DETERMINING THE IMPACT OF THE FRACTION SIZE OF THE FEEDING PRODUCT AND THE WIDTH OF THE DISCHARGE PORT OF A COMPLEX PENDULUM JAW CRUSHER ON ITS PERFORMANCE

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ABSTRACT. In the literature describing the theory of operation of jaw crushers, the topic of the influence of the constructive parameters on the technological ones is is touched upon, but separately. For example, when determining the performance of jaw crushers with a complex swinging of the jaw (or complex pendulum jaw crushers), the size of the discharge port is indicated as the main parameter of influence. However, it is not clear how the fraction size of the product to be crushed affects the performance of the mill. This is shown partially in the fraction size characteristics of the crushers, but it is not possible to be analytically determined. In the present study, an attempt is made to determine the simultaneous impact of these two parameters on the performance of a laboratory-scaled jaw crusher with complex swinging of the jaw used for a coarse crushing. For this purpose, an experiment was performed with a laboratory-scaled complex pendulum jaw with the size of the feeding gap of 0.7 x 1.05m. After processing the results of the experiment, several mathematical models were obtained describing the influence of the width of the sizing gap for the discharge and the fraction size of the feeding material on the productivity of the crusher. The model with the highest values of confidence has been chosen and the relevant conclusions were made.

Keywords: jaw crushers, analytical determination, productivity, rate of crushing

ОПРЕДЕЛЯНЕ ВЛИЯНИЕТО НА ЕДРИНАТА НА ПОСТЪПВАЩИЯ ПРОДУКТ И ШИРОЧИНАТА НА ИЗПУСКАТЕЛНИЯ ОТВОР НА ЧЕЛЮСТНА ТРОШАЧКА СЪС СЛОЖНО ЛЮЛЕЕНЕ ВЪРХУ ПРОИЗВОДИТЕЛНОСТТА Й

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РЕЗЮМЕ. В литературата, описваща теорията на работа на челюстните трошачки, е засегнат въпросът за влиянието на конструктивните параметри върху технологичните, но поотделно. Например, при определяне на производителността на челюстните трошачки със сложно люлеене на подвижната челюст като основен параметър, оказващ влияние, е посочена широчината на изпускателния отвор на трошачката. Не е ясно обаче какво е влиянието на зърнометричния състав на постъпващия за трошене продукт върху производителността на машината. Това е показано частично в зърнометричните характеристики на трошачките, но не е възможно да се определи аналитично. В настоящата разработка е направен опит да се определи едновременното влияние на тези два параметъра върху производителността на челюстна трошачка със сложно люлеене на подвижната челюст, използвана най-често за едро трошене. За целта е направен експеримент с лабораторна челюстна трошачка със сложно люлеене на подвижната челюст с размери на приемния отвор 0,7 x 1,05m. След обработка на резултатите от експеримента са получени няколко математически модела, описващи влиянието на широчината на изпускателния отвор и зърнометричния състав на постъпващия за трошене материал върху производителността на машината. Избран е моделът с най-високи стойности на достоверност и са направени съответните изводи от получения резултат.

Ключови думи: челюстна трошачка, аналитично определяне, продуктивност, степен на трошене

Introduction

In the analytical determination of the performance of jaw crushers, the width of the sizing gap for discharge (or: the discharge port) and the movement of the jaw are indicated as main parameters of influence (Цветков, 1976; Минин, 2012). This is determined according to the following formula:

$$Q_v = 60.k_1.k_p.n\frac{(2b+s).s.L}{2.tg\alpha}, m^3/s \qquad (1)$$

where:

Q_v is the volumetric efficiency of the crusher;

b, m is the maximum width of the discharge port;

k_1 is a coefficient that depends on the type of the crusher. For crushers with a complex swinging of the jaw, it is in the range of > 1 because the jaw moves downwards, thus increasing the productivity of the machine.

k_p is a coefficient of ore bulking;

s, m is the movement of the jaw;

$n, \min^{-1}$ are the RPMs of the eccentric shaft of the crusher;

α^0 is the angle between the jaws;

L, m is the length of the inlet gap.

The mass performance is calculated by the formula:

$$Q = \rho . Q_v \, , t / h \qquad (2)$$

where $\rho, t / m^3$ is the density of the ore to be crushed.

