50 years University of Mining and Geology "St. Ivan Rilski"
Annual, vol. 46, part III, Mechanization, Electrification and Automation in Mines, Sofia, 2003, pp.51-53

RESARCH OF CENTRIFUGAL-IMPACT-VIBRATING MILL /CIVM/ WORKING PROCESS

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ABSTRACT
In this paper is described working process of CIVM, that is protected by patent, using theoretical-experimental method. For objective function is chosen quality of final product and for ruling factors-weight of material in the mill, weight of grinding balls in the mill and time for grinding.
A experimental plan is created for two level of the ruling factors. A statistical analyst of the experimental resent is made.

INTRODUCTION

CIVM is a mill for fine grinding of are and building materials. It is a new mill protected by patent (Assenov, 1977).

The aim of this paper is to represent the results of theoretical-experimental research of working process of CIVM.

CIVM is built [fig.1] of a rotate parabolic part 1 with vertical axis, a vertical shaft 2, the bearings 3, a plate 4, the springs 5, the base 6, fixed parabolic part 7, the columns 8. There are grinding balls 9 and are falling trough tube 10, and the grids 11.

CIVM is working as follows:
The grinding balls and material [are] to be milled are put into the parabolic part 1. The motor 12 rotate the part 1 and because of that grinding balls and ore are rotated and are raised by the centrifugal forces. These forces press the balls to the inner face of rotated part 1 and grinding the material [ore].

The rotated balls goes to the fixed parabolic part 7. There they press again the material. When the kinetic energy of balls decreases they falls on the bottom of part 1. Here the balls hit the material and crushed. The movement of flow of balls and material call forth the vibrations of the whole mill that is put on the springs 5. These vibrations crush the ore.

Thus the material is crushed by pressure originate from centrifugal forces, by slug of falling balls and finally by vibrations.

BASE THEOTY AND EXPERIMENTAL WORK

The CIVM working process is studded by cybernetic theory of experiments (Assenov,1988; Bojanov,1973 etc) .

Xi are the input parameters (ruling factors); Yi – objective functions and ξ – disturbance.

In this study for objective function is chosen the quality of product that is measured by the sieve analysis. There is no information for the input parameters that is way, it is made the list of all parameters that would influence on quality. This list is:

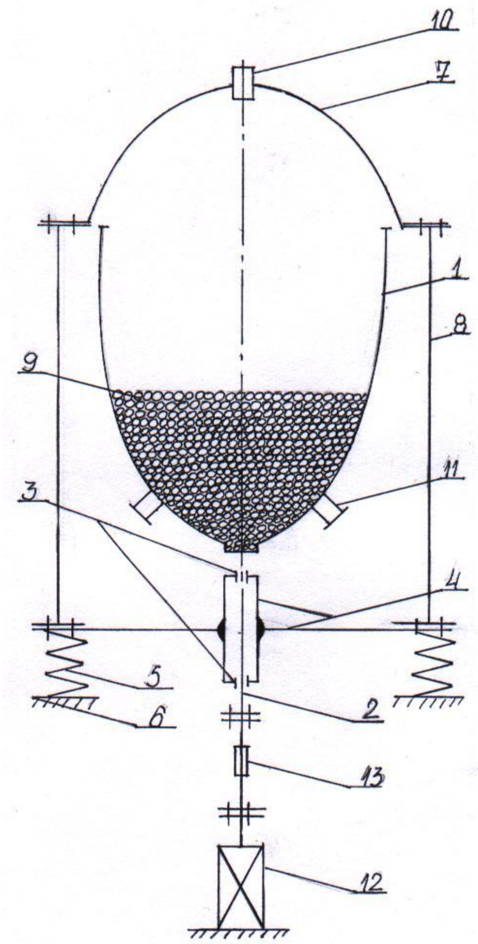

Figure 1. The model of CIVM

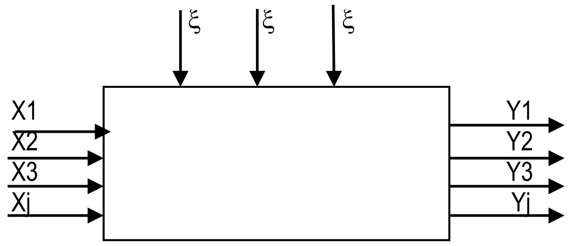

Figure 2. Cybernetic model of black box

Gm- the weight of material [ore] to be grinder [kg];
Gt – the weight of the grinning ball [kg];
t – the time for grinning [min];
n – the angular velocity of parabolic part 1 [min-1];
c- the stiffness coefficient of the springs [N/m];
dt – the ball is diameter [mm];
m – sort of material-quartz sand;

An active experiment is made for the first 3 parameters and the another were constant:
c = 290 .10³ [N/m];n = 800 [min^{-1}]; dt = 15 [mm];
dm = 0 ÷ 3 [mm];

The basic levels, intervals of the input parameters variation are given on table 1.

Xi = 0 - Signbasic level
λI - Interval
Xi = -1 - Lower level
Xi= +1 - Upper level

Table 1. Basic level for input parameters

parameter	Xi = 0	λi	Xi = -1	Xi= +1	Dimension
X1-Gm	4	1	3	5	[kg]
X2-Gt	4	1	3	5	[kg]
X3-t	2	1	1	3	[min]

The matrix of the plan of experiments is 2². The plane of experiments and the result are given in table 2.

