DEPARTMENT OF
APPLIED COMPUTING AND SYSTEM ENGINEERING
FACULTY OF MINING AND GEOLOGY
UNIVERSITY OF BELGRADE

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The XIII Balkan
Mineral Processing Congress BMPC 2009

Bucharest, Romania
14-17. June 2009.

First Circular

Official language of the Congress is English.

Abstracts should be prepared in English, no more than 300 words. Deadline for submission of abstract: 15. October 2008; acceptance of abstracts will be distributed by the Organizing Committee within 15 November 2008. Each author cannot send more than three abstracts, only with the payment of other registration fee.

Please send your abstract in oner way once by e-mail, as attachment in a .doc extension, at the Congress Secretariat. The file must be named after the leading author.

Full paper submission (prepared according to the papers guidelines): 31 January 2009.

Papers should not exceed 8 pages A4 format (210 x 296 mm), including formulas, tables, pictures and references

Papers accepted to the oral presentation will be presented in 2 sessions during 3 days. Each presentation takes about 15 minutes, followed by 5 minutes question time.

Each poster presentation will take half a day. Some of the authors may have an opportunity to give five-minutes short oral presentation one day before the schedules poster presentation.

Registration Fee and Payment

	Before March 31 2009	After March 31 2009
Authors	250 €	300 €
Participants	300 €	350 €
Accompanying persons	100 €	120 €
Students	80 €	100 €

Congress fee include participation at the Congress, proceedings, Welcome Party, three meals, coffee breaks and the Gala Dinner. Payment should be made by either credit card or bank transfer. The details will be presented on the web site: www.bmpc2009.ro

Exhibition

A trade exhibition is planned during the Congress.

Hotel accomodation

Rooms will be reserved. The special Congress rates will be presented on the web site: www.bmpc2009.ro

Congress topics

1. Material analysis and mineral characterization
2. Comminution and classification
3. Flotation and surface chemistry
4. Gravity and other concentration methods
5. Industrial mineral processing
6. Coal processing, agglomeration and briquetting
7. Dewatering and other auxiliary processes
8. Technologies and design for processing plants
9. Simulation, modelling and optimization in mineral processing
10. Metallurgy, bio-metallurgy and bio-processing
11. Environmental aspects in mineral processing
12. Waste processing and recycling
13. Soil remediation
14. Sustainability in mineral processing
15. Education and other subjects related to the mineral processing

Under the auspices of the:

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FOREWORD

Romania is one of the countries, which, on 30th of September 1971 at Athens, has signed **the Protocol for the Foundation of the Scientific and Technical Permanent Conference of the countries from the South-East of Europe.** Since then, the Romanian specialists have always been very active participants to all those events, up to now. Moreover, it has organized the second edition (on 1980, chairman eng. Stanca Patraş) and the seventh one (on 1997, chairman prof.dr.Paraschiv Ilie) of the Balkan Conference. The ninth edition of that event organized in Istanbul, has become **Balkan Congress**.

Now we feel much honored to be for the third time the hosts of this outstanding scientific event.

For the XIIIth BMPC edition at the end of the process 152 papers were selected. Their authors (369) are from 27 countries from all over the world. Participation of specialists from so many countries outside the Balkan is the best evidence of the increasingly high prestige of the Congress throughout the world.

Therefore we have the great pleasure to address on this occasion, **all the participants in this edition, a very warm welcome to Romania.**

Authors' high interest for all the proposed scientific sessions are well reflected by the large number of the submitted papers. Most of them are included on the sections: „Flotation and surface chemistry", „Technologies and design for processing plants" and „Solid and liquid waste treatment". It is also important to note that a large number of the papers (41) are focused on the environment protection problems (sessions 11th, 12th and 13th).

As always to edit the proceeding was a very challenging but in the same time very rewarding task, meaning that it involved many successive stages starting with September 2008 as follows: abstracts receiving and selection, their acceptance communication, full papers receipt, their peer review, some of the works were re-submitted to the authors for the final corrections and, at the end, their integration within a volume of best quality. The editors took the liberty to do some minor grammar corrections and to format the text, where was the case. With all the efforts granted there is no doubt that some errors still

occurred therefore the editors would like to address their sincere apologies to the readers for any inconvenience.

We do glad to have the opportunity to add the XIIIth BMPC Proceeding volume, which is a testimony of the high level reached now by the research and technology in the field of mineral resources processing, to the other twelve ones, beside which represents **a written proof of Balkan Congress' history** during its 36 years of existence.

