

Improvement of jaw crushers reliability using elastic pneumatic elements in the connection of kinematic pairs

A G Nikitin¹, A V Abramov¹, E Ya Zhivago¹, L T Dvornikov¹ and L A Saruev²

¹Siberian State Industrial University, 42 Kirova street, Novokuznetsk, 654007, Russia

²Tomsk Polytechnic University, 30 Lenina ave, Tomsk, 634050, Russia

E-mail: nikitin1601@yandex.ru

Abstract. Downtimes associated with the replacement of the plain bearing liners because of their tear and wear are among the numerous technical reasons for relatively short-term but rather frequent downtimes in the conditions of operation of jaw crushers. The rapid wear of the liners is the result not only of contact friction between axle journals and liners, but also the action of dynamic forces. Dynamic forces that arise during the operation of jaw crushers are due to the presence of a gap in the kinematic pairing of the links (journals and bearing lining) and discrete speed values of the relative movement of the links inside the clearances of plain bearings. Thus, the reliable operation of the machine largely depends on the creation of conditions that ensure a gapless contact of the conjugated links. It was experimentally proved that the use of mechanisms for the selection of gaps with elastic elements, which during the whole cycle of operation of the crank and rocker mechanism select a gap in the joints of kinematic pairs, prevent the appearance of additional dynamic loads and, thereby, increase the reliability of the jaw crushers.

1. Introduction

In almost all metallurgical operations crushed material is required as a raw product obtained using crushing machines, as well as processing products of metallurgical industry: slags, ferroalloys and others. The main indicator of the quality of crushers, characterizing their technical level and competitiveness, are their reliability and durability under operating conditions, which can be quantitatively estimated by the number of machine failures in the process of obtaining finished products [1]. It is obvious that any reduction in machine downtime for elimination of failures increases the productivity of the machine as a whole.

Downtimes associated with the replacement of the plain bearing liners because of their tear and wear are among the numerous technical reasons for relatively short-term but rather frequent downtimes in the conditions of operation of jaw crushers.

The rapid wear of the liners is the result not only of contact friction between axle journals and liners, but also the actions of dynamic forces that are the source of machine vibrations, noise, premature breakdown of threaded joints and breakdowns of parts caused by an increase in the number of loading cycles of alternating loads, fatigue strength of its elements.

Dynamic forces arising during the operation of jaw crushers are due to the presence of gaps in the kinematic pairs of links connection (journals and bearing linings) and discrete speed values of the relative movement of the links inside the clearances of the plain bearings.



Nodes and parts of jaw crushers in the process of their operation are exposed the dynamic forces caused by shock loads that arise when the load is released, when the (technological) force is removed from the previously elastically deformed mechanical system when the crushing zone of the jaw crusher is discharged, since under the force of the technological resistance of the journal is pressed against the surface of the bearing lining located on the opposite side of the crushing zone, and after removing the force of the technological resistance the journals under the action of elastic forces moves to the opposite side by the size of the gap, bumping against the liner [2], with a runaway of the gap followed by bounces that decay in strength due to damping. Emerging dynamic (shock) effects lead to the excitation of elastic vibrations of the mechanical system: bearings, bearing housings, the frame as a whole.

Clearances in kinematic pairs, the presence of which are unavoidable in order to ensure relative mobility of links, with increasing duration of operation of jaw crushers, gradually increase, which leads to a decrease in the smooth operation of the machine and the quality of the product obtained (change in fractional composition), and to the increase in additional dynamic forces.

Thus, the reliable operation of the machine largely depends on the creation of conditions that ensure a gapless contact of the connected links. In practice, this problem is traditionally solved by the application of either conical conjugate surfaces [3], which cause difficulties in their manufacture or mechanical systems with spring compression of the half-sleeves of plain bearings [4]. If steel springs with a small damping capacity are used, their parameters change significantly over time, which does not allow realistic monitoring of their condition. In addition, it is impossible to create automatic or automated control systems for devices with the selection of gaps by means of spring elements. All of the foregoing stipulates the need for the development of constructive measures for the creation of a gapless connection of the elements of kinematic pairs.

2. Results and discussion

Studies showed that the necessary effect can be obtained by using small elastic pneumatic elements (figure 1), embedded in a kinematic pair [5]. Constantly acting on the movable body with the antifriction liner fixed on it, the elastic element chooses the gap between the journal and the liner. It is installed from the side opposite to the effect of the force of technological resistance on the bearing, which contributes not only to the selection of the gap in the connection, but also provides compensation for the liner wear. The magnitude of the overpressure inside the elastic element is set to such a value that, as a result of the action of the elastic forces acting on the journal after the reset of the technological resistance forces, there is no opening of the gap in the connection.

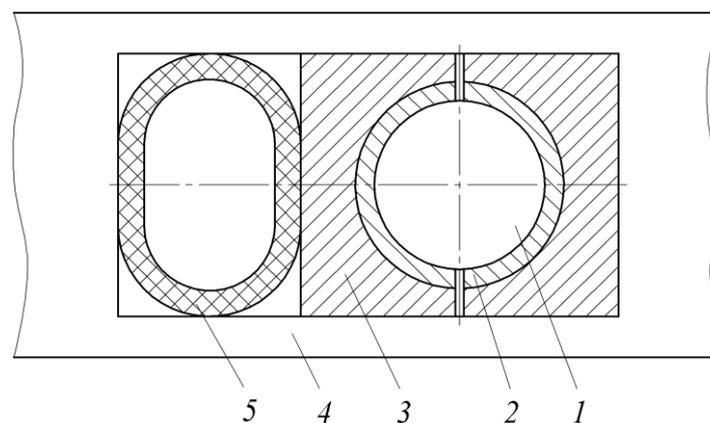


Figure 1. Scheme of support with an elastic pneumatic element: 1 – journal; 2 – liner; 3 – mobile semi-support; 4 – frame; 5 – elastic pneumatic element.

