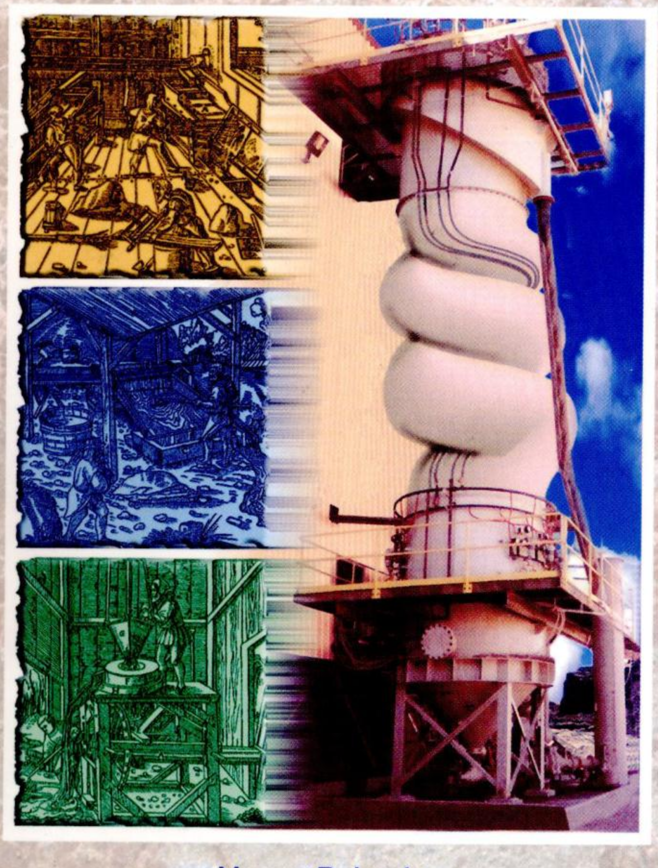
MINERAL PROCESSING IN THE 21ST CENTURY



Varna, Bulgaria
June 15 - 20, 2003

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OPTIMIZATION OF HYDROCYCLONE WORK PARAMETERS

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ABSTRACT:

The paper presents the procedure of optimization of laboratory hydrocyclone work by the application of dispersion analysis and planning with Greek-Latin square. The application of this method makes possible significant reduction of the number of tests and close optimization of the whole process. Tests were carried out by D-100 mm hydrocyclone. Optimization parameters are as follows: contents of solid in pulp, underflow diameter, overflow diameter and inlet pressure.

The influence of optimization parameters on hydrocyclone classifying efficiency according to class -0.074 mm is described by mathematical model.

Keywords: Classifying, hydrocyclone, efficiency in classifying

INTRODUCTION

The basic characteristics of the process of classifying are efficiency and cut- size. They depend, first of all, on working conditions in which hydrocyclone works.

Parameters that may vary with hydrocyclones are: constructive elements (the diameter for underflow and overflow, the relation between lengths of cylindrical and conical parts, angle of conical part) as well as working conditions in hydrocyclone (inlet pressure, capacity and content of solid in pulp).

EXPERIMENTAL

The subject of this investigation is the study of the performance of laboratory cyclone D = 100 mm (Fig.1) in classifying of copper ore depending on four variable parameters.

Since with the traditional method of study the total number of tests for four factors at three levels amounts to 81, the authors applied the dispersion analysis which makes possible significant reduction of the number of tests, simultaneous assessment of all factors studied and close optimization of the process.

