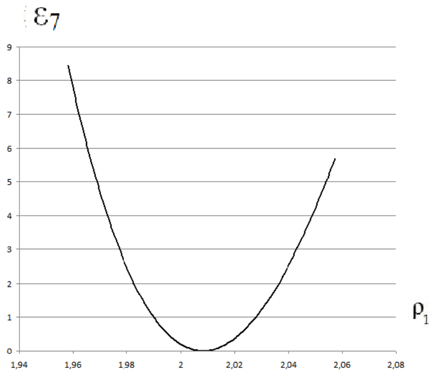

Fig. 15. A plot of $\varepsilon_7(\rho_1)$

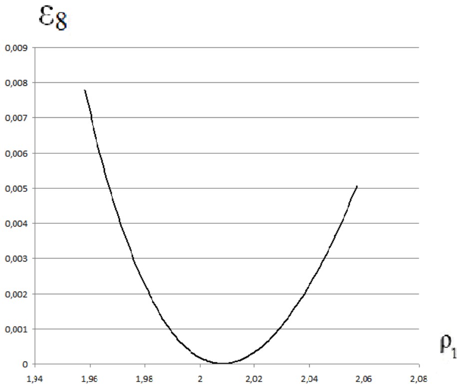

Fig. 16. A plot of $\varepsilon_8(\rho_1)$

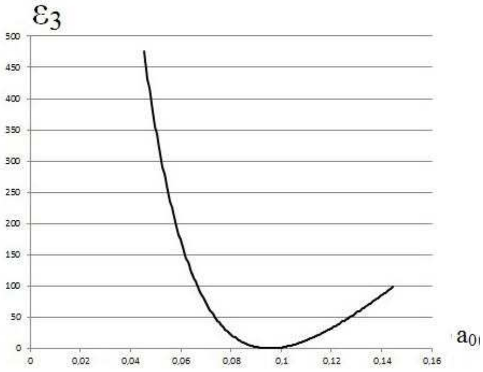

Fig. 17. A plot of $\varepsilon_3(a_0)$

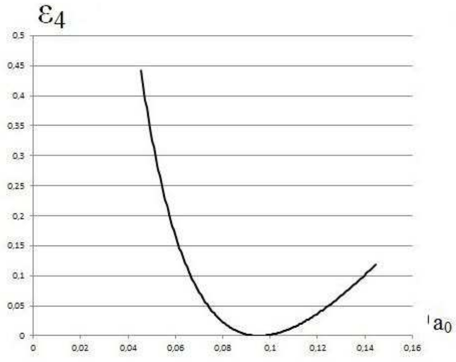

Fig. 18. A plot of $\varepsilon_4(a_0)$

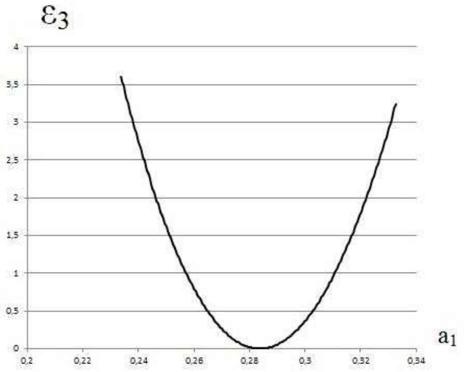

Fig. 19. A plot of $\varepsilon_3(a_1)$

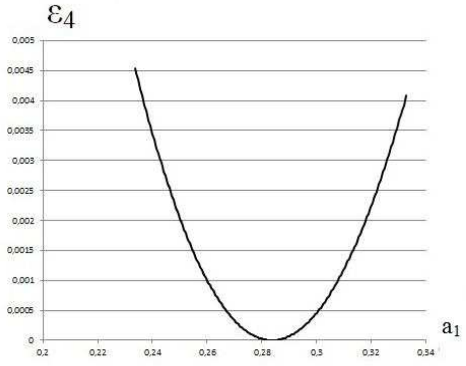

Fig. 20. A plot of $\varepsilon_4(a_1)$

Let's do the numerical experiment in a neighborhood of the parameter ρ_1 optimal value. Results analysis showed that estimation of all types of calculated errors related to the output values (figures 17-18) in interval $[0,09462967;0,09612221]$ are close to 0, excluding the estimation of the absolute error (which is not more than 0,05 in the neighborhood of the optimum value). The behavior of the model in determining the average ash content (Figures 19-20) is almost the same excluding the estimation of the absolute error (which is not more than 0,05 in the neighborhood of the optimum value).

CONCLUSIONS

The analysis showed that in the neighborhood 0.05 of the parameters optimal values of the fractional composition describing model is not very sensitive to changes in parameter values, and almost always (except, perhaps, the values at the boundaries of the range) does not exceed the error of obtaining experimental data.

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АНАЛИЗ УСТОЙЧИВОСТИ МОДЕЛИ ОПИСАНИЯ ФРАКЦИОННОГО СОСТАВА УГЛЯ

Олег Грачев

Аннотация. В статье выполнен анализ устойчивости модели описания фракционного состава угля. Численный эксперимент проведен в окрестности оптимальных значений каждого параметра. Анализ результатов численного эксперимента показал, что в окрестности 0,05 оптимальных значений параметров модели описания фракционного состава не превышает погрешности получения экспериментальных данных.

Ключевые слова: фракционный состав, весовые функции распределения, анализ устойчивости.