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Determination of Stress Condition of Vibrating Feeder for Ore Drawing from the Block under Impact Loads

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In this article the results of the experimental studies of dependence of stress in the vibrating feeder container, time of impact and protective layer properties are given. This research was performed on the laboratory bench modeling vibrating feeder container. It is shown that the protective rubber lining of vibrating feeder reduces stress concentrations in the contact zone of impact of vibrating feeder container with falling collision boxes vibratory feeder with falling chunks of ore is more than five times, it reduces the weight of the moving parts of the machine and the drive power.

Keywords: VIBRATION FEEDER, ORE, RUBBER LINING

In the mining industry vibration units are widely used in the implementation of mechanized production, such as underground ore mining. They are the main machines under these conditions for the production and delivery of ore from the stope to the highway means of transportation. The usage of vibrating feeders and systems can intensify the process of ore production from the stope within the treatment units and systems thus improving the efficiency of ore deposits development system with a massive ore collapse. Numerous studies and a long operating experience proved that the advantages of using vibrating units in the form of vibratory feeders, vibratory systems, vibrating tables, vibrating screens lie in the fact that due to the vibration ore discharge from the drawn pit and directed forced displacement of rock mass is improved. This increases the permeability of the workings and largely eliminates ore overhang. It was found that the effective area of draw hole increases by almost twice and the coefficient of friction inside the ore flow output decreases considerably. Thus, applied vibrating units are simple in construction and manufacturing, they are easy to maintain and have a high productivity and relatively low power consumption. Since the usage of these machines meet the requirements of modern mining technology, their production is provided by several plants in Ukraine.

An analysis of the most prospective designs of heavy-duty vibratory units operating in the conditions of ore drawing from the blocks showed that they are in a complex stress state and require a solution for a number of special problems associated with additional research, development of calculation methods and new design solutions for their improvement. During developing thick ore deposit the volume of ore draw per one unit varies in the range of 150-200 thousand tons. Taking into account the interaction with a lumpy abrasive rock mass and oversize yield, vibrating feeders on direct drawing have significant impact loads at which the stress in the metal construction often exceed allowable values and lead to premature failure of the machine. In addition to significant static loads, they undergo impact from falling pieces in the process of destruction of the arches and secondary crushing of oversized material with explosion.

Failures of machines for the mentioned reasons, repairs and fault time associated with it, make up a significant part of the value of mined ore. Therefore it was suggested to increase the reliability of these machines by the usage of protective coatings of their operating devices [1-3], since increasing the reliability by increasing the margin of safety is not advisable as it increases the weight of the movable parts of the unit and drive power. One of the prospective methods of the protection of operating devices of vibratory feeders, allowing to reduce the stress in the metal constructions at the impacts and to improve the wear resistance of working surfaces is to use a rubber lining. The solutions of issues connected with the calculations, design and manufacturing are represented in many studies [1-3], which show the effectiveness of rubber lining application for protection from impact and abrasion work of surfaces. Fig. 1 shows an option of such a decision when during the drawing of exploded ore from the block at its underground mining through the draw hole 1, lumpy rock mass is reloaded by vibrating feeder 2 onto the haulage entry into the mine car 5. There also the interaction of the falling ore oversized material 3 with the rubber lining 4 of the vibrating feeder is shown.

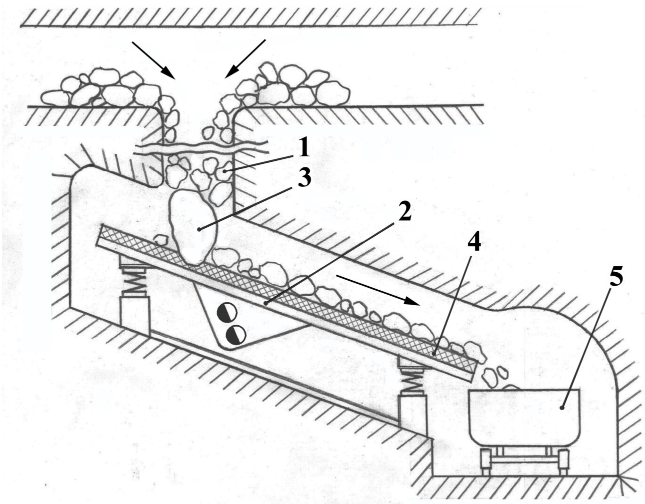

Figure 1. The scheme of interaction of falling ore piece with the vibrating feeder

In previous studies there was made a quantitative evaluation of the lining effectiveness, and also the methods to calculate it for reasons of preserving the integrity under deformation with a lumpy rock mass were shown [4].

The purpose of these studies is to identify the dominant factors and their numerical values in the process of interaction of piece of falling rock mass directly in the contact area with the working device surface which has a protective layer or has not.

The studies were performed on a laboratory bench in the form of vibratory feeder chute, made in 1:3 scale, during a central impact interaction with the falling mass. In this study there was investigated a feeder without a protective layer, a feeder with a protective layer in the form of fine ore and a feeder with a rubber lining of different hardness (in nominal units on a standard hardness tester TM-2). Experimental procedure is described in a detailed way in the study [5]. During the research the impact energy and the character of protection from it on a feeder chute were varied. The measured parameters were the stresses in the contact area of the collision, which were determined using a strain-gauge method, the duration of the impact and the surface of collision area, fixed by a print in the moment of impact. During the experiment, the feeder chute had a rigid bearing without elastic supports.

Fig. 2 shows the results of experiments in a form of dependence of a stresses σ at the bottom of the feeder chute in the contact zone of the collision on the impact energy Ek with the unprotected chute surface (curve 1), with the rubber lining with hp=12 mm (thickness) and hardness of 85 units (curve 2), with protection of fine ore layer, b=10 mm (curve 3) and with rubber lining protection with thickness hp = 12 mm (thickness) and hardness of 56 units (curve 4).