The stiffness of the elastic pneumatic element, made in the form of a cylinder with a limited axial deformation, is determined [6] by the relation

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

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

The experiments were carried out on a research facility – jaw crusher. The level of vibration was estimated indirectly through the values of the frame acceleration, in which accelerometers are installed in the horizontal and vertical planes.

Experiments showed that in the presence of gaps in plain bearings, the level of acceleration in the horizontal plane (figure 2a) is $0.4 \div 0.5 \text{ m/s}^2$ at idle speeds. Under the influence of the technological resistance forces (in the process of single crushing) and during their relief, peaks of acceleration appear in magnitude up to 5 m/s^2 , and in the vertical plane (figure 3a), respectively, $0.3 \div 0.4 \text{ m/s}^2$ and $1.5 \div 2 \text{ m/s}^2$.

If the gaps in the supports are chosen with the help of elastic pneumatic devices, then the level of accelerations decreases insignificantly in the horizontal plane at idle speeds and amounts to $0.3 \div 0.4 \text{ m/s}^2$, and in the process of crushing and when the load is dropped, the magnitude of the accelerations is much less than in operation of bearings with gaps $2 \div 2.5 \text{ m/s}^2$ (figure 2 b).

In the vertical plane, the selection of gaps practically does not affect the level of acceleration (figure 3 b). Obviously, the lower the level of acceleration that occurs when a jaw crusher works, the less is the vibration level of the machine.

It should be noted that attenuation of acceleration values in the presence of gaps in bearings during load relief occurs over $3 \div 4$ periods of oscillation, while using devices for gaps selection damping occurs almost immediately, which indicates a high damping capacity of elastic pneumatic elements.

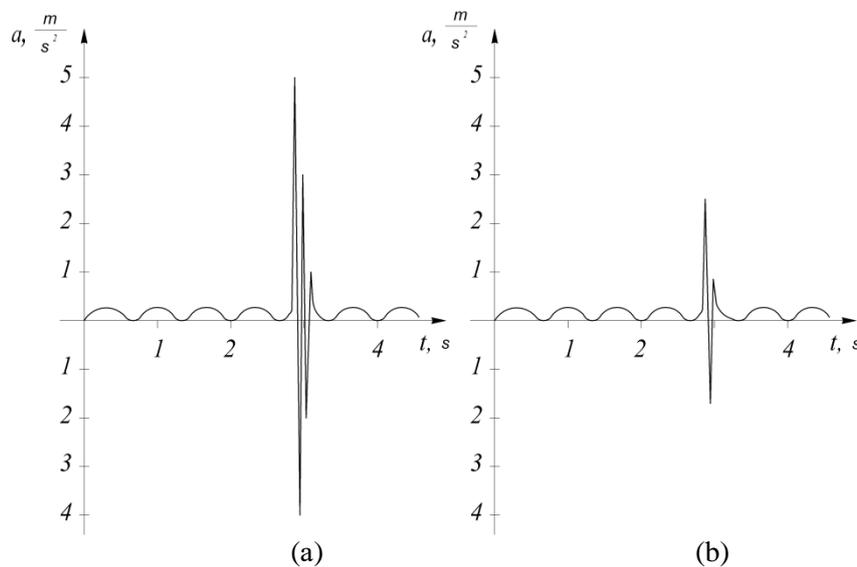


Figure 2. Oscillograms of the frame acceleration in the horizontal plane: a – in the presence of gaps in the support; b – for selected gaps.

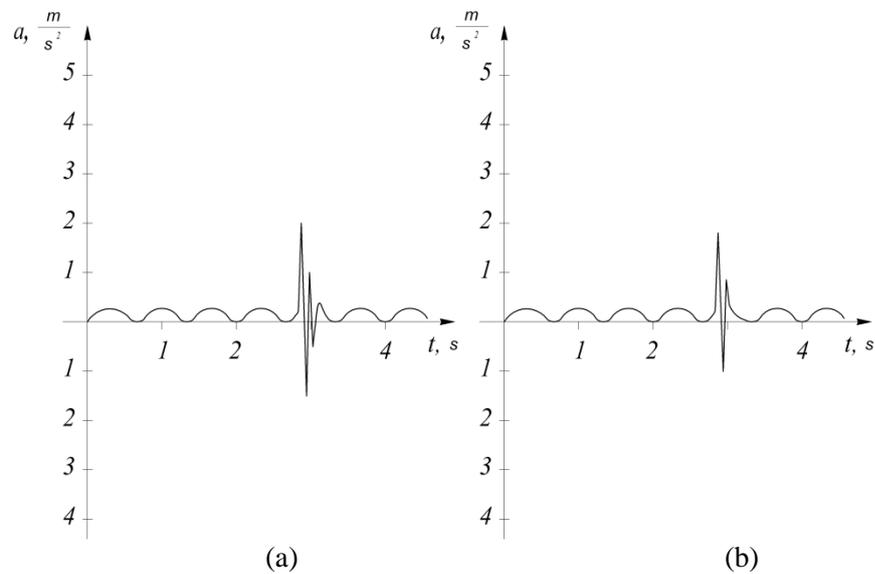


Figure 3. Oscillograms of the frame accelerations in the vertical plane: a – in the presence of gaps in the support; b – for selected gaps.

3. Conclusion

The influence of the vibrational action due to the presence of gaps in the plain bearings on the reliability of the jaw crushers is determined. The design of the elastic pneumatic device for the selection of gaps in plain bearings during the jaw crusher operation is described and the reduction of the vibration level by eliminating gaps is experimentally proved.

References

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