Usage advanced technological methods for the recovery of cone crusher equipment

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Abstract. Cone crushers of various sizes and modifications are used widely for rock processing now.

The most widespread are crushers of the KDM and KMDT types. Depending on the types and modifications, crushers are used in various industries: crushing abrasive, extra strong rocks and building materials, in the production of cement and other materials in the construction industry; for crushing rocks in the mining industry.

1 Introduction

During the operation of crushers, large dynamic loads act on their main units, leading to wear and damage to the seats of the support bodies and the crusher bowl.

One of the main elements of a cone crusher is a crushing cone (armor), the surface wear of which causes [3].

As a result, at a processing rate of 1 million tons, the actual amount of rock is processed from 500 to 700 thousand tons before the armor is replaced. The sizes of rock fractions also change upward.

Research and modeling of processes and modes of operation of cone crushers are one of the main directions for improving their design and increasing work efficiency [14-37].

Despite this, the issues related to the restoration of elements subject to increased wear are very relevant for production.

Typical consequences of wear and damage to seats are [4]:

- destruction of armor by turning it on the seats;
- deterioration of technological indicators;
- the danger of non-crushing bodies falling into the crushing cavity and the need for safety equipment;
- irreversible destruction of seats;
- extrusion of the filler from the technological cavity;
- increase in operating costs;
- emergency stops, e.t.c.

A certain negative effect on the productivity and operational characteristics of cone crushers is exerted by the removal during operation of the filler from the technological cavity of the crusher [5-10].

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After the armor is installed on the cone, the technological cavities are filled with bitumen, concrete or liquid zinc.

Bitumen is used on small crushers of the KSD type. On large crushers, where the temperature reaches 60-70 ° C in the ore mixing zone, bitumen softens and fills the armor; therefore, it is not used.

Concrete crumbles during the operation of cone crushers, which leads either to the failure of the crusher or to a sharp deterioration in performance. Zinc filling process cavities is costly and unsafe.

The processes of melting and pouring liquid zinc into a cone crusher are labor-intensive and negative from an environmental point of view.

During operation, zinc begins to crumble from shock loads, which often leads to deformations or destruction of the armor part [13].

When changing the armor, which is carried out at least once a quarter, the remaining zinc is removed from the surface of the cones and sent for remelting. In this case, from 50 to 70% of the previously used zinc is used [12].

2 Materials and Methods

Considering the disadvantages of using the above materials when filling the technological cavities of cone crushers, fundamentally new technology was proposed using special composite materials.

Its implementation was carried out at the "Enterprise Karatau".

A polyurethane composite was chosen as the poured material, and after adjusting its composition following the Customer's requirements, it was named "Multiplast".

The proposed composite material is a relatively low-viscosity composition that flows easily and has a high penetrating ability. After curing, the composite can function as a structural material with high resistance to impacts, vibrations, and sudden temperature changes.

The cure speed of the composite can be easily adjusted from a few minutes to several hours. The material is resistant to the action of water, oils and petroleum products, "Multiplast" consists of two components, A and B. Its main characteristics are presented in table 1.

Figure 1 shows the place of pouring the composite into the technological cavity of the cone crusher type KMD - 3000.

The filling of the cavity with the "Multiplast" composite can be carried out both manually and mechanically. Depending on the amount of material, the pot life of the mixture of components A and B can be adjusted downward.

The technology of pouring the composite "Multiplast" into the cavity is relatively simple and easy to master by the production personnel. The surfaces of parts filled with liquid compound should be cleaned of dirt and rust and wiped thoroughly.

To prevent adhesion of the compound to the metal, the cleaned surfaces should be lubricated with a uniform layer of plastic or liquid grease. Components A and B must be premixed with each other and poured into the technological cavity within no more than 30 minutes until it is completely cured.