We would like to thank to all Scientific Committee BMPC's members and to the Romanian Organizing Committee, who achieved papers revision.

All our appreciation goes to all the authors because, without their extremely precious personal contribution, this volume wouldn't exist.

We do hope that our younger colleagues, who has decided to dedicate their lives to that wonderful profession related to the minerals' fascinating world, will find in that book valuable ideas and solutions, provided by experienced scientists. So, in the same spirit, they will continue the struggle for finding out new rules, procedures and appropriate technologies, to get the right answer to the more sophisticated issues involved now and in the future by the minerals processing. Therefore we do encourage them to continue the **tradition of top scientific level meetings within the next Congresses**.

Prof.dr. Sanda Krausz
Chairman of the XIIIth BMPC

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MATHEMATICAL MODEL OF CLASSIFYING CUT POINT BY LABORATORY HYDROCYCLONE

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ABSTRACT

The paper presents the procedure of mathematical modelling the cut point of copper ore classifying by laboratory hydrocyclone. The application of dispersion analysis and planning with Latin square makes possible significant reduction the number of tests. Tests were carried out by D-100 mm hydrocyclone. Variable parameters are as follows: content of solid in pulp, underflow diameter, overflow diameter and inlet pressure. The cut point is determined by partition curve

The obtained mathematical model and the values of the coefficients make it possible to find the classifying cut point for variable factors.

1. INTRODUCTION

The commonest method of representing cyclone efficiency is by a performance of partition curve, wich relates the weight fraction, or percentage, of each particle size in the feed which reports to the apex, or underflow, to the particle size. The cut point, or separation size, of the cyclone is often defined as the point on the partition curve which 50% of particles in the feedof that size report to the underflow. Particles of this size have an equal chanse of going with the overflow or underflow. This point is usually referred to as the d_{50} size. Many mathematical models of hydrocyclones include the term "corrected d_{50}" taken from the "corrected classification curve. It is assumed that in all classifiers, solids of all sizes are entrained in the coarse product liquid by short-circuiting in direct proportion to the fraction of feedwater reporting to the underflow.

The effects of changing operating and design parameters in cyclones are very complex. 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).

2. EXPERIMENTAL

The subject of this investigation is the study of the performance of laboratory cyclone D = 100 mm (Figure 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.

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.

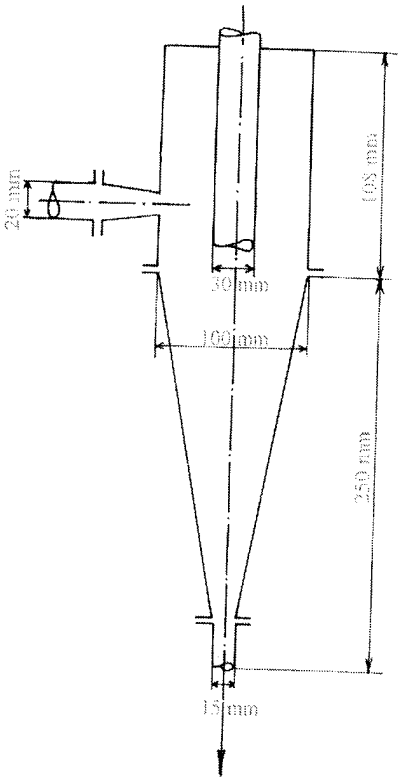


Figure 1. Scheme of the hydrocyclone

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 (Table 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 each classes in underflow and overflow was determined by screening analysis.

The order and partition curves are shown in Table 2 and Figures 2-10.