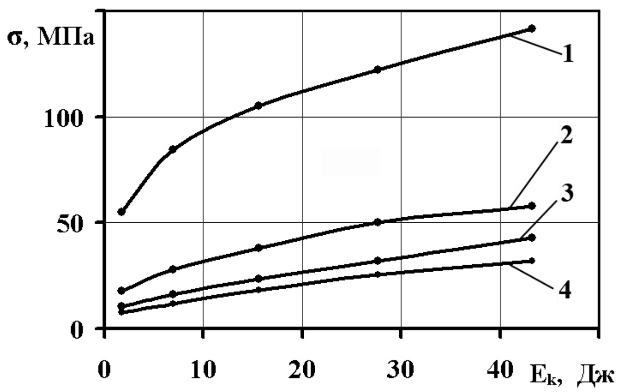

Figure 2. Dependence of the stress in vibrating feeder chute on the impact energy: 1 – without protective layer; 2 – rubber lining (E = 85); 3 – protective layer of material (b = 10 mm); 4 – rubber lining (E = 56)

Figure 3 shows the results of experiments in a form of dependence of collision contact time **t** on the energy of impact to the protected surface of chute with ore layer (b=10 mm) (curve 1); to the surface protected with rubber lining (hp = 12 mm and hardness of 85 units) (curve 2); to the surface protected with a rubber layer (h_p = 12 mm and hardness of 56 units); to the unprotected surface (curve 4).

Figure 4 shows the results of the interaction of falling load in the form of a dependence of collision contact diameter **D** on the impact energy. To improve the accuracy of the experiment the impact surface of the mass falling on the feeder is taken as a sphere. Curve 1 characterizes the interaction of feeder chute lined with rubber (h_p=12 mm, hardness is 56 units), curve 2 characterizes the interaction of feeder chute lined with rubber (h_p=12 mm, hardness is 85 units) and the curve 3 characterizes a chute without protective layer.

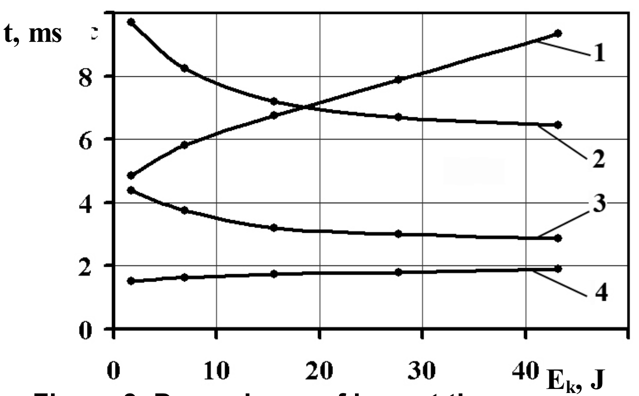

Figure 3. Dependence of impact time on impact energy: 1 – protective layer of material (b=10 mm); 2 – rubber (E=56); 3 – rubber (E=85); 4 – without protective layer

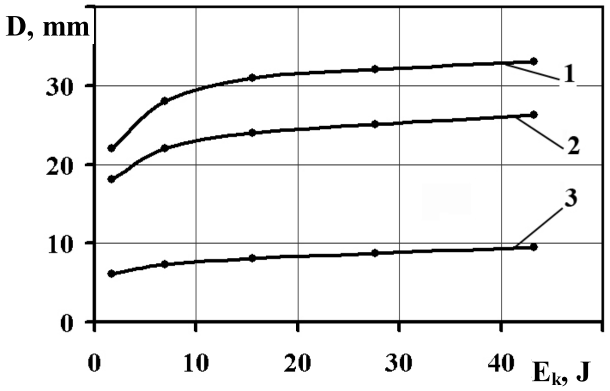

Figure 4. Dependence of print diameter on impact energy: 1 – rubber (E = 56); 2 – rubber (E = 85); 3 – no protective layer

In all cases of the experiment, the impact energy varied with the same spacing, so there was an opportunity to determine the relationship between the stresses in the contact area of the interaction, the contact time and the diameter of its area. The positive effect of increasing contact time at the constant impact energy is in divisible reduction of the impact, and increasing the diameter of the contact area allows us to reduce the concentration of shock to the square, not to the point of impact. Both of these factors significantly reduce the stress in the vibratory feeder chute at impact loads; and the character of dependence on each of them and quantification of stresses in the chute allow defining the rational parameters of structures. It should be noted that although the positive effect on the protective ore layer on the feeder chute was observed, this method is not functional because it is associated with drawing technology and can not ensure the stability of the layer thickness parameters.

Conclusions

The performed investigations showed that the protective rubber lining reduces stress concentrations in the contact zone of impact of the working device of the vibratory feeder with falling ore prills for more than 5 times. This takes place due to deformation and dissipative properties of the rubber layer, providing an increase in contact time and the distribution of the increased area of contact stresses. Moreover, with a decrease of hardness of the lining rubber layer its positive influence increases; it must be considered when designing device outline or choosing the lining.

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Определение напряженного состояния вибропитателя для выпуска руды из блока при ударных нагрузках

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Приводятся результаты экспериментальных исследований, проведенных на лабораторном стенде, моделирующим короб вибропитателя, по определению зависимости напряжения в коробе вибропитателя, времени удара и диаметра контактного соударения от энергии удара и свойств защитного слоя. Показано, что защитная резиновая футеровка вибропитателя обеспечивает снижение концентрации напряжений в зоне контакта соударения короба вибропитателя с падающими кусками руды более чем в пять раз, что позволяет снизить вес подвижных частей машины и мощность привода.