Table 1. Main characteristics of full-nitane composite

The name of indicators	Value of indicators
Component Ratio A: B	2:1
Density, g / cm2 component A component B	1.3 1.2
Component viscosity at 20 ° C, from to B 3-4, no more component A component B	100 80
Hardness, Mpa	68
Strength Mpa: under tension bending	26 60
Strength of the adhesive bond of metals, MPa, at shear, at 20 ° C steel 3 - steel 3 duralumin D-16 - duralumin D-16	15 11
Elongation at break,%	7
Specific impact strength, kJ / mm ²	6
Elastic modulus, Mpa	5000
Shrinkage after curing	Absent
Temperature resistance, °	from – 30 to+60
Pot life, min	42

Fig. 1. Place of pouring the composite into the technological cavity

The hardened compound is a light brown polymer that is resistant to shock and vibration loads, temperature changes, and chemical resistance to water and oil and petrol products.

When dismantling a cone crusher, in contrast to zinc, the compound is easily separated from the base metal and can be removed as a whole or in parts, for which it must be cut axially with an angle grinder [9].

Replacing zinc by filling the cavities of a cone crusher with composite material has shown the high efficiency of the proposed method.

The usage of this technology and new materials on KMD-3000 cone crushers at one of the enterprises confirmed the expediency of the application.

According to the previously used casting technology, about 1500 kg of liquid zinc is required per crusher, while according to the new technology, only 250 kg of the compound.

Stone crushers at the Karatau plant, where the introduction of new technology was carried out, six cone crushers were involved, i.e. the armor is changed at least 24 times a year.

The process of filling technological cavities is also used the same number of times. Calculations showed that the annual economic effect at this enterprise amounted to 920 335 000 million cm with a payback of the costs associated with introducing new technology within seven months. The above figures confirm the high efficiency of the new advanced method and provide the basis for its widespread implementation.

Successful work was also carried out on cone crushers to restore the seating surface for the installation of armor.

The performance of cone crushers and their service life is significantly influenced by the condition of the cone seating surface on which the crusher's armor is installed.

The intensive operation of cone crushers leads to the appearance of various types of defects that impede the normal operation of the equipment. Such defects include:

- defects on the bearing surface of the cone;
- uneven wear of the cone armor seat along the circumference;
- uneven fit of the armor;
- uneven fit of the armor;
- ellipse and non-concentric armor;
- increased clearance between the armor and the cone seat;
- positioning of the armor below the cone seat

One of the main reasons for the appearance of the above defects is the so-called "fretting corrosion".

During fretting corrosion, mechanical-corrosive wear of the contacting bodies occurs at small relative displacements. As a result of wear, intense brittle destruction of the friction surface occurs [6].

In fretting corrosion, two processes occur simultaneously - setting and oxidation, and their intensity is much higher than under the conditions of conventional sliding friction. Adhesion - local bonding of contacting surfaces - can be observed even at low loads [1].

It is these processes that occur in the contact zone of the armor with the cone support surface. Destruction of the surface during fretting corrosion is manifested in rubbing, adhesions, cavities or tears filled with wear products [7].

The first diagnostic sign of fretting corrosion is the appearance of coloured spots on the friction surfaces, which contain deformed oxides. Growth in the vibration amplitude of rubbing bodies leads to surface destruction due to the exfoliation of material particles and an increase in the thickness of oxide films, and wear products are usually not removed from the contact zone.

Clothes with micro setting and oxidation processes wear are intensified by fatigue processes and abrasive destruction [11].

The decisive role of these processes depends on the specific wear conditions.

The last stage of fretting corrosion is associated with the final destruction of damage zones, previously loosened by fatigue and corrosion processes [4].

Considering the possibility of electrochemical processes, this stage can be called corrosion - fatigue failure [2].

During this period, the surface layers of the metal, which have been subjected to cyclic deformations for a long time, become so weakened that they lose stability, and their progressive separation begins, which manifests itself in an increase in the wear rate.

Fretting corrosion is also accompanied by a structural change in the surface layers of the metal, which is a negative factor [4].

