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Study of the Centrifugal Impact Vibrating Mill [Civm] Productivity

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ABSTRACT. The aim of this work is to present a study of productivity of centrifugal impact vibrating mill. Using theory of similarity and theory of experiment criteria of similarity and criterion equation are derived. Experimental plan is made and the results are statistically assessed. Criterion equation is adequate.
Key words: theory of similarity, criterion, experimental plan, statistics.

ИЗСЛЕДВАНИЯ ВЪРХУ ПРОИЗВОДИТЕЛНОСТТА НА ЦЕНТРОБЕЖНА УДАРНО-ВИБРАЦИОННА МЕЛНИЦА
РЕЗЮМЕ. Целта на тази работа е да се представят резултатите от изследването на производителността на центробежна ударно-вибрационна мелница. Изведени са критерии и критериални уравнения като се използва теорията на подобието и планирането на експериментите. Съставен е план на експеримента в критерии и са дадени резултатите от статистическия анализ на резултатите. Получено е адекватно критериално уравнение за производителността на мелницата.

Introduction

The quality, productivity and energy consumption of CIVM (Assenov,1977) were studied in (Assenov, 2003) and (Assenov, 2003). The ruling factors were: Gm –the weight of material to be grinded, Gt- the weight of the grinding balls, ω- angular velocity of rotated cone and t- the time of grinding. Statistical equations were derived based on nature experiments in CIVM model.

The aim of this work is to present a study of productivity of CIVM when simulation and experiment theory are applied.

Theoretical base

The results about CIVM mentioned above are valid only for the values of interval of variation of ruling factors Gm, Gt, dm, t. When we have to design series of CIVM with different productivity we have to transfer those results with out restriction of values of interval variation. For this purpose both theory of simulation and theory of experiment were put into practice.

In the theory of similarity (Venikov, 1979) the base concepts is "phenomenon" as a complex of processes that are describe by equation connected process parameters and examined system parameters. In the CIVM relationship between productivity and ruling factors are consider. The processes in the real system and model must be similar.

There are (Venikov, 1979) three theorems and additional states on the theory of similarity. The first two theorems states the relationship between similar phenomena parameters and the third one determines the way to realization of similarity.
Sufficiently condition for existing of similarity of processes is similarity criterion to be:

$$P_i=item \quad (1)$$

The most simple case for similarity is proportionality:

$$P_i/R_i=mi \quad (2)$$

where P_i and R_i are system and model parameters, m_i is coefficient of similarity. If m_i=constant there is a linear similarity, if $m_i \neq$constant –pseudo similarity.

Estimation of similarity criteria for the CIVM productivity.

The estimation method for similarity criteria of the CIVM productivity is:

1. Describe the ruling parameters $P_1, P_2 \ldots P_m$
2. Make the dimension matrix for those "m" parameters.
3. Chose the K independent parameters.
4. Define the criterion.
5. Make the criterion' equation.

The ruling parameters of the CIVM productivity are:
G_m- the weights of gnats sand to be grinder;
G_t- the weight of the grinding balls;
ω- the angular velocity of rotated come;
t- the time for grinding;
d_m- the diameter of quarts sand;
P- the productivity;
The dimensions DUSI unites of the parameters are:

$$[G_m]=[kg];\ [G_t]=[kg];\ [\omega]=[s^{-1}];\ [t]=[s];\ [d_m]=[m];\ \text{and}\ [P]=[kg.s^{-1}]; \quad (3)$$

The dimensions system is:

$$\begin{aligned}[G_m] &= [M]^1.[L]^o.[T]^o\\ [G_t] &= [M]^1.[L]^o.[T]^o\\ [\omega] &= [M]^o.[L]^o.[T]^{-1}\\ [t] &= [M]^o.[L]^o.[T]^1\\ [d_m] &= [M]^o.[L]^1.[T]^o\\ [P] &= [M]^1.[L]^o.[T]^{-1}\end{aligned} \quad (4)$$

Three independent parameter for instance are:
$[G_t]$, $[d_m]$ and $[\omega]$

The check for independence of these parameters is made by value of determinant:

$$D = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{vmatrix} \neq 0 \qquad (5)$$

