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DIRECTION OF IMPROVEMENT OF THE WORKING BODIES OF HAMMER

Abstrakt

Among the many types of grinding machines used in enterprises of grain processing, food and other industries, an important place belongs to hammer crushers. This is explained by the possibility of their use for grinding materials of various origins (plant, animal, mineral, as well as various wastes of food production), various particle size distribution (lumpy, briquetted, granular, fibrous), having different strength properties (hard, medium hard, soft, brittle, viscous), capable of being crushed once or requiring double sequential crushing. In addition, hammer crushers are characterized by relative simplicity of design, and most importantly - they destroy materials in the most rational way - by impact loading as a result of two successive strokes: a hammer on a particle and particles on the surface of the deck.

The execution of these attacks at right angles creates the conditions for the intensification of the destruction process. However, the wear of the hammers leads to a rounding of their impact faces, which makes the angles of attack in the active zone of the hammers significantly different from the direct one. Under the influence of shock-frictional loads, their working surfaces quickly wear out, which leads to a decrease in productivity and crushing efficiency, to an increase in energy consumption, a disturbance in the balance of hammer rotors, an increase in the vibroacoustic activity of crushers, and other negative consequences

The invention of the "Hammer of the crusher" provides for the use of ring-shaped multi-toothed hammers, the durability of which, when using traditional materials and conventional heat treatment, is increased by 4...5 times, eliminates the need for periodic rearrangement of hammers, stabilizes the operation of crushers. The possibility of self-sharpening ring-shaped multi-toothed hammers after reversing the hammer rotor simplifies the maintenance of crushers, eliminates personnel errors when replacing worn hammers.

If multi-toothed hammers are subjected to liquid non-electrolysis boration and heat treatment using an optical quantum generator, then their durability can increase by more than ten times.

Key words: *hammer; wear of work surfaces; heat treatment of hammers; reversal of a hammer rotor; replacement of worn hammers; ring-shaped multi-tooth hammer; chemical heat treatment.*

Hammers of the hammer crushers during operation perceive intense shock-frictional loads, which lead to the rapid wear of their working surfaces. There is a decrease in productivity and grinding efficiency, an increase in energy consumption, an increase in the vibroacoustic activity of crushers and other negative phenomena.

Therefore, hammers are usually made of materials with high wear resistance - from alloy steels 30хгс, 30хгса, 35хгс and 35хгса, which require cementation and hardening, as a result of which the hardness of the impact part on both sides of the hammers from the edge to the hanging hole is equal to нrc 55...56.

Despite this, high tension concentrations occurring at the vertices of the right angles of plate hammers under shock loads cause specific wear of a set of hammers of 0.5...1.0 g/t, and the average operating time of one set does not exceed 300...340 hours.

Studies have shown [1] that the shape, size and thickness of hammers also affect the wear resistance of hammers. Now the prevailing form of hammers is considered rectangular. Rectangular plate hammers with two hanging holes are the most technologically advanced for reasons of manufacturing and consumption of scarce sheet steel. The length **a** of the hammers and the width **b** depend on the diameter **D** of the hammer rotor **a = 0.23d, b = 0.1d**. Recently, the thickness of hammers **Δ** has been predominantly taken equal to 6 mm.

The technical literature describes attempts to use cylindrical hammers with a diameter of 18 mm [1]. Their wear resistance increased by 1.5...1.8 times, which should be recognized as positive, but still insufficient. In this regard, the technology of chemical-thermal processing of hammers developed at the Moscow Technological Institute of the Food Industry [2] deserves attention. They developed and introduced the technology of liquid (non-electrolysis) boron and heat treatment of hammers using an optical quantum generator (OQG).

Liquid borating of hammers made of 3ОХГСА steel was carried out in a molten salt. A metallographic analysis of the microstructure and micro hardness of the surface layers showed that a boride layer 30...40 μm thick with a micro hardness of 8000 ... 12000MPa was formed on the surface of the hammers.

To prevent damage, boron hammers were subjected to heat treatment - high-temperature tempering in a high-vacuum installation, which led to a decrease in the structure of the transition zone material and a decrease in the heterogeneity of its structure and chemical composition.

