Cone vibration crusher for grinding grain materials

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Abstract. The article provides an analysis of the schemes of cone-vibration crushers used for grinding mountain and mineral materials and offers an improved structural and technological scheme, device and principle of operation of the cone vibration crusher for grinding grain materials for animal and bird feed.

1. Introduction
One of the decisive conditions for accelerating the growth in the rate of production of livestock products, improving their quality and reducing production costs is the feed base - providing animals and poultry with full-fledged feeds, balanced in nutrition in accordance with the planned productivity. When organizing the proper feeding of animals, the rational use of concentrated feed is very important, since grain is one of the main components of compound feed and other types of feed mixtures. When feeding crushed grain increases the digestibility of nutrients. Grain fodder, crushed to a certain size by zootechnical requirements, increases the average daily gain in live weight by 25 ... 28%. Therefore, the grinding of grain feed is carried out in order to bring the source material to a certain particle size distribution.

For grinding feed use various designs of grinding machines. A progressive scheme is cone inertial crushers [1]. Pieces of materials in cone-inertial crushers undergo fatigue failure under the action of inertial loading.

2. Methods
The analysis of various schemes of cone vibratory crushers for grinding grain with various degrees of grinding.

Known disk mill containing a housing with a receiving funnel, inside of which are coaxially arranged facing each other working surfaces with cutting ribs disks, one of which is mounted on the housing, and the other movable, by means of a ball bearing mounted on the drive shaft, the ball bearing is made with two diametrically opposite protrusions, and the movable disk with grooves in which the protrusions of the ball bearings are located with the possibility of rocking motion, and the working surfaces of the disks are made from the central with recesses extending to each other with curved walls, some of the cutting ribs on them are made curved, and some are straight and protruding above the latter [2].

A disadvantage of the known disk mill is that when the gap between the disks is reduced to obtain fine grinding, productivity drops sharply and the temperature of the working surfaces of the disks rises. The use of water jackets on a fixed disk contributes to the condensation of moisture on the
working surfaces, the formation of a pasty mass and clogging of the notches of the disks, which leads to an increase in specific energy consumption and even downtime of the mill. The closest in technical essence to the proposed one is a cone vibration crusher containing a bed on which a control ring with an outer cone is placed, a cooling system for friction units in the form of annular flow cavities for a cooling medium, a spherical bearing for the inner cone with a vertically located shaft on which fixed unbalance having a transmission with bearing bearings in the housing [3]. However, in the crusher it is impossible to regulate the force of the inner cone on the grain material and provide a variable pinching angle, as well as synchronize the forced vibrations created by the unbalance, drive and suspension, which leads to an increase in the specific energy consumption of crushing, a decrease in the efficiency and quality of grinding at various degrees of grinding, as well as a decrease the efficiency of the collection and unloading of crushed material. The objective of the work is to create a cone vibratory crusher, which reduces the specific energy consumption of crushing, increases the efficiency of collection and unloading of crushed material, as well as improves the efficiency and quality of grinding at various degrees of grinding.

3. Results and discussion
The problem is solved in that in a cone vibratory crusher for grinding grain materials containing a bed, on which there is a control ring with an outer cone, an inner cone with a vertically located shaft mounted on two bearing bearings with V-belt transmission, on which the unbalance is fixed, and a cooling system friction units, the upper bearing support is placed in a housing attached to the frame by means of spring-loaded adjusting bolts. In addition, the crusher is equipped with a collector for the crushed material with an unloading disk mounted on the shaft and an unloading chute, as well as the inner cone in a vertical section, it is made curved and the upper unbalance is planted with a freely rotating gap. The installation of the upper bearing on the shaft, made uniform and in the housing with adjusting bolts on the springs, allows you to adjust the compression force of the springs, and therefore the amplitude and vibrations of the inner cone and the force acting on the grain material, which leads to a decrease in the specific energy consumption of crushing at various degrees of grinding. The supply of the shaft collector with an unloading tray and an unloading disk for the crushed material can improve the efficiency of the process of collecting and unloading the crushed material. The execution of the inner cone in a vertical section curved allows you to adjust the fineness of the grinding of the material, which leads to improved efficiency and quality of grinding material of the grain material at various degrees of grinding. Pushing the upper unbalance onto the shaft with a freely rotating clearance allows you to synchronize the forced vibrations created by the unbalance, drive and suspension, which improves the efficiency of grinding grain material.

