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# Problems and methods of improving the quality of jaw crushers

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**Abstract.** Practically in all metallurgical treatment the raw product needs to be crushed by crushing machines. The main indicator of the crushers quality, which characterize their technical level and competitiveness, is their reliability and durability in the operating conditions, which can be quantitatively assessed by the number of failures in the process of obtaining the finished product on the machine. Among numerous technical reasons for the relatively short, but rather frequent downtimes in the operating conditions of jaw crushers, a significant place is occupied by the downtimes associated with the replacement of the plain bearing liners due to their wear. The rapid wear of liners is the result of not only contact friction between the axle trunnions and liners, but also the action of dynamic forces. The dynamic forces arising from the operation of jaw crushers are due to the presence of a gap in the kinematic pair of link junctions and velocities discrete values of the relative displacement of the links inside the gaps of the friction bearing. Consequently, the reliable operation of the machine largely depends on the creation of conditions that ensure the backlash-free contact of the mating links. It was experimentally proven that the use of mechanisms for taking up the wear of bearings with elastic elements that during the entire cycle of operation of the crank-beam mechanism taking up the wear in the kinematic pairs mating, prevents the appearance of additional dynamic loads and, thereby, increases the reliability of jaw crushers. Thus, the quality of the machine increases, as well as its productivity.

## 1. Introduction

Scientific and technical progress in industry depends largely on the level of development of equipment. Improvement of the quality of mining equipment is a complex, multidimensional problem associated with the solution of often contradictory tasks that cannot be solved using a single-criterion selection of the optimization parameter, requiring further development of the fundamental science about deformations and stresses, taking into account the maximum approximation to the actual conditions of production and machine operation.

## 2. The state of the problem

The quality of technological machines as products, determined by the combination of properties that are laid in the process of scientific research, technological and engineering developments, is set in the

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production process of the machine and detected during their operation, and therefore tends to deteriorate due to physical and moral obsolescence [1].

In modern conditions, quality indicators should have not only a quantitative measurement, but also a mandatory value assessment of the cost for achieving them and a stable preservation of a numerical value for a given time. Numerous indicators of the technological machines quality, which are dynamic, time-varying quantities, are divided into two mutually influential groups.

The first group includes indicators of the accuracy of the products obtained and the stability of this accuracy for a given time or during production program. Obviously, this indicator depends not only on the chosen technological process, but also on the perfection of the applied processing means (crusher, separator, etc.). The relationship between the accuracy parameters of the finished product and the design of the machine is manifested through the stiffness coefficient of the power system of the latter.

However, a not limited increase in stiffness does not at all mean a proportional increase in the accuracy of the product obtained and a decrease in energy consumption for elastic deformation, but is associated with an increase in such important machine indicator as material consumption, because it leads to an increase in the cross section of the power system components and dynamic effects on the processed material and the environment (foundation, building), in which people work.

The second group includes equipment quality indicators characterizing its performance, reliability and durability, energy consumption and material intensity, labor comfort, determined by ergonomics, aesthetics, safety engineering and environment.

Machines for materials processing belong to the process equipment, which has the most ample opportunities for an almost unlimited increase in labor productivity. However, these possibilities do not mean that a qualitative indicator of productivity can only be assessed according to the theoretically possible speed of technological movements of the machine’s working parts and the minimum possible processing time.

The limiting factors of the value of the performance indicator are consistently achievable indicators of reliability and durability of machines with a mandatory assessment of the economic costs of production, operation and maintenance of machines to achieve stable reliability and durability. Thus, the performance indicator should be assessed not only by the quantity of products per unit of time, but mainly by the quantity of products per unit of time referred to the material costs of obtaining this quantity of products.

The formation of energy intensity indicators of technological processes and processing means must be carried out with due regard for the speed of movement of the working bodies and the elastic properties of not only the material being processed, but also the power elements of the machine as a single system. Elastic deformations of the system together with the speed of movement of the working body are not only a source of dynamic effects on the processed body, but also the main factors determining the movement speed of the working body during the execution of the technological operation, namely, this speed is the determining energy and process intensity of the machine.

The quality indicator – material consumption can be attributed both to the quality of the technological process, characterized by the utilization of the material, and to the quality of the machine determining its mass.

The importance of the value limit of this quality indicator is not only in its influence on the capital costs of production and the cost of the machine, but it also depends on the mass of the machine and its constituent elements related indicators of the accuracy of the resulting product through the stiffness coefficient and the bearing capacity of the machines (reliability, strength, performance), through the parameters of vibration resistance and vibration activity affecting not only the reliability of the machine, and hence its performance, but also the indicators of comfort (vibration, noise, safety, etc.).

One of the main indicators of the quality of crushing machines, characterizing their technical level and competitiveness, is reliability in the operating conditions, which is quantitatively evaluated by the absence of failures in the process of operation. Among the many technical reasons for the relatively short, but quite frequent downtimes of machines with crank drive in the operating conditions, the first place is occupied by downtime due to the failure of the elements of the kinematic chain joints (bearings).