From the formulae shown, it is not clear how the fraction size of the product to be crushed affects the productivity of the machine. This can be roughly defined by the fraction size characteristics of crushers, but it is not possible to be determined analytically. With the present study, an attempt is made to determine the simultaneous impact of two parameters (the width of the sizing gap for discharge and the fraction size of the feeding product) on the performance of a laboratory-scaled complex pendulum jaw crusher used for coarse crushing through an experiment with a laboratory-scaled jaw crusher (Fig. 1) with a complex swinging of the movable jaw with the size of the feeding gap of 0.7 x 1.05m.

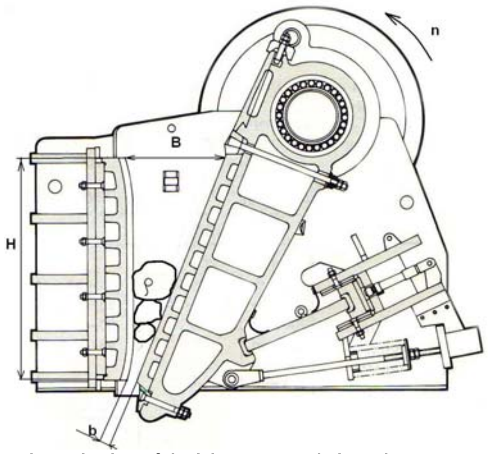

Fig.1. A schematic view of the laboratory-scaled crusher

Results from the experiment on a laboratory - scaled crusher with a complex swinging of the movable jaw

In the study, the following possible parameters were identified as driving factors:

1. An average diameter of the fractions that are fed into the crusher. This size is the average of the appropriate class of selected and pre-cut material. The experiments were made with the materials of dimensions shown in Table 1. They are consistent with the width of the inlet gap of the laboratory-scaled crusher.

Table 1.

Class	***D***	***Class***	***D***
+45-55	50	+35-45	40
+25-35	30	+15-25	20

2. The width discharge port of the crusher. This parameter has also been selected according to the dimensions and capabilities of the laboratory machine and with values of 6, 8, 12, 16, and 20 mm.

Measurements of the productivity were performed. The productivity was obtained after measuring the crushing time of a certain quantity of material, pre-weighed with a digital balance.

The performance of the machine can be calculated using the formula:

$$q = \frac{M_{сум.}}{t}, g / s \qquad (3)$$

where:

q is the productivity of the machine;

$M_{сум.}, g$ is the total amount of the crushed material. This parameter is measured by an electronic balance.

t, s is the time for ore crushing.

The obtained results and calculations are given in Table 2:

Table 2.

D, mm	**b, mm**	**q, g/s**
50	20	364.9969
50	16	235.9133
50	12	171.9044
50	8	166.18
50	6	101.1798
40	20	334.7136
40	16	263.2581
40	12	191.3529
40	8	147.937
40	6	115.9501
30	20	421.9943
30	16	312.0862
30	12	245.5491
30	8	158.1779
30	6	111.9926
30	20	334.3384
20	16	386.9281
20	12	346.6667
20	8	134.9
20	6	127.2314
20	6	107.1524

As a result of the experiment, the parameters were transformed into a Fisher matrix shown in Table 3:

Table 3.

	X_1	X_2	Y_2
№	**D, mm**	**b, mm**	**q, g/s**
1	50	20	364.9969
2	50	16	235.9133
3	50	12	171.9044
4	50	8	166.18
5	50	6	101.1798
6	40	20	334.7136
7	40	16	263.2581
8	40	12	191.3529
9	40	8	147.937
10	40	6	115.9501
11	30	20	421.9943
12	30	16	312.0862

13	30	12	245.5491
14	30	8	158.1779
15	30	6	111.9926
16	30	20	334.3384
17	20	16	386.9281
18	20	12	346.6667
19	20	8	134.9
20	20	6	127.2314
21	20	6	107.1524

For the purpose of the practical study of the performance process, models and regression coefficients were sought which can be assumed with confidence levels of 95%. It is expected that acceptable engineering error margins of 5% are normal for technical devices such as jaw crushers. The method of operation (Божанов,1979) is illustrated at Figure 2.