The criteria of similarity π1 are derives from the system of exponents α', β', γ'.

$$\pi_1 = \frac{[P]}{[G_t][d_m][\omega]} = \frac{[M]^1[L]^0[T]^{-1}}{[M]^{\alpha 1}[L]^{\beta 1}[T]^{\gamma 1}} = \frac{P}{G_t \omega}$$

$$\pi_2 = \frac{[G_m]}{[G_t][d_m][\omega]} = \frac{[M]^1[L]^0[T]^0}{[M]^{\alpha 2}[L]^{\beta 2}[T]^{\gamma 2}} = \frac{G_m}{G_t} \qquad (6)$$

$$\pi_3 = \frac{[t]}{[G_t][d_m][\omega]} = \frac{[M]^0[L]^0[T]^1}{[M]^{\alpha 3}[L]^{\beta 3}[T]^{\gamma 3}} = \omega.t$$

The mathematical formulation of the problem is:

$$\pi_1 = f[\pi_2, \pi_3] \qquad (7)$$

$$P/G_t.\omega = f[G_m/G_t, \omega t] \qquad (8)$$

The theory of experiment (Bojanov, 1972; Jeff Wu, 2000) are used to reveal the function f. The experimental results from (Assenov, 2003) are transformed as follows:

1. The criterion's πi are calculated using equation (6).
2. The experimental plan for criteria is made and is shown in the table (1).

Table №.1
The experimental plan for criteria

№	π_1	π_2	Y
1	1	5026,547	5,3184E-05
2	1,6666667	5026,547	0,0001439
3	0,6	5026,547	6,2906E-05
4	1	5026,547	4,6619E-05
5	1	15079,64	0,00010902
6	1,6666667	15079,64	8,4883E-05
7	0,6	15079,64	2,9086E-05
8	1	15079,64	7,8185E-05
9	1	5026,547	5,1725E-05
10	1,6666667	5026,547	0,00013661
11	0,6	5026,547	5,9444E-05
12	1	5026,547	4,8874E-05
13	1	15079,64	0,00010206
14	1,6666667	15079,64	7,9688E-05
N	π_1	π_2	Y
15	0,6	15079,64	3,1552E-05
16	1	15079,64	8,4949E-05
17	0,75	5026,547	7,2963E-05
18	1,25	5026,547	0,00010047
19	0,75	7539,821	5,461E-05
20	1,25	7539,821	7,3278E-05
21	0,75	15079,64	3,0886E-05
22	1,25	15079,64	5,8108E-05
23	0,75	22619,46	2,7023E-05
24	1,25	22619,46	4,0231E-05
25	0,75	5026,547	7,6842E-05
26	1,25	5026,547	0,00010842
27	0,75	7539,821	5,4212E-05
28	1,25	7539,821	7,6262E-05
29	0,75	15079,64	3,6158E-05
30	1,25	15079,64	6,1838E-05
31	0,75	22619,46	2,7885E-05
32	1,25	22619,46	4,1999E-05

The experimental data are processed by the program Regression of Data-Analysis in Excel.The results of Data Analysis are shown in table №2

Table №2
Result of statistic analysis

Regression Statistics	
Multiple R	0,752248
R Square	0,565876
Adjusted R Square	0,535937
Standard Error	2,08E-05
Observations	32

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1,63E-08	8,17E-09	18,900625	5,56E-06
Residual	29	1,25E-08	4,32E-10		
Total	31	2,89E-08			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3,02E-05	1,41E-05	2,143	0,040	1,38E-06	5,91E-05
X Var.1	5,75E-05	1,13E-05	5,084	2,007E-05	3,44E-05	8,06E-05
X Var. 2	-2E-09	5,97E-10	-3,350	0,002	-3,22E-09	-7,8E-10

Finally the regression equation for productivity in criteria is:

$$P/G_t.\omega = 3{,}02 \cdot 10^{-5} + 5{,}75 \cdot 10^{-5}.G_m/G_t - 2 \cdot 10^{-9}.\omega t \qquad (9)$$

Conclusions

1. The similarity' criteria for CIVM productivity are derived – equation (6).
2. A criteria equation for productivity is obtained – equation (9).
3. Equation (9) will be use for making of serial CIVM with similarity process.

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