Jaw crushers in metallurgical production [2-5] are used to crush the material, with different requirements for the final crushing product which are mainly related to dimensional accuracy and configuration. In jaw crushers, the material is crushed due to crushing, splitting and partial attrition in the space between the two cheeks as they periodically approach to each other.

The nature of the movement of the movable cheek, providing the specified characteristics of the quality of the final crushed product, depends on the kinematic features of the jaw crusher mechanism. Over the course of time a large number of various kinematic schemes of the crusher mechanism have been proposed and implemented.

The classification of jaw crushers proposed by B.V. Klushantsev [6] is based on the nature of the swing jaw movement, since it determines the most important technical and economic parameters of crushers. With all the variety given in the classification of the kinematic schemes of the swing jaw mechanism, it should be noted that all of them are implemented using joints that provide the mobility of machine parts. However, the joints have a significant drawback, namely, that the pin in the cage is gapped [7,8]. This circumstance is significant, as it causes the impact of joint elements during their relative movement in the gap when the direction of the driving member changes (gap overtravel) during mechanism operation, and, as a consequence, increased wear of joint elements, as well as the occurrence of additional dynamic forces, reaching considerable size and reducing the reliability of the machine as a whole.

Thus, the reliable operation of the machine depends largely on the creation of conditions that ensure the gap-free contact of the coupled links. In practice, this problem is traditionally solved by using either conical mating surfaces [9], which causes difficulties in their manufacture, or systems with spring preload of half-bushes of friction bearings [10], however, steel springs have a low damping capacity, their parameters requires constant monitoring of their condition, as well as spring elements, it is impossible to create automatic or automated control systems for devices for taking up the wear of bearings. The above stated necessitates the development of constructive measures to create a gapless combination of elements of kinematic pairs.

## 3. The object of study

Studies have shown that the desired effect can be obtained by applying compact elastic pneumatic elements (figure 1) embedded in a kinematic pair [11].

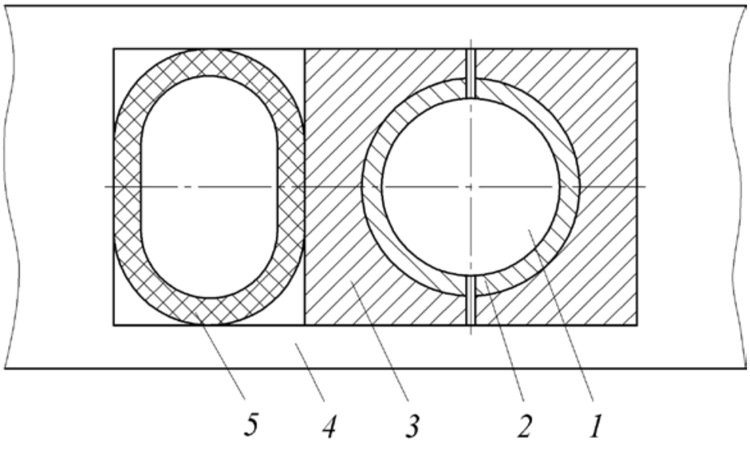


**Figure 1.** Scheme of a joint with an elastic pneumatic element: 1 – trunnion; 2 – liner; 3 – movable half support; 4 – frame; 5 – elastic pneumatic element.

The use of mechanisms for taking up the wear in the joints of the kinematic chain, which during the entire cycle of operation of the crank-rocker mechanism of the crusher's jaw swing, ensures constant contact of the movable links surfaces, prevents gaps from overtravelling and, consequently, the occurrence of additional dynamic forces.

Constantly acting on a movable body with an anti-friction liner attached to it, the elastic element selects the gap between the trunnion and the liner. It is installed from the side opposite to the effect of technological resistance on the bearing, which contributes not only to the choice of the gap in the joint, but also compensates for the liner wear. The magnitude of the excess pressure inside the elastic element is set to eliminate the opening of the gap in the joint as a result of the action of elastic forces acting on the trunnion after the relief of technological resistance forces. The stiffness of an elastic pneumatic element made in the form of a cylinder with limited axial deformation is determined by the relation [12]

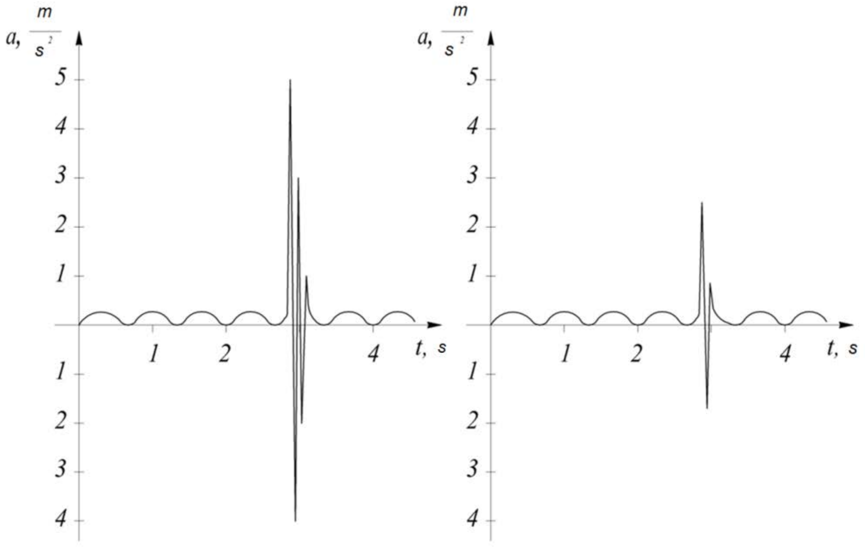
$$C = \frac{\pi \cdot l \cdot p_0}{2},$$

