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METHOD OF EXTREME CONTROL FOR ORE SELF-CRUSHING MILLS

Igor Novitskiy[1], **Yuliya Shevchenko**[2]
[1]full professor of the System Analysis and Control Department,
State Higher Educational Institution «National Mining University»,
Dnipro, Ukraine
[2]assistant professor of the System Analysis and Control Department,
State Higher Educational Institution «National Mining University»,
Dnipro, Ukraine, e-mail: shevchenko.yu.o@nmu.one

Abstract. Method of extreme control for ore self-crushing mills considered, estimation of comparative efficiency of using such a method proved.

Keywords: ore self-crushing mill, extreme search engines, intensity of fluctuations inside in self-crushing mill, the way of extreme control.

СПОСІБ ЕКСТРЕМАЛЬНОГО КЕРУВАННЯ БАРАБАННИМИ МЛИНАМИ САМОПОПОДРІБНЕННЯ РУДИ

І.В. Новицький[1], **Ю.О. Шевченко**[2]
[1]професор кафедри системного аналізу і управляння,
Державний вищий навчальний заклад «Національний гірничий університет»,
м. Дніпро, Україна
[2]асистент кафедри системного аналізу і управляння,
Державний вищий навчальний заклад «Національний гірничий університет»,
м. Дніпро, Україна, e-mail: shevchenko.yu.o@nmu.one

Анотація. В роботі розглянутий спосіб екстремального керування барабанними млинами сомоподрібнення руди, виконана оцінка порівняльної ефективності використання такого способу управління барабанними млинами.

Ключові слова: барабанний млин самоподрібнення руди, екстремальні пошукові системи, інтенсивність коливань всередині барабанного млина, спосіб екстремального керування.

Introduction.

Extreme search engines are used in conditions of incomplete a priori information about the management object. The effectiveness of the method of extreme control is determined by the amount of this a priori information.

Therefore, it is advisable to used maximum information about the object when implementing a search engine, which was obtained as a result of theoretical or experimental studies.

Productivity of a ore self-crushing mill for a newly formed finished product can be increased by excitation of load oscillations inside the mill, which occurs when the drum rotates [1, 2]. The intensity of the load oscillations inside the mill is determined by the degree of filling of the drum and can be measured with the help of sensors.

It is established, that the dependence of the oscillation intensity A from the degree of filling the drum with ore looks like a bell and structurally described by the Gauss curve:

$$A = \frac{C}{\sqrt{2\pi}\delta} e^{-\frac{(Y-M)^2}{2\delta^2}}, \quad (1)$$

where C, δ, M - parameters that depend on the properties of the ore and the design features of the equipment.

The degree of filling Y is easily regulated by changing the flow of the initial ore to the self-crushing mill.

Formulation of the problem.

Purpose of the control - maintain such a degree of filling Y^* that the intensity of the oscillations A would be maximum. Since the values C, δ, M depend on the properties of the ore and changed, then the extreme characteristic $A(M)$ drifts. Therefore, it is advisable to use an automatic search engine. Significant inertia of the object through the channel "initial ore flow - degree of filling of the self-crushing mill" determines the use of a step search procedure.

Solution of the problem.

Suppose that three pairs of values of the parameter Y and the optimization criterion A are obtained as a result of three consecutive search steps, i.e. (Y_i, A_i) $i = \overline{1,3}$. Using these data, we formulate a system of equations:

$$A = \frac{C}{\sqrt{2\pi}\delta} e^{-{(Y_i-M)^2}/{2\delta^2}}, \qquad i = \overline{1,3} \quad (2)$$

Dividing the first equation of system (2) by the second and third, we obtain a system of two equations:

$$\begin{cases} {}^{A_1}/_{A_2} = e^{\frac{(Y_2-M)^2-(Y_1-M)^2}{2\delta^2}} \\ {}^{A_2}/_{A_3} = e^{\frac{(Y_3-M)^2-(Y_2-M)^2}{2\delta^2}} \end{cases};$$

after the logarithm we obtained:

$$\begin{cases} \frac{\ln\left({}^{A_1}/_{A_2}\right)}{2\delta^2} = (Y_2 - M)^2 - (Y_1 - M)^2; \\ \frac{\ln\left({}^{A_2}/_{A_3}\right)}{2\delta^2} = (Y_3 - M)^2 - (Y_2 - M)^2. \end{cases} \quad (3)$$