X-ray and microstructural analysis showed that the phase composition, microstructure and micro hardness vary depending on the depth of the diffusion zone: the zone of iron borides FeB - has a thickness of 30 μm

and a micro hardness of 12000 MPa; zone of iron borides Fe2B - 20 μm and 8000 MPa, respectively; the zone of a solid solution of boron in iron is 70 μm with a gradual decrease in micro hardness from the surface to the middle of 8000...2200 MPa. Under the influence of radiation from the generator, the solubility of boron in steel increases.

Chemical-thermal treatment allows obtaining a protective layer up to 1.5 mm thick on the surface of the hammer, which consists only of Fe2B, which reduces its brittleness.

Tests of boride coated hammers subjected to heat treatment with the use of laser showed that the wear resistance of the hammers of the А1-ДМИ-20 crusher increased by 3...4 times. However, this method has not yet received industrial distribution.

We have proposed the construction of a ring-shaped multi-toothed hammer [3], which when using traditional materials and conventional heat treatment increases the durability of hammers by at least 4-5 times. If the proposed hammers are subjected to the aforementioned chemical-thermal treatment, then their durability will increase even more.

The multi-toothed ring-shaped hammer **1** (Fig. 1) is freely mounted on the carrier disk **2**, which has three side plates **3**, one of which contains a removable stop **4** and a closing link **5**. The hammer is mounted on a suspended axis of the usual type, for which the carrier disk has eccentric pendant hole.

The invention is aimed at stabilization of the grinding process in time due to self-rotation of a multi-toothed ring-shaped hammer in such a way that at any time within the overhaul cycle, the least worn tooth appears in the shock position. This occurs under the influence of centrifugal inertia forces and forces of impact-friction interaction between the hammer and the grinding product.

If, for example, ten teeth are arranged along the perimeter of the ring, then, taking into account the reverse of the directions of rotation of the rotor, twenty working faces successively appear at the shock position, having the geometry originally provided, which ensures the maximum crushing effect. To increase the efficiency of crushing, the teeth are bent from the plane of symmetry of the ring: paired in one side and unpaired in the other by half the thickness of the hammer. So, for example, if the thickness of the hammer is 6 mm, then the teeth are bent 3 mm from the axis in different directions. This allows you to expand the crushing zone and eliminates the obstruction of the teeth from adjacent teeth (the effect of obscuring the cutting edges of the teeth by adjacent teeth is eliminated).

This provides a more uniform distribution of the cutting edges of the teeth in the working area of the crusher.
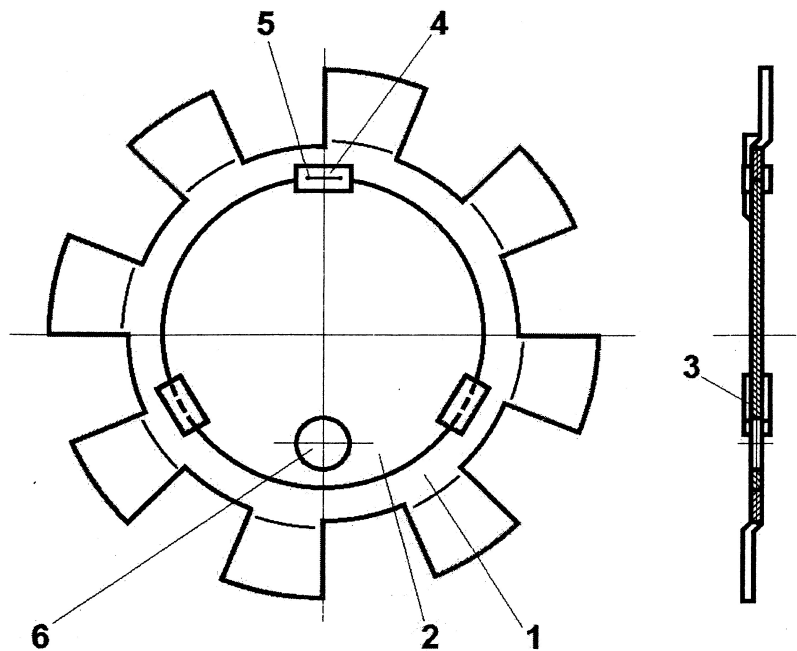

Fig. 1 - The scheme of the hammer crushers made in accordance with the invention No. 1764691:
1 - ring-shaped multi-toothed hammer; 2 - carrier disk; 3 - side plates;
4 - removable stop; 5 - closing link; 6 - suspension hole

As a result, the number of simultaneously working cutting edges of the teeth increases, therefore, the productivity of the crusher increases when using hammers of a new design.