where $p_0$ – the value of excess pressure; $l$ – cylinder length.

The experiments were carried out at a research jaw crusher. The vibration level was estimated indirectly through the values of the accelerations of the bed frame in which the accelerometers in the horizontal and vertical planes are installed.

## 4. Results and discussion

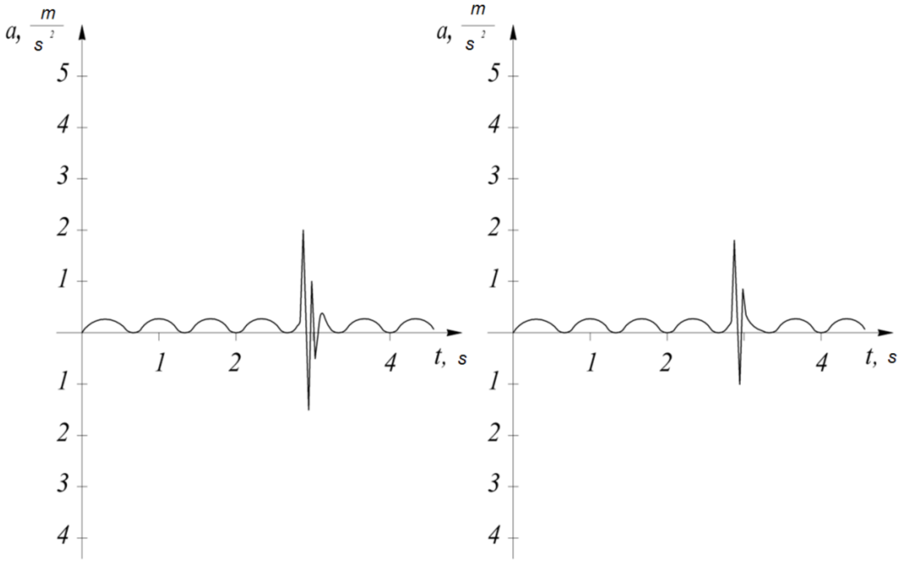
The experiments show that when there are gaps in friction bearings, the level of accelerations in the horizontal plane (figure 2 a) is $0.4 \div 0.5$ m/s$^2$ at idle strokes, under the influence of technological resistance forces (in the process of single crushing) and when they are reset, the peaks of accelerations of magnitude up to 5 m/s$^2$ occur, and in the vertical plane (figure 3a) – $0.3 \div 0.4$ m/s$^2$ and $1.5 \div 2$ m/s$^2$. If the gaps in the supports are selected with the help of elastic pneumatic devices, then in the horizontal plane when idling, the level of acceleration decreases slightly and is $0.3 \div 0.4$ m/s$^2$, and during crushing and during load drop the value of acceleration is much less than during operation of bearings with gaps and is $2 \div 2.5$ m/s$^2$ (figure 2 b).



(a) (b)

**Figure 2.** Oscillograms of the bed frame accelerations in the horizontal plane: a – if there are gaps in the support; b – at selected gaps.

In the vertical plane, the clearance adjustment has virtually no effect on the level of acceleration (figure 3 b). Obviously, the lower the level of acceleration occurring during the jaw crusher operation, the lower is the machine vibration level.



(a) (b)

**Figure 3.** Oscillograms of the frame bed accelerations in the vertical plane: a – if there are gaps in the support; (b) – at selected gaps.

It should be noted that the attenuation of acceleration values in the presence of gaps in bearings during load drop occurs during 3÷4 periods of oscillation, while when using devices for clearance adjustment, the damping occurs almost immediately, which indicates a high damping capacity of elastic pneumatic elements.

The experimental studies show that when using elastic pneumatic devices, wear of the elements of the kinematic pairs forming a joint is reduced, dynamic loads are significantly reduced, and the time between repairs increases. Thus, the quality of the machine improves as well as its productivity.

## 5. Conclusion

The influence of vibration, arising due to the presence of gaps in the friction bearings of the crank-beam mechanism of the movable cheek swing, on the reliability of jaw crushers is determined. The design of an elastic pneumatic device for taking up the wear of bearings during operation of a jaw crusher is described, and it is experimentally proved that the reduction of vibration by eliminating gaps, increases the period between repairs of a jaw crusher. Thus, the quality and productivity of the machine improve.

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