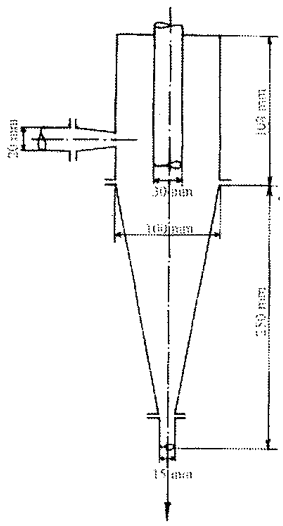

Figure1. Scheme of the hydrocyclone

Tests planning was done according to Greek-Latin square and the factors studied were marked as follows:

- inlet pressure (I-III): I-0,05MPa; II-0.075 MPa; III-0.1 MPa
- content of solid in pulp (1-3): 1-35%; 2-40%; 3-45%
- underflow diameter (A-C): A-13mm; B-15mm; C-17mm
- overflow diameter (α-γ): α- 25mm; β-30mm; γ-35mm.

The pattern of various systems, according to Greek-Latin square is such that each value of one factor combines with a value of other three factors (Tab.1).

Table 1. Tests plan

	I	II	III
1	Bγ	Cα	Aβ
2	Cβ	Aγ	Bα
3	Aα	Bβ	Cγ

Each test was performed twice and the content of class -0.074 mm in underflow and overflow was determined by screening analysis.

The order and the results are shown in tables 2 and 3.

Table2. Order of tests

Test No	Solid [%]	$d_{underflow}$ [mm]	$d_{overflow}$ [mm]	P [MPa]
1	35	15	35	0.050
2	35	17	25	0.075
3	35	13	30	0.100
4	40	17	30	0.050
5	40	13	35	0.075
6	40	15	25	0.100
7	45	13	25	0.050
8	45	15	30	0.075
9	45	17	35	0.100

Table3. Content of -0.074mm [%]

No	Feed	Up product	Sands
1		68.83	10.70
2	37.44	84.66	20.58
3		58.15	14.49
4		73.93	17.95
5	37.70	51.35	10.82
6		60.92	17.28
7		50.29	12.06
8	37.83	57.94	16.39
9		69.27	19.66

The classifying efficiency was calculated by the formula:

$$E = \frac{(a-b)\cdot(c-a)}{a(100-a)\cdot(c-b)}\cdot 10^4$$

where:
a - the content of class -d+0 in inlet; (%)
b - the content of class -d+0 in underflow; (%)
c - the content of class -d+0 in overflow; (%)

RESULTS AND DISCUSSION

The results obtained for the values for classifying efficiency calculated are written in Table 4 with the tests plan.

Table4. Results for classifying efficiency

61.97	51.19	47.24
62.57	52.37	49.80
53.05	41.44	46.39
54.37	43.68	48.71
37.97	44.76	48.03
39.57	44.04	46.32

1. Calculation of sums for individual group of factors Y_i ... Yγ and general Y.

Y(I) = 309.50 Y(II) = 277.48 Y(III) = 286.49
Y(1) = 325.14 Y(2) = 287.64 Y(3) = 260.69
Y(A) = 259.70 Y(B) = 308.44 Y(C) = 305.33
Y(α) = 276.2 Y(β) = 293.26 Y(γ) = 304.01

Y(gen)= 873.47

2. Calculation of the sums of squares in lines,

$$\sum I - III = \sum_{j}^{k}\left(\frac{Y_j^2}{n}\right) - \frac{Y^2}{N} = 90.884$$

columns and letters:

$$\sum 1-3 = \sum_{i}^{n}\left(\frac{Y_i^2}{k}\right) - \frac{Y^2}{N} = 349.242$$

$$\sum A-C=\sum_{l}^{p}\left(\frac{Y_l^2}{p}\right)-\frac{Y^2}{N}=248.186$$

$$\sum \alpha-\gamma=\sum_{m}^{r}\left(\frac{Y_m^2}{r}\right)-\frac{Y^2}{N}=65.556$$

