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Improving the efficiency of a cone crusher by investigating the key factors in its working process

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Improving the efficiency of a cone crusher by investigating the key factors in its working process

Jonibek Mavlonov[1], Jasurjon Olimov[1,a)], Sohibjon Shirinov[1], Saidikrom A'zamov

[1]Navoi State University of Mining and Technologies, Navoiy, Uzbekistan
[2] Andijan State Technical Institute, Andijan, Uzbekistan

[a)] Corresponding author: olimovjasur2328@gmail.com

Abstract. At present, crushing processes are one of the most energy-intensive operations, accounting for more than 50-60% of the total energy resources of processing enterprises. Therefore, in the process of ore preparation and development, it is urgent to select equipment to improve energy efficiency, use high-performance equipment with large unit capacity, strengthen crushing processes and develop technical solutions. Therefore, modern experimental design methods were used to study the energy consumption of cone crushers under the influence of many factors, and a high-precision mathematical model was proposed. Experimental experiments were conducted using the main parameters (crushing (fractionation) coefficient, compression force, cone rotation speed and load), as well as optimization by calculating the influence of the main factors, resulting in a 20% reduction in energy consumption, and the main priority tasks for achieving energy efficiency for an optimal work process were identified.

INTRODUCTION

Energy consumption in cone crushers depends on many factors, including ore hardness, grain size, loading uniformity, rotation frequency, chamber geometry, technical condition of the crushing zones, and other important factors. It is important to determine the relationship between these factors and create an effective operating mode. Rational use of energy not only increases production efficiency. In this regard, an in-depth study of energy consumption in cone crushers, its assessment based on mathematical and experimental models, and the development of energy-saving modes are among the urgent scientific and practical tasks of modern mining science.

EXPERIMENTAL RESEARCH

To determine the specific energy consumption of a crusher (energy consumption per unit volume of ore) and assess its energy efficiency, it is necessary to study its energy characteristics and the relationship between the crusher's operating conditions and its average power consumption. Because, using a numerical experimental method using an analytical model, the power consumed and specific energy consumption are determined depending on the parameters of the crushed material and its operating modes [1-5]. In the research work, the following formula (1) was used to determine the consumed electrical energy.

$$N_m = \frac{\sigma_{sj}^2 \pi D_k}{0{,}01224\eta E}(D_{sv}^2 - d_{sv}^2)nK_{pr} \quad (1)$$

Where ; σ_{sj}- material time during squeeze strength, MPa; D_k - crushing cone base diameter, m; E - material modulus of elasticity, MPa; η – of the material mechanic efficiency; D_{sv} and d_{sv} – suitable accordingly starting material and chopped of the product average size, m; n – grinding cone rotation frequency, rpm; K_{pr} - crusher size, design, grinding process dynamics and grinding camera filling level into account received without general correction coefficient [4].

Conical grinder volumetric productivity formula (2) following expression according to is determined .

$$V = \pi d_{sb} D_k \ln \mu \quad (2)$$

Where ; $l = D_k/12$ - parallel zone height ; μ - material crush coefficient .

Research on KMD-150 conical crushurs have been performed, because this kind of grinder high reliability, high productivity, simple and easy service show to the characteristics has [6-10].

KMD-150 conical crusher technician features: productivity Q - 190-720 t/h; recommended done maximum power N_{max} - 220 kW; motor shaft speed n - 150-200 rpm; moving conical of the base diameter D_k - 1.078 m; discharge of the cavity width b - 0.01- 0.045 m; mechanical efficiency of crusher η - 0.85.

Crushed of the material parameters Muruntov to the mine suitable comes from: material time during compression power σ_{sj}- 60-130 MPa; material compression of strength average value σ_{sj}- 99 MPa; material modulus of elasticity E - 7000 MPa; the material soften coefficient m – 0.5; ore density r_m – 2.7 t/m^3 what organization will reach [11-18].

Under study various parameters for electricity energy spending calculation for K_{pr} - crusher size and design descriptive general correction coefficient calculation need.