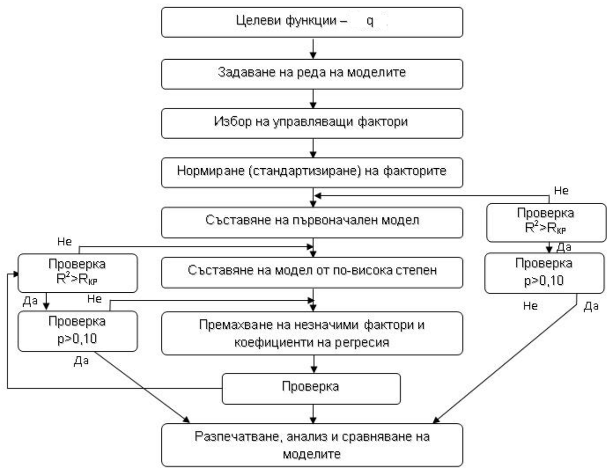

Fig. 2. A flow-chart of the operation mode

The results of the conducted experiment were statically processed with the STATGRAPHICS program, because it is appropriate for this study.

As a result of the experiment, 10 mathematical models with the parameters were obtained and they are shown in Table 4:

Table 4.

Model №	P-value criterion	Significance of F	$R^2(adj)$ %	R^2 %
1	>0.05	0	88.9	88
2	>0.05	0	97.1	97
3	>0.05	<0.05	33.4	36
4	0	0	84	84
5	0	0	55	57
6	0	0	42.9	43
7	>0.05	0	89.2	90
8	0	0	98.3	98
9	>0.05	0	84.6	85
10	>0.05	0	96.6	97

The assessment of the significance of the coefficients of regression is performed according to the Student`s t-test criterion at a level of significance and 8 degrees of freedom (Минин, 2012). In the program, this procedure is known to evaluate the expectancy of significance of the regression coefficients. If this probability is

$$P\text{-value} < \alpha \qquad (4),$$

the coefficient of regression is significant (α-confidence probability).

Similarly, the adequacy of the equation is evaluated by means of the significance of the Fisher criterion (Significance of F). If the significance of the criterion is < α, the equation is adequate.

Model № 8 is the best-performing of all obtained models (Table 4) and it can be evaluated as a high-performance model. The multiple correlation coefficient is 98.36% and the corrected multi-correlation factor is over 98%. This model has the best performance among all others. The confidence probability index (P-criterion) for the model is below the critical value of 0.05, i.e. it can be assumed that the model is adequate with a confidence probability of over 98%. The parameters of Model № 8 are shown in Table 5.

Table 5.

Parameters	Value	Standard error		P-value criterion
b	26.4465	2.05081		0.0000
D*b	-0.215449	0.0548965		0.0009
	Sum of squares of the model	***Degrees of freedom***	***F-value criterion***	***Significance of F***
Model	1.288986	2	570.57	0.0000
Residual	21461	19		
Total	1.310446	21		
Multiple correlation coefficient			98.3623%	
Adjusted coefficient of multiple correlation			98.2761%	
Standard error			33.6085	
Average absolute error			24.2421	
Statistics of Durbin - Watson			2.04736	

Then, the equation of the model with natural variables is logically chosen to be:

$$q = 26,446.b - 0,215.D.b \ \ ,g/s \qquad (5)$$

The model is presented graphically in Figure 3.

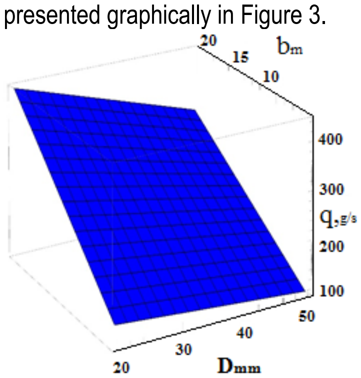

Fig.3. The productivity of the crusher depending on the width of the sizing discharge gap and the fraction size of the feeding product

Conclusions

1. The performance of the jaw crusher is significantly affected by two parameters: the size of the feeding fractions and the width of the discharging port.

2. An increase of the width of the outlet gap leads to an increase in the productivity of the machine, possibly due to the fact that it reduces the discharging time of the crushing chamber.

3. An increase of the size of the ore fractions feeding the machine results in a reduction in the productivity, possibly due to the fact that the time of discharging the crush chamber is increased.

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