After all ten teeth have been wear to the maximum permissible state, the rotor of the crusher is subjected to reversal, which includes the work of the yet not worn opposite edges of the teeth. In this mode, the geometry of the worn edges of the teeth is partially restored due to self-sharpening, the effectiveness of which still needs to be confirmed during the practical use of multi-toothed hammers in real operating conditions.

Since a conventional rectangular-shaped hammer with four working faces (or eight, taking into account the reverse), the durability of a ten-pointed hammer with twenty working faces increases 2.5 times. If they are subjected to the above chemical-thermal treatment, then the durability can increase by 7.5...10 times. This fully compensates for the costs of increased consumption of sheet steel and its waste, which are created in the manufacture of hammers of an annular shape.

In the case of the use of multi-toothed ring-shaped hammers in hammer crushers with monolithic rotors, as provided, for example, in crushers of the Dutch company Van Aarsen, the design of hammers can become more advanced. In this case, the pads **3** (Fig. 1) become unnecessary, therefore the hammers **1** together with the carrier disks **2** are located inside the annular grooves (Fig. 2), the width of which can be δ+0.5 mm without bent the teeth. If the tooth bent is to be carried out, then on both sides of the carrier discs, when assembling the rotor, distance washers 3 mm thick should be installed, and the width of the grooves can be 12...13 mm.

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For balancing a hammer crusher on impact, according to the theory of M.M. Gernet [4], the square of the radius of inertia of the hammer ρ relative to the sus pension axis should be equal to the product of the distance from the suspension axis to the center of mass of the hammer c by the distance from the suspension axis to the impact line l, i.e.

$$\rho^2 = c \cdot l. \tag{1}$$

The square of the central radius of inertia of the hammer, which is assembled in the form of a flat disk of mass m and radius r, we find

$$\rho^2 = \frac{I_z}{m}, \tag{2}$$

where I - is the moment of inertia of the hammer relative to the z axis, that is, the product of the hammer mass m by the square of the distance from its center of mass r to this axis. Therefore, we have

$$I_z = m \cdot \rho^2. \tag{3}$$

The square of the radius of inertia of the hammer relative to the suspension axis ρ^2 is determined by the Huygens-Steiner theorem (according to the parallel axis theorem)

$$\rho^2 = \rho_c^2 + c^2. \tag{4}$$

Neglecting the presence of a suspension hole and hollows depressions between the teeth, we determine the square of the central radius of inertia of the hammer according to (2), taking $I_{cz} = m\frac{\rho^2}{4}$ from the tables of moments of inertia

$$\rho^2 = \frac{I_{cz}}{m} = \frac{\rho^z}{4}. \tag{5}$$

The distance from the suspension axis of the disk hammer to the line of impact (Fig. 2) is

$$l = c + r. \tag{6}$$

After transformations (4), (5) and (6), provided that the impact reaction on the axis of the suspension of the hammer is $R_X = 0$, we obtain
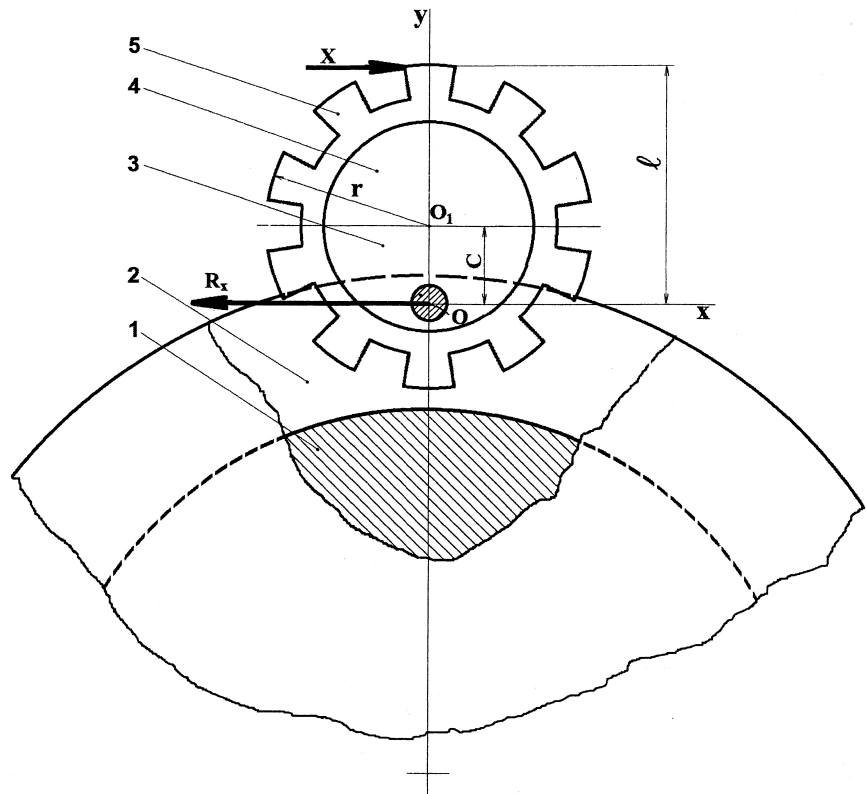