The proposed cone vibratory crusher in the presence of a water jacket in the working chamber does not produce moisture condensation, since contact with the crushed material of the inner and outer cone is provided over a limited area, unlike disk mills, in which this contact is provided over the entire surface of the disks.
In fig. 1 shows a cone vibratory crusher for grinding grain materials in a longitudinal section.
Figure 1. The structural and technological scheme of the cone vibratory crusher for grinding grain materials: 1-upper part of the bed; 2-lower part of the bed; 3-plate; 4-frame; 5-gasket; 6 bolt connection; 7-regulating ring; 8, 14, 15-ring sealed cavities; 9-outer cone; 10th compilation; 11-tray; 12, 13-bearing bearings; 16-shaft; 17-inner cone; 18-unloading disk; 19, 20 unbalance; 21 V-belt drive 22-body; 23-adjusting bolt; 24-spring; 25-31 fittings; 28, 32-highway.

The cone vibratory crusher for grinding grain materials contains a bed, consisting of two parts - the upper part 1 of the bed and the lower part 2 of the bed, mounted on the plate 3, which is mounted on the frame 4 using shock-absorbing rubber gaskets 5 and bolted joints 6. On the upper part of the bed are placed the regulating ring 7 with an annular tight cavity 8, the outer cone 9 and the collector 10 with the unloading tray 11. In the middle of the upper part 1 of the bed and the lower part 2 of the bed in the bearing bearings 12 and 13 provided with ring sealed cavities 14 and 15, placed vertically located shaft 16, which is equipped with an inner cone 17, the discharge disk 18, unbalances 19 and 20 V-belt transmission 21 from an electric motor (not shown). The upper bearing support 12 is installed in the housing 22, which is fixed in the middle of the lower part 2 of the bed by means of adjusting bolts 23 on the springs 24. Each of the cavities 8, 14 and 15 are equipped with fittings 25 to 27, respectively, for supplying coolant, such as water, to them combined into one line 28. Cavities 8, 14 and 15 are also equipped with fittings 29 - 31 for water drainage, combined into a common line 32. Fittings for water supply 25 - 27, 29 - 31 and lines 28, 32 form a cooling system for friction units.

When the crusher is operated by rotating the unbalance 19 and 20, a centrifugal force is created causing the inner cone 17 to vibrate inside the outer cone 9 and destroy the material fed into the
chamber formed by the cones 9 and 17, which is variable in the vertical section plane. The crushed material enters the collector 10 and, with the help of the unloading disk 18, exits through the unloading tray 11. The oscillation amplitude of the inner cone and the force exerted on the material are regulated by adjusting bolts 23 and springs 24. Cooling water circulating in the cavities 8, 14 and 15, takes heat from the crushing bodies, which ensures the continuity of the crushing process without stopping the crusher for cooling.

4. Conclusions
The proposed design in comparison with the prototype allows you to adjust the amplitude and fluctuations of the inner cone and the force of impact on the material, which leads to a reduction in specific energy consumption by 15-20% at various degrees of grinding, supplying the shaft with a collector with an unloading tray and an unloading disk for the crushed material allows to increase the efficiency the process of collecting and unloading the crushed material, the execution of the inner cone in a vertical section curved allows you to adjust the fineness of the grinding of the material, as well as Mounting the upper unbalance on the shaft with clearance freely rotating can synchronize forced vibrations created unbalance, the drive and suspension leading to ensure improved efficiency of grinding of 10-15% and increase the quality of milling grain material material.

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