$$\sum gen=\sum_{ij}^{N}Y_{ij}^2-\frac{Y^2}{N}=767.094$$

3. Calculation of sum of the error for reproductivity:

$$\sum rep=\sum gen-\sum I-III-\sum 1-3-\sum A-B-\sum \alpha-\gamma$$

$$\sum rep=13.225$$

4. Degree of freedom for group of factors:

$f_{I-III}=3-1=2\quad f_{1-3}=2\quad f_{A-C}=2\quad f_{\alpha-\gamma}=2$

5. Degree of freedom for general dispersion:

$f_{gen}=N-1=18-1=17$

6. Degree of freedom for general reproductivity:

$f_{rep.}=f_{gen}-f_{I-III}-f_{1-3}-f_{A-C}-f_{\alpha-\gamma}=17-2-2-2-2=9$

7. Dispersion of reproductivity is:

$$S_{rep}=\frac{\sum rep}{f_{rep}}=1.469$$

8. Dispersion of the influence of groups is:

$$S_{I-III}^2=\frac{\sum I-III}{f_{I-III}}=45.442$$

$$S_{1-3}^2=\frac{\sum 1-3}{f_{1-3}}=174.621$$

$$S_{A-C}^2=\frac{\sum A-C}{f_{A-C}}=124.093$$

$$S_{\alpha-\gamma}^2=\frac{\sum \alpha-\gamma}{f_{\alpha-\gamma}}=32.778$$

9. Assessment of the influence of factors according to Fischer's criterion calculated is:

$$F_{I-III}=\frac{S_{I-III}^2}{S_{rep}^2}=30.924$$

$$F_{1-3}=\frac{S_{1-3}^2}{S_{rep}^2}=118.831$$

$$F_{A-C}=\frac{S_{A-C}^2}{S_{rep}^2}=84.446$$

$$F_{\alpha-\gamma}=\frac{S_{\alpha-\gamma}^2}{S_{rep}^2}=22.306$$

For the level of probability p = 95%, Fischer's criterion amounts to $F_{tab}=3.9$. Since $F_{tab}<F_{ass}$, it follows that the influence of all factors examined is significant for the efficiency of classifying. The influence of the content of solid in inlet pulp and underflow diameter are the largest.

10. Determination of coefficients of the model:

$\bar{y}=Y/N$; $a_j=Y_j/n-\bar{y}$; $b_i=Y_i/k-\bar{y}$; $c_l=Y_l/p-\bar{y}$;

$\bar{y}=Y/N=873.47/18=48.526$

$a_I=3.057$; $a_{II}=-2.279$; $a_{III}=-0.778$;

$b_1 = 5.664$; $b_2 = -0.586$; $b_3 = -5.078$

$c_A = -5.243$; $c_B = 2.881$; $c_C = 2.362$

$d_\alpha = -2.493$; $d_\beta = 0.351$; $d_\gamma = 2.142$

11. Model of classifying efficiency.

Taking in consideration that according to tabular values for the criterion of Student at f=2 and the level of probability 90-95%, t = 2.92 and $S_{rep.} = \sqrt{1.469} = 1.21$, the model for efficiency will be:

$$E = 48.526 + a_j + b_i + c_l + d_r \pm 3.53$$

Maximum efficiency of classifying should be expected at working conditions as follows: P=0.5 bar; C=35%; d_{ov}=15 mm; d_{un}=15 mm. At these working conditions the efficiency would be:

$$E = 48.526 + a_l + b_3 + c_B + d_\gamma \pm 3.53$$
$$E = 48.526 + 3.057 + 5.664 + 2.881 \pm 3.53$$
$$E = 62.27 \pm 3.53$$

CONCLUSIONS

The application of dispersion analysis makes possible significant reduction of the number of tests, simultaneous assessment for all factors tested and close optimization of the process. Tests planning in the paper is done based on Latin square so that the total number of tests for three factors at three levels amounts to nine.

The mathematical model obtained and the values of the coefficients make it possible to find out the optimum conditions for the work of the hydrocyclone for variable factors.

It was determined that if classifying is carried out at working conditions such as P=0.05 MPa; C=35%; d_{un} =15 mm; d_{ov} =35 mm, then efficiency of classifying of 62% could be expected.

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