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

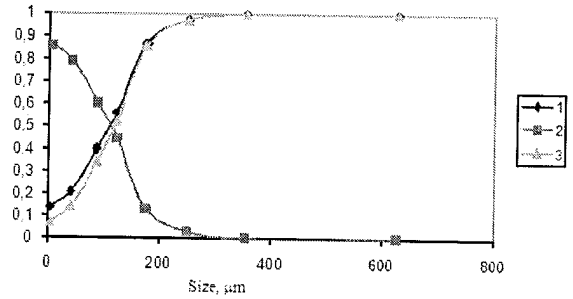


Figure 2. Uncorrected-1 and corrected-3 curve for test 1

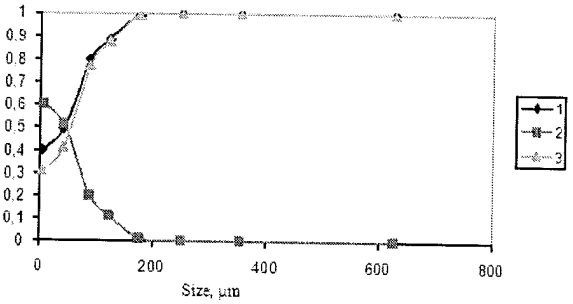
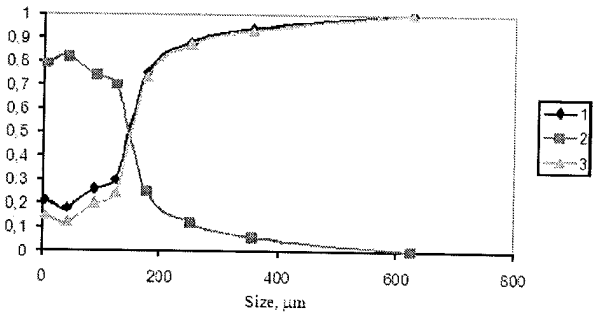


Figure 3. Uncorrected-1 and corrected-3 curve for test 2



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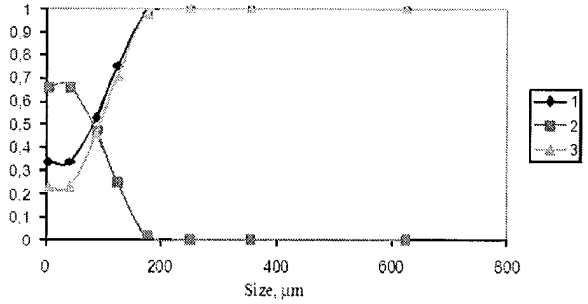
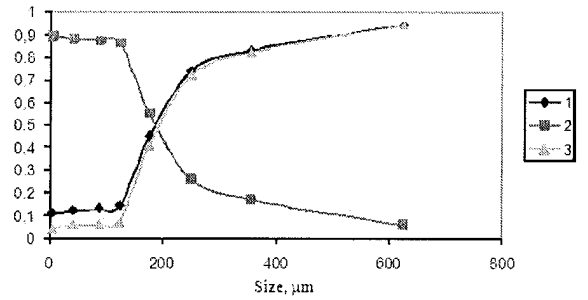


Figure 5. Uncorrected-1 and corrected-3 curve for test 4



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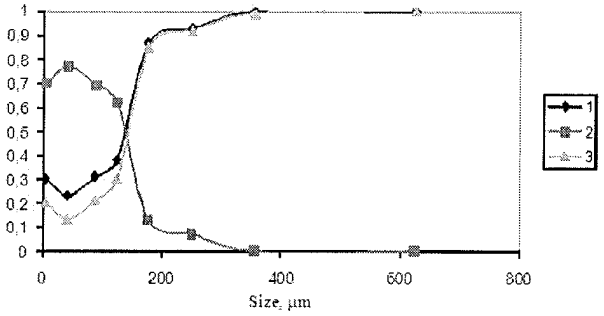