Fretting corrosion is observed in shafts, rolling bearings, couplings and other parts in moving contact.

As a result of the study of joints operating under fretting corrosion conditions, it was found that surface hardening allows creating a favorable structure and increases wear resistance by 1.5-3 times, depending on the carbon content in steel and test parameters [4].

Increased resistance to fretting corrosion is also achieved by laser hardening of steels, nitriding, surfacing, and thermal spraying [1].

The practice of restoring the seating surfaces of cone crushers has shown the feasibility of applying measures related to the strengthening of contact surfaces and the use of surfacing and spraying methods [5].

So, when carrying out restoration work at the Sorsk ferromolybdenum plant in the process of diagnosing the state of the supporting surface under the armor, significant deviations were revealed, and the estate:

- wear of the seat under the armor from | up to 8 mm;
- radial run out of the seat from - 4.6 to + 0.4 mm;
- deviation of the tapered surface from a given angle from | up to 8 °.

In fig. 2, a shows a photo of defects in the support surface of the cone under the armor, and in Fig. 2, b - a consequence of defects - a break in the armor of the bowl.

Fig. 2. Defects of the bearing surface of the cone (a) and their consequences (b)

To eliminate the detected defects using the developed technology, metal surfacing was carried out on the worn surface in the places of chips and cavities. The deposited layer was 8 mm. After surfacing, a turning treatment of the deposited surface was carried out, followed by grinding.

Technologically, the required angle of the tapered surface was ensured, which was controlled by a specially prepared gauge.

There were no deviations from the specified dimensions. Thanks to the presented technology, the following is achieved:

- ensuring the original geometric dimensions;
- hardening of seats of hardness up to 400 HB, i.e. almost double the original;
- an increase in the contact zone of the lower seat with the cone armor, and as a consequence, a decrease in the load on the seat;
- ensuring the tight connection of the upper and lower seats of the cone with the seats of the armor.

Defects in its support bowl also have a negative impact on the performance of the cone crusher. They appear on both the outer and inner cylindrical surfaces as well as the tapered surface of the shank.

Defects appear in the form of surface development, shells, cracks. There is also increased run out in the seat.

The causes of damage are often vertical deviations when installing the support block, exceeding the permissible level of vibrations arising from the destruction of armor due to the ingress of unmilled materials, a damaged bushing seat, damage to the tail and armor bushing of the crushing cone.

In fig. 3 clearly shows the defects of these parts arising during the operation of the equipment.

The elimination of defects in the support bowl at the Sorsk FMZ was carried out by the method of metal surfacing on damaged surfaces, followed by machining using portable turning and grinding equipment [3].

The state of surfaces after processing is shown in Fig. 4.

Special rotating devices were developed and manufactured to ensure the required accuracy, thanks to which the required geometric characteristics were obtained on the processed parts. As a result, the factory dimensions of the equipment were practically restored (Table 2), and due to the surfacing of metal with higher mechanical characteristics, the hardness of the treated surfaces was increased 2 times, which made it possible to operate the cone crushers for a long time before changing the armor.

Fig. 4. Condition of supporting surfaces after restoration: a is outer cylindrical surfaces: b is inner cylindrical surfaces: c is shank surface

Table 2. The factory dimensions of the equipment

The name of indicators	Indicator values	
Radial run out of bearing parts: • cylindrical seats (external and internal); • conical seat; • shank surface	-0.9....+0.6 -0.9....+0.7 1.2....4.2	0.9 0.08 0.04
WEAR: • cylindrical places • conical seat	to 6 mm to 2.2 mm	Eliminated ____ ” _____
Ring marks on the shank: • depth (max) • width (min)	6 10	____ ” _____ ____ ” _____
Sinks on cylindrical surfaces:	1....6	____ ” _____
Roughness	4.2 mm	0.4

Thus, a set of new technological solutions for restoration ensures a reduction in unscheduled crusher shutdowns and, accordingly, a decrease in the number of technically difficult and dangerous repairs, an increase in units' efficiency, and a decrease in operating costs.