According to formula (1) K_{pr} value found:

$$K_{pr} = \frac{0{,}01224 E N_m \eta}{\sigma_{sj}^2 \pi D_k (D_{sv}^2 - d_{sv}^2) n} \tag{3}$$

In terms of KMD-150 conical crusher for D_{sv} = 60 mm unloading of the cavity width 10 mm and crushed particles average size d_{SV} =20 mm increases, coefficient K_{pr} =1.39.

RESEARCH RESULTS

Crushed of the product size unloading of the cavity to the width assuming that the efficiency (Q) is equal to of the engine consumption made power (P) and conical grinder comparison energy consumption (W) grinding coefficient (i) to dependencies calculating will be released and in the table .

TABLE 1. Private energy spend fractionation to the coefficient connection.

Exit of the slot diameter d, m	Fragmentation coefficient *i*	Energy by $\sigma_{сж}$ = 60 MPa in compression consumption to be done power	Energy by $\sigma_{сж}$ = 100 MPa in compression consumption to be done power	Energy by $\sigma_{сж}$=130 MPa in compression consumption to be done power	Productivity Q, t/h	$\sigma_{сж}$ = 60 MPa in compression comparison energy expense	$\sigma_{сж}$=100 MPa in compression comparison energy expense	$\sigma_{сж}$=130 MPa in compression comparison energy expense
0,010	6.00	52.26	141.38	240.63	296.45	0.17	0.48	0.81
0.013	4.62	51.25	138.57	235.88	385.09	0.13	0.36	0.61
0.016	3.75	48.98	135.04	229.90	472.73	0.10	0.29	0.49
0.019	3.16	46.44	132.76	222.68	562.36	0.08	0.23	0.40
0.022	2.73	45.63	127.76	214.23	651.00	0.07	0.20	0.33
0.025	2.40	44.57	121.02	204.53	738.64	0.06	0.16	0.28
0.032	1.88	38.73	105.79	177.10	944.46	0.04	0.11	0.19
0.038	1.58	32.57	87.71	148.23	1123.73	0.03	0.08	0.13
0.045	1.33	24.07	66.07	108.28	1328.55	0.02	0.05	0.08

Based on the above table, it can be concluded that increasing the diameter of the discharge slot at the ore outlet of a cone crusher significantly reduces energy consumption. At the same time, energy consumption is considered to be small for ores with low strength [19-24].

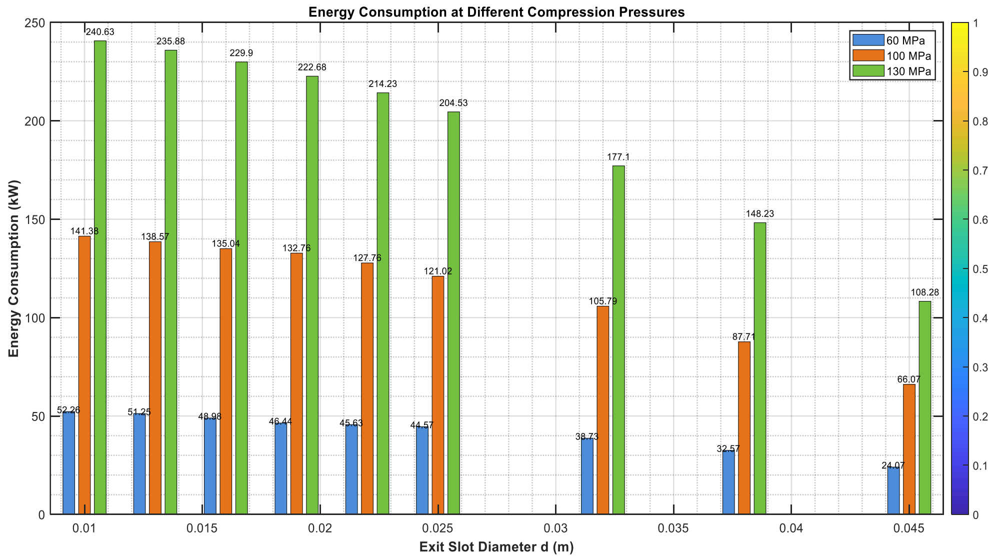

FIGURE 1. Marked energy spend fractionation to the coefficient connection.