Eliminate the parameter δ from system (3) and divide the first equation by the second:

$$\frac{\ln({}^{A_1}/_{A_2})}{\ln({}^{A_2}/_{A_3})} = \frac{Y_2^2 - 2Y_2M - Y_1^2 + 2Y_1M}{Y_3^2 - 2Y_3M - Y_2^2 + 2Y_2M}$$

The last equation is easily solved with respect to the parameter M and determines the optimum point on the optimization parameter Y:

$$Y^* = M = \frac{\ln\left({}^{A_1}/_{A_2}\right)(Y_3^2 - Y_2^2) - \ln\left({}^{A_2}/_{A_3}\right)(Y_2^2 - Y_1^2)}{\ln\left({}^{A_2}/_{A_3}\right)(2Y_1 - 2Y_2) - \ln\left({}^{A_1}/_{A_2}\right)(2Y_2 - 2Y_3)}. \quad (4)$$

Hence, in the search algorithm it is necessary to foresee the calculation of the optimum point in accordance with expression (4) for three consecutive pairs of values $\{Y_i, A_i\}$.

Conclusion.

This method of extreme control is more effective than the known search algorithms, because it is based on apriori information about the structure of the extreme curve (2).

Two stages of extreme control should be analyzed to assess the comparative effectiveness of this method.

1. The phase of exit to the extreme region. The range of drift of the extreme characteristic for the drum mills is ...% of the degree of fill-

ing. For such a range, the approximation error according to the expression (4) was about 0.5% of the filling the mill (it takes three steps to reach the extremum).

On the other hand, the application of the known "golden section" method will reduce the initial uncertainty interval by Y (10 %) in 20 times (up to 0,5 %) for 6 steps.

2. The phase of holding the extremum. A search algorithm, based on approximation in two steps to the third, by expression (4), provides an optimal arrangement of operating points on the extreme characteristic in terms of losses.

   Schematically, the optimal location of points 1, 2, 3, 4, 5, 6, 7 ... is shown in figure 1.

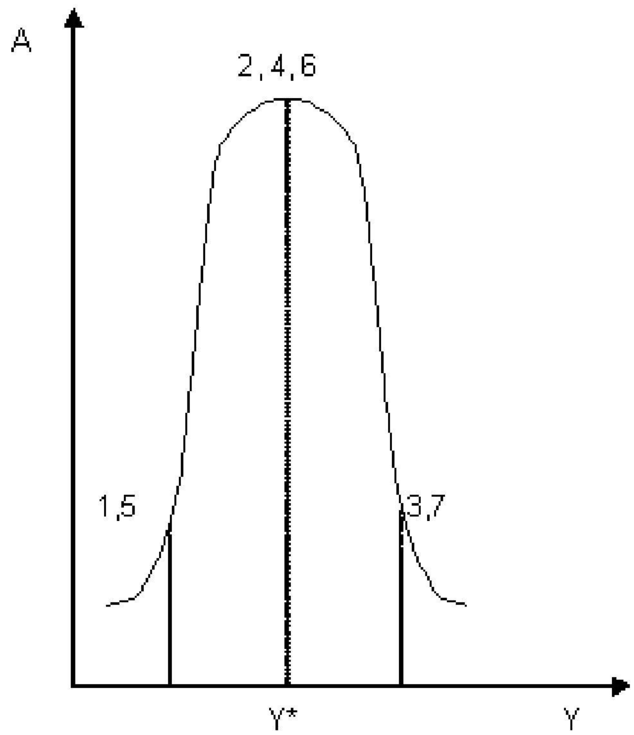

Figure 1 – Optimum positioning of operating points on a statistical characteristic

Any other arrangement of successive operating points of the stepping algorithm will be characterized by large losses.

The method of extreme control, based on the approximation of the statistical characteristic, was applied in the development of an extreme control system for ore self-crushing mills at the concentrating factories of Krivbass [3].

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