Fig. 2 - The scheme of the hammer rotor with ring-like multi-tooth hammers:
1 - monolithic rotor; 2 - ring-like groove; 3 - hanging rod; 4 - disk drive; 5 - ring-like hammer

$$\frac{r^2}{4} + c^2 = c(c + r), \tag{7}$$

where do we get

$$\frac{r^2}{4} + c^2 = c^2 + cr. \tag{8}$$

Finally, find

$$c = \frac{r}{4}. \tag{9}$$

Expression (9) allows you to construct a hammer so that the shock reaction on the axis of its suspension is zero, regardless of the force shock X and the acceleration created by it.

Ring-shaped hammers, in comparison with conventional plate hammers, also provide a significant reduction in the complexity and time spent on the readjustment and maintenance of crushers.

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НАПРЯМОК УДОСКОНАЛЕННЯ РОБОЧИХ ОРГАНІВ МОЛОТКОВИХ ДРОБАРОК

Анотація

Серед багатьох типів подрібнюючих машин, що застосовуються на підприємствах переробки зерна, у харчовій та інших галузях промисловості, важливе місце належить молотковим дробаркам. Це пояснюється можливістю їх використання для подрібнення матеріалів різного походження (рослинного, тваринного, мінерального, а також різних відходів виробництва харчових продуктів), з різним розподілом розмірів частинок (крупнокускових, брикетованих, зернистих, волокнистих), з різними міцностними властивостями (твердих, середньо-твердих, м'яких, крихких, в'язких), здатних подрібнюватися за один раз або вимагати подвійного послідовного подрібнення. Крім того, молоткові дробарки характеризуються відносною простотою конструкції, а головне - вони руйнують матеріали найбільш раціональним способом - ударним навантаженням в результаті двох послідовних ударів: молотком по частці і часткою на поверхні деки.

Виконання цих ударів під прямим кутом створює умови для інтенсифікації процесу руйнування. Однак знос молотків призводить до округлення їх ударних граней, що робить кути атаки в активній зоні молотків суттєво відмінними від прямих. Під впливом ударно-фрикційних навантажень їх робочі поверхні швидко зношуються, що призводить до зниження продуктивності та ефективності здрібнення, до збільшення енерговитрат, порушення балансу молоткових роторів, збільшення віброакустичної активності дробарки та інших негативних наслідків.

Винахід «Молоток дробарки» передбачає використання кільцеподібних багатозубчастих молотків, довговічність яких при використанні традиційних матеріалів та звичайної термічної обробки збільшується в 4...5 разів, що виключає потребу в періодичній перестановці молотків. Можливість самозаточування кільцеподібних багатозубчастих молотків після реверсування молоткового ротора спрощує технічне обслуговування дробарки, усуває помилки персоналу при заміні зношених молотків.

Якщо багатозубчасті молотки піддати рідинному не електролізному боруванню та термічній обробці за допомогою оптичного квантового генератора, то їх довговічність може зрости більш ніж у десять разів.

Ключові слова: молоток; зношування робочих поверхонь; термообробка молотків; реверсування молоткового ротора; заміна зношених молотків; кільцеподібний багато зубчастий молоток; хіміко-термічна обробка.

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