This recovery method significantly reduces equipment downtime and ensures the reliability of further operation.

The enterprise "Karatau - a unitary enterprise for regular use of roads", which carried out similar restoration work at several enterprises with the scientific and technical support of specialists from KSU named after Berdakh, guarantees at least 5 years of operation of cone crushers without repairs.

Simultaneously, production increases not as a result of emergency shutdowns but for the processing of at least 1 million tons of rocks, which is 1.5-2 times higher than the output of cone crushers that have not undergone such restoration. It should be emphasized that "Karatau is a unitary enterprise for regular use of roads" restoration work directly at the enterprises operating such equipment.

The whole range of works takes, per crusher, no more than two weeks. Whereas when sending the cones to the repair shops or the manufacturer, it takes at least one year.

Thanks to innovative technologies and high economic efficiency, the proposed solutions should be widely used at enterprises of the construction and mining industries. [38-39].

References

1. Tushinsky L.I., Plokhov A.V., Tokarev A.O. Methods of materials research, Moscow, Mir, p. 3842004.
2. Semenova I.V., Khoroshilov A.V., Florinovich GM. Corrosion and corrosion protection, Moscow, p. 376, 2006.
3. Goncharov A.B., Tulinov A.B., Odintsov L.G. Installation for grinding. Patent No. 2385795, Bul. № 10, (2010)
4. Ostrovsky M.S. Fretting as a cause of reduced reliability of mining machines, Mining equipment and electromechanics, № 9, pp. 18-23, (2011)

5. Boyko P.F. Repair restoration of the accuracy of the cones of the crushers, Mining information and analytical bulletin (scientific and technical journal), S5, pp. 12-15, 2015
6. Boyko P.F. Restoration of the working capacity of large-sized shafts of crushing units -Mining information and analytical bulletin (scientific and technical journal), № 2, pp. 377-378. (2009)
7. Verzhansky A.P., Ostrovsky M.S., Mnatskanyan V.U. Modern technologies of maintenance and repair of mining machines and equipment, Mining information and analytical bulletin (scientific and technical journal), № 1. pp. 422-449, (2014)
8. Mnatskanyan V.U., Zinovieva I.I. Modern methods of restoring parts of mining equipment, Mining information and analytical bulletin (scientific and technical journal), № 4-6, pp. 66-68, (2011)
9. Tulinov A.B., Ivanov V.A., Goncharov A.B. Progressive technologies and materials for the restoration of mining equipment, Collection of scientific papers of the seminar "Modern technologies in mining engineering", p. 445, Moscow, (2012)
10. Blazy, P. Vibroinertial comminution principles and performance, Int. J. of Mineral Processing. № 41. pp. 33-51, (2010)
11. Petrini Poli. Quelques elements de technologie dans les appareils de concassage-broyage et criblage, № 469, p. 30-36, (2011)
12. Iridin G.R. Fracture Mechanics, Instructural Mechanics, Proc.Ist Symposium on Naval Structure Mechanics, pp.557-591, (1990)
13. Wells A.A. Application of Fracture mechanics at and beyond general yielding. British Welding Journal, 10(11), pp.563-570, (1993)
14. Eloranta J., Influence of Crushing Process Variables on the Product Quality of Crushed Rock. Tampere University of Technology, (1995)
15. Evertsson C.M. Modelling of flow in cone crushers, Minerals Engineering, **12**(12), pp. 1479-1499, (1999)
16. Evertsson C.M., Cone Crusher Performance, In Dept. of Machine and Vehicle Design. Chalmers University of Technology, Sweden, (2000)
17. Whiten W.J., The Simulation of Crushing Plants with Models Developed using Multiple Spline Regression. J. SAIMM, 1972. 072(10) p. 257-264.
18. Evertsson C.M., Modelling of flow in cone crushers. Minerals Engineering, **12**(12): pp. 1479-1499(1999)
19. Eloranta J., Influence of Crushing Process Variables on the Product Quality of Crushed Rock, 1995, Tampere University of Technology: Tampere.
20. Liu, H.Y., S.Q. Kou, and P.A. Lindqvist, Numerical studies on the inter-particle breakage of a confined particle assembly in rock crushing. Mechanics of Materials, **37**(9), pp. 935-954(2005).
21. Evertsson C.M., Cone Crusher Performance, in Dep. of Machine and Vehicle Design Chalmers University of Technology, Göteborg, 2000
22. Couroye, C., Z. Ning and M. Ghadiri, Distinct element analysis of bulk crushing: effect of particle properties and loading rate. Powder Technology, **109**(1-3), pp. 241-254, (2000)
23. Liu J. and Schönert K. Modelling of interparticle breakage. International Journal of Mineral Processing, pp. 44-45, pp. 101-115, (1996)
24. Bengtsson M. Quality-Driven Production of Aggregates in Crushing Plants, in Dep. Product and production Development, Chalmers University of Technology: Gothenburg, Sweden, (2009)
25. Potyondy D.O. and P.A. Cundall A bonded-particle model for rock. International Journal of Rock Mechanics and Mining Sciences, **41**(8), pp. 329-1364, (2004)