Above from data come, it turns out that for s_{max} = 130, crushing coefficient from 1.3 to 6 when changing crusher productivity from 1328 t/h to 296 t/h decreases; electricity driver by consumption to be done power 108 kW from 240 kW up to, comparative energy consumption and from 0.08 kW/t to 0.81 kW/t increases [25-54]. Typical energy spend source of the material pressure to the power dependency in the table 2 and Fig 2.

TABLE 2. Energy comparison consumption start of the material pressure to the power dependency.

Compression power $\sigma_{сж}$, MPa	In the coefficient power expense	In the coefficient power expense	In the coefficient power expense	Productivity at i=1.9	Productivity at i=3.2	Productivity at i=4.6	Comparison at i=1.9 energy expense	Comparison at i=3.2 energy expense	Comparison at i=4.6 energy expense
60	37.7	47.4	50.2	945.5	561.4	384.1	0.04	0.08	0.13
70	51.3	64.4	68.4	945.5	561.4	384.1	0.05	0.12	0.18
80	67.1	84.3	89.3	945.5	561.4	384.1	0.07	0.15	0.23
90	84.9	106.7	113.1	945.5	561.4	384.1	0.09	0.19	0.29
100	104.8	131.8	139.6	945.5	561.4	384.1	0.11	0.23	0.36
110	126.8	159.4	168.9	945.5	561.4	384.1	0.13	0.28	0.44
120	150.9	189.7	201.0	945.5	561.4	384.1	0.16	0.34	0.52
130	177.1	222.7	235.9	945.5	561.4	384.1	0.19	0.40	0.61

As can be seen from the above information, if the crushing coefficient is reduced, the energy consumption for the cone crusher also decreases proportionally. The crushing coefficient is of course determined based on the physical and chemical properties of the ore [7].

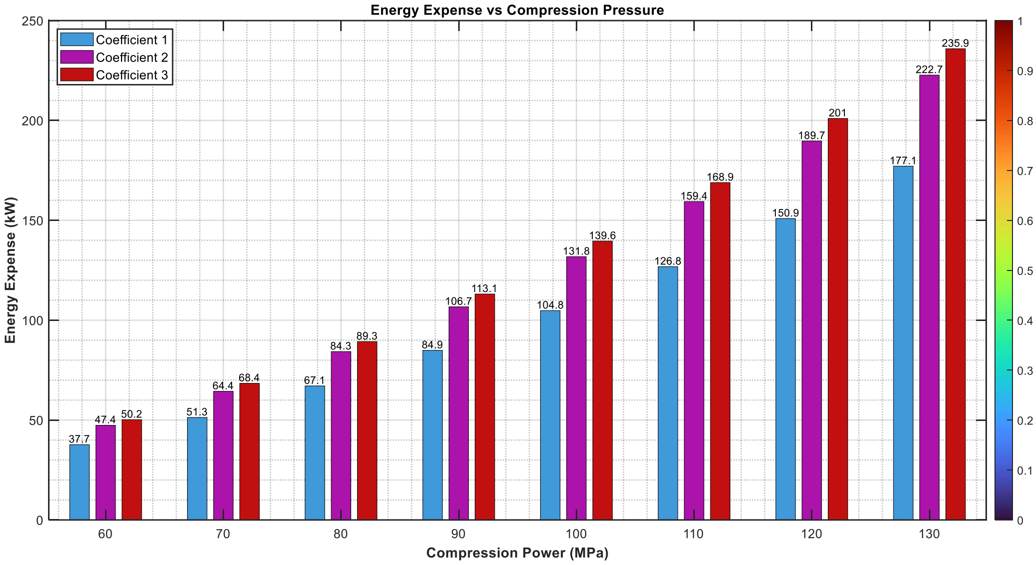

FIGURE 2. Special energy spend initial of the material compression to the power connection.