Figure 7. Uncorrected-1 and corrected-3 curve for test 6

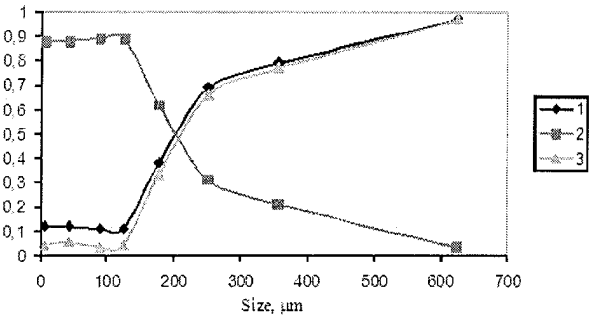

Figure 8. Uncorrected-1 and corrected-3 curve for test 7

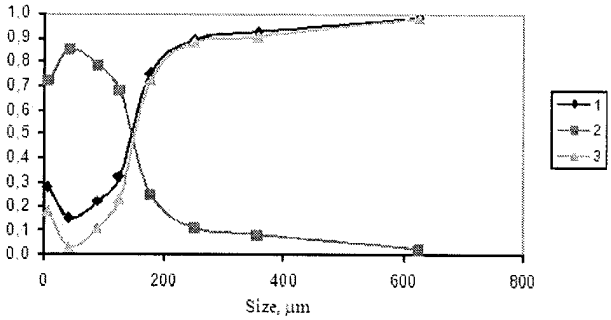

Figure 9. Uncorrected-1 and corrected-3 curve for test 8

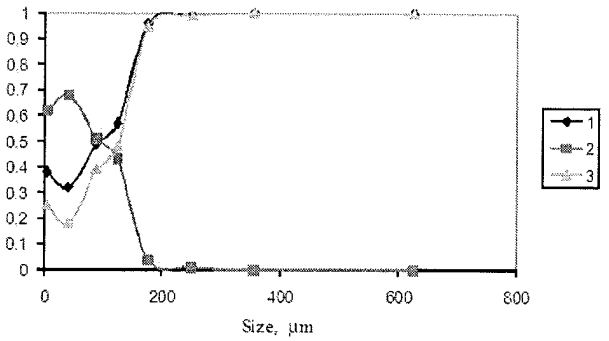

Figure 10. Uncorrected-1 and corrected-3 curve for test 9

3. RESULTS AND DISCUSSION

The results for the cut points are written in Table 3 with the tests plan.

Table 3. Results for corrected cut poin

125	60	150
115	62	149
97	199	142
100	196	139
202	155	119
200	153	118

1. Calculation of sums for individual group of factors Y_i ... $Y\gamma$ and general Y.

Y(I) = 839 Y(II) = 825 Y(III) = 817
Y(1) = 661 Y(2) = 873 Y(3) = 947
Y(A) = 1096 Y(B) = 829 Y(C) = 556
$Y(\alpha)$ = 805 $Y(\beta)$ = 804 $Y(\gamma)$ = 872
Y(gen)= 2481

2. Calculation of the sums of squares in lines, columns and letters:

$$\sum I-III=\sum_{j}^{k}\left(\frac{Y_j^2}{n}\right)-\frac{Y^2}{N}=41{,}33$$

$$\sum 1-3=\sum_{i}^{n}\left(\frac{Y_i^2}{k}\right)-\frac{Y^2}{N}=7345.333$$

$$\sum A-C=\sum_{l}^{p}\left(\frac{Y_l^2}{p}\right)-\frac{Y^2}{N}=24301.0$$

$$\sum \alpha-\gamma=\sum_{m}^{r}\left(\frac{Y_m^2}{r}\right)-\frac{Y^2}{N}=506.333$$

$$\sum gen=\sum_{ij}^{N}Y_{ij}^2-\frac{Y^2}{N}=32264.5$$

3. Calculation of sum of the error for reproductivity:

$$\sum rep=70.500$$

4. Degree of freedom for group of factors:

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

5. Degree of freedom for general dispersion:

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

6. Degree of freedom for general reproductivity:

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

7. Dispersion of reproductivity is:

$$S_{rep}=\frac{\sum rep}{f_{rep}}=7.833$$

8. Dispersion of the influence of groups is:

$$S_{I-III}^2=\frac{\sum I-III}{f_{I-III}}=20.667$$

$$S_{1-3}^2=\frac{\sum 1-3}{f_{1-3}}=3672.667$$

$$S_{A-C}^2=\frac{\sum A-C}{f_{A-C}}=12150.5$$

$$S_{\alpha-\gamma}^2=\frac{\sum \alpha-\gamma}{f_{\alpha-\gamma}}=253.167$$

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

$$F_{I-III}=\frac{S_{I-III}^2}{S_{rep}^2}=2.638$$

$$F_{1-3}=\frac{S_{1-3}^2}{S_{rep}^2}=468.851$$

$$F_{A-C}=\frac{S_{A-C}^2}{S_{rep}^2}=1551.128$$

$$F_{\alpha-\gamma}=\frac{S_{\alpha-\gamma}^2}{S_{rep}^2}=32.319$$

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 cut point except inlet pressure. The influence of the underflow diameter and the content of solid in inlet pulp are the largest.

10. Determination of coefficients of the model:

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

$\bar{y} = Y/N = 2481/18 = 137.83$

$a_I = 2.003; \quad a_{II} = -0.333; \quad a_{III} = -1.667$

$b_1 = -27.667$; $b_2 = 7.667$; $b_3 = 20.000$

$c_A = 44.833$ $c_B = 0.333$; $c_C = -45.167$

$d_\alpha = -3.667$; $d_\beta = -3.833$; $d_\gamma = 7.500$

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 $S_{rep.} = \sqrt{7.833} = 2.79$ the model for corrected cut point will be:

$$d_{50C} = 137.833 + a_j + b_i + c_l + d_r \pm 8.15$$

The obtained mathematical model and the values of the coefficients make it possible to find the classifying cut point for variable factors.

4. CONCLUSION

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 four 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.

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