26. Hulthén, E. and C.M. Evertsson, Algorithm for dynamic cone crusher control. *Minerals Engineering*, 22(3), pp. 296-303, 2009.
27. Hulthén E., Real-Time Optimization of Cone Crushers, in *Dep. Product and Production Development*, Chalmers University of Technology, Göteborg (2010)
28. Khanal, M., W. Schubert, and J. Tomas, Discrete element method simulation of bed comminution. *Minerals Engineering*, **20**(2), pp. 179-187, (2007)
29. Quist J.C.E., Evertsson C.M. Application of discrete element method for simulating feeding conditions and size reduction in cone crushers. In *XXV INTERNATIONAL MINERAL PROCESSING CONGRESS*. Brisbane, QLD, Australia, (2010)
30. Schubert W., Jeschke H. DEM-simulation of the Breakage Process in an Impact Crusher. *New Orders of the Comminution* 4, (2005)
31. Quist, J.C.E. Device for calibration of DEM contact model parameters. In *EDEM Conference 11'*. Edinburgh, (2011)
32. Lichter J., New developments in cone crusher performance optimization. *Minerals Engineering*, 22 (7-8), pp. 613-617, 2009.
33. Mindlin R.D., Compliance of elastic bodies in contact. *Journal of Applied Mechanics*, 16, pp. 259-268, (1949)
34. Quist J.C.E., Evertsson C.M., Simulating Capacity and Breakage in Cone Crushers Using DEM, in *Comminution 10' 2010*: Capetown, South Africa, (2010)
35. Schönert K., The influence of particle bed configurations and confinements on particle breakage. *International Journal of Mineral Processing*, pp. 44-45, (1996)
36. Delaney G.W., Morrison R.D., Sinnott M.D., Cummins S., Cleary P.W., DEM modelling of non-spherical particle breakage and flow in an industrial scale cone crusher. *Minerals Engineering*, 74, pp. 112-122, (2015)
37. Tavares, L. M., Breakage of Single Particles: Quasi-Static, in *Handbook of Powder Technology*, M.G. Agba D. Salman and J.H. Michael, Editors. Elsevier Science B.V. p. 3-68. (2007)
38. Khankelov T., Askarhodzhaev T., Mukhamedova N. Determination of key parameters of device for sorting municipal solid waste. *Journal of Critical Reviews*, 7 (4), pp. 27-28, (2020)
39. Khankelov T., Tursunov Sh., Maksudov Z. Domestic Solid Waste Crusher. *International Journal of Psychological Rehabilitation*, 24(07), pp. 8090-8091, (2020)