Compression power From 60 MPa to 130 MPa at *i*=4.6 when changing crusher electricity spent power quadratic function as 50 kW from 235 kW to increases , productivity and 384 t/h equal become remains and comparison energy consumption from 0.13 kW/h to 61 kW/h to increases. Table 3 and in the Fig 3 power, productivity, self typical energy consumption conical rotation to the speed dependence explained [7].

TABLE 3. Energy spend conical rotation to the speed connection

AC motor rotation speed, rpm	Electricity consumption to be done power, kW	Productivity Q, t/h	Special energy expense kW/t
700	128.3	172.3	0.745
800	146.7	197.0	0.745
900	165.0	221.6	0.745
1000	183.3	246.2	0.745
1100	201.7	270.8	0.745
1200	220.0	295.5	0.745

Based on the above table, it can be understood that as the cone rotation speed increases, the electrical energy consumption also increases. However, the productivity also increases proportionally. Therefore, choosing the optimal speed will lead to increased productivity.

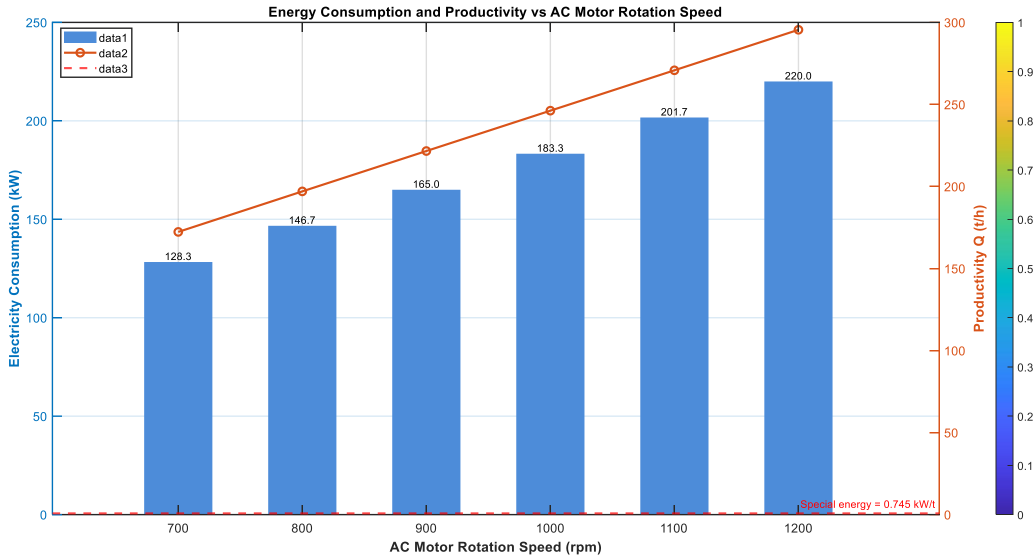

FIGURE 3. Marked energy spend conical rotation to the speed connection.

From figure 3, it turns out that the crusher rotation speed from 700 to 1200 rpm when increased, productivity from 172 t/ h to 295 t/h increases , power and grinder fertility straight away proportional 128 kWt from 220 kWt until increases and comparison energy consumption 0.7 kWt to does not change [8].

CONCLUSIONS

The study allowed us to identify the parameters that affect certain energy consumption. Based on the above relationships, the following conclusions can be drawn:

1. As the grinding ratio increases, the power consumed by the electric drive motor increases unevenly, the efficiency of the crusher decreases, and the specific energy consumption index increases;
2. With an increase in the compression force limit and a constant grinding ratio, the power consumed by the electric motor of the crusher and the specific energy consumption increase, but the efficiency does not change;
3. With an increase in the rotation speed, the power consumed by the electric motor of the crusher and the productivity of the crusher increase in direct proportion. In this case, the specific energy consumption does not change;
4. The established dependences of specific consumption on the initial material parameters and the operating modes of the crusher allow assessing its energy efficiency and can be used to automate the crushing process.

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