Table 2. Matrix plan and experimental results

№	X_1 code	X_2 code	X_3 code	Doubled experiment	Result Y
1	-1	-1	-1	80.20 78	79,1
2	+1	-1	-1	43,4 41,2	42,3
3	-1	+1	-1	52,7 49,8	51,25
4	+1	+1	-1	70,3 73,7	72
5	-1	-1	+1	54,8 51,3	53,05
6	+1	-1	+1	76,8 72,1	74,45
7	-1	+1	+1	73,1 79,3	76,2
8	+1	+1	+1	39,3 42,7	41

THE RESULTS AND DISCUSSIONS

The regression coefficients are calculated by the formulae (Assenov, 1977).

bi=Σfij .Yi ./ n (1)

The coded regression equation is:

$$Y = 61.044 – 3.606X_1 – 0.931X_2 + 14.394X_3 + 0.25X_1X_2+1.387X_2X_3–0.406X_1X_3 \quad (2)$$

Statistical analyst:
There are doubled experiments and we can check hypothesis for homogeneous of dispersions by the Kochren criterion:

$$Si = \frac{\Sigma\left(Ypq - \overline{Yp}\right)^2}{l-1} \quad (3) \quad ; \quad l = 2 \quad ;$$

The maximum dispersion was for the sixth experiment.

$$\frac{1}{G} = \frac{\Sigma Si}{Smax} = \frac{11,045}{37,775} = 0,2924 \quad (4)$$

The table value of Kochren criterion is taken from table 5 (Bojanov, 1973) and have Gt= 0,6798.
Hence the dispersions are homogeneous.

We calculate the dispersion of experiment by condition of uniformity experiments and for degree of freedom v= 8.
The estimated dispersion is

$$Q\varepsilon 1 = \sum_{p=1}^{n}\sum_{q=1}^{v}\left(Ypq - \overline{Yp}\right)^2 = 37,775 \quad (5)$$

$$S^2\varepsilon 1 = \frac{Q\varepsilon\varepsilon}{Y\varepsilon\varepsilon} = \frac{37,775}{8} = 4,722 \quad (6)$$

Significant regression coefficients are derived using Student`s criterion for confidence level α= 0,05 and degree of freedom df = 8. The student`s table value is tτ=2,896. We calculate the dispersion of regression coefficients as

$S^2\{bi\} = S^2\varepsilon 1/ N = 4.722 / 16 = 0,295$ (7)

, than calculate multiplication: tτ * $S^2\{bi\}$ = 1,579 (7’)
Each coefficient that is grater than (7’) are significant.
The final regression equation is

$$Y = 61,044–3,606X_1+14.394X_3 \quad (8)$$

We check the adequate equation with Fisher criterion.

$F = Sl^2/S^2\varepsilon = 5,7 / 4,722 = 1,207$ (9)

,where $Sl^2=Ql/vl$ is the estimated dispersion of insignificant; vl- degree of freedom.

$$Ql = Vl.\Sigma\left(\bar{Y}p - \hat{Y}_p\right)^2 = 28,5 \qquad (10)$$

The table value of Ft = 3,69 is derived from table (Assenov,1988; Bojnov,1973 etc.) when α=0.05;vl=4;ve=8. Hence the regression equation is adequate.

We have made another experiment, where the milling factors were: Gm, n and t. the n is angular velocity of the rotated parabolic part 1. The factors were constant.

The basic level, the intervals of variation of the parameters are given on table 3.

Xi = 0 - sign
λi – interval
Xi =-1 - lower level
Xi =+1 - upper level

Table 3. Basic level, intervals of parameters

Para-Meter	Xi = 0	λi	Xi =-1	Xi =+1	Dimension
Z_1	4	1	3	5	[kg]
Z_2	1000	200	800	1200	[min^{-1}]
Z_3	2	1	1	3	[min]

The plane matrix and the results are given in table 4. The coded regression equation is

Table 4. Matrix plane and the second results

№	X_1	X_2	X_3	Expermental results -Y	Mean value Y
1	-1	- 1	-1	48,9 51,1	50,2
2	+1	- 1	-1	40,4 43,6	42
3	-1	+1	-1	54,9 54,5	54,7
4	+1	+1	-1	44,2 46	45,1
5	-1	- 1	+1	62,1 72,7	67,4
6	+1	- 1	+1	70,1 74,6	72,7
7	-1	+1	+1	81,5 84,1	82,8
8	+1	+1	+1	72,8 76,0	74,9

The regression equation is

$$Y = 61,225 – 2,55X_1 + 3, 15X_2 + 13,225X_3 - 1,825X_1X_2 + 1.25 X_2X_3 +1,9 X_1X_3 \qquad (11)$$

After statistical analyst is derived final equation

$$Y = 61,225 – 2,55.X_1 + 3,15.X_2 +13,225.X_3 \qquad (12)$$

CONCULUSION

1. From the equation (8) and (12) we draw a conclusion that when the weight of grinding material increases the quality of final product decrease. When the angular velocity of rotated parabolic part 1, and the grinding time increases the quality of final product also increases.
2. When we increases the weight of grinding material Gm with 1 kg this decreases the quality with 2,55%.
3. When we increase the angular velocity with 200 [tr/min] this increases the quality with 3,15 %.
4. When we increase the grinding time with 1[min] the quality of final product increases with 13,25%.

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