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FORAGE CHOPPER: EFFICIENCY AND MODERNIZATION

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Abstract :

As part of the development of animal husbandry, it is necessary to create a solid forage base. Improving the methods of preparing feed with the use of more sophisticated machines and equipment that make it possible to process the required materials into high-quality feed. Certain requirements are imposed on the fodder base, that is, it must ensure: a complete and uninterrupted supply of livestock breeding with a variety and high-grade cheap fodder throughout the year, the optimal ratio in the ration of feed units, digestible protein, minerals and trace elements, rational use of agricultural land for maximum fodder production , production of the maximum amount of feed per unit of land area at the lowest labor and cost per unit. The most valuable part of the feed ration is compound feed, which allows to increase the highest growth of livestock productivity.

Keywords: crushing, root and tuber crops, efficiency, modernization.

Introduction :

Adequate feeding is one of the main ways to increase the productivity of animals and poultry, increase their production, while reducing costs. Therefore, the rational use of feed provides for feeding them to animals and poultry only in a prepared form, as well as in a mixture with other components and with a high quality of preparation. Preparation of feed is one of the most labor-intensive technological operations on farms, which takes up to 40% of the total labor costs for servicing animals. On cattle farms and complexes, both stationary and mobile shredders are used (Timofeev, Frolov & Morozova, 2017). In the diet of animals concentrated feed - 20-32%. Their main component is crushed grain fodder. The nutritional value of the grain depends on the quality of grinding. There are different methods of physical destruction of grain material, such as: free impact, constrained impact, abrasion, chipping, crushing, cutting. At present, there is no such device in which one of these methods is used in its pure form. The choice of method depends on the properties of the processed material. Morgulis M.L. believes that it is more advantageous for fragile ones to use shock and crushing loading methods, for plastic ones - shear, viscous - abrasion, for fibrous ones - tearing and cutting. According to S.V. Melnikov, grain, along with some others, such as wood and plastic, is included in the group of elastic-viscous-plate materials, the features of which are in the presence of a structure, pronounced anisotropy and significant stability of the entire range

of strength characteristics, mainly due to the influence of moisture (Kurdyumov, 2008a). When grinding grain mechanically, two main processes prevail: cutting and crushing. Many studies have noted that cutting is the least energy-intensive process when grinding grain. But dry grain in terms of physical and mechanical properties is close to abrasive materials, due to which the edges of the knives wear out quickly, which limits the use of this method. When processing grain, the main task is to control the mechanical processes of deformation and destruction of dispersed systems of various kinds and, ultimately, to obtain a product with desired properties. Among other things, one should take into account the degree of energy consumption for the preparation of feed, as well as the simplicity of the design and the complexity of operation. In the theory of grinding solid materials, two sets of questions are considered. The first is to study the relationship between the energy consumption for grinding materials and the result of the process (the quality of the final product). The second is the study of the basic laws in the distribution of particles by size in order to find methods for determining the average particles, their specific surface area and numerical values of the degree of grinding.

Materials and Methods :

Currently, up to 70% of all energy costs in the preparation of feed for feeding falls on the grinding process, and this in turn accounts for approximately 50% of the economic costs of their processing (Kurdyumov, 2008a). In connection with the development of farming, it became necessary to produce and develop small-sized forage grinders. At the moment, there is no sufficiently complete substantiation of the design parameters of the knives of the chopping apparatus, their durability and energy consumption of chopping feed. The theory of cutting plant materials was developed by Acad. V.P. Goryachkin. It was further developed in the works of V.A. Zheligovsky, N.E. Reznik, G.I. Novikov and other scientists. Depending on the direction of movement of the knife or root crop relative to the cutting edge of the knife, cutting is divided into normal (cutting), inclined and sliding. Root crushing machines most often operate on the principle of chopping, which significantly increases energy costs. However, V.P. Goryachkin established that in the process of cutting with a blade, the sliding (lateral) movement of the knife is of decisive importance, since it significantly lowers the normal pressure limit on the material, which is necessary to initiate the cutting process, and provides a cleaner cut. Sliding cutting is the least energy intensive, but difficult to implement due to the large values of the angle of friction of root crops on the edge of the metal wedge. Therefore, most often in root crop grinders, oblique cutting is used, which provides a relatively low energy consumption and good grinding quality. To reduce the energy consumption of grinding and improve the quality of the resulting product, it is necessary to conduct research on the cutting process of feed materials aimed at identifying general cutting patterns in order to substantiate the optimal parameters and operating modes of the grinding apparatus. According to V.A. Zheligovsky, with an increase in the sliding angle, an increase in the specific work of cutting occurs. Later, other scientists found that when grinding root crops, the specific cutting work has a minimum value at a sliding angle of 35-45 ° (Lemaeva, 2007; Manko, 1988; Tikhonov, 1983). Some scientists (Reznik, 1975) argue that with an increase in the speed of the knife, the cutting force decreases, others (Zheligovsky, 1960; Goryachkin, point to the independence of the specific pressure for cutting plant materials from the speed of action of the cutting tool, and some (Tikhonov, 1983; Goryushinsky, 2004; Meilash, 1974) determined the optimal speed for each a separate case

in relation to a specific design of the grinder (Kurdyumov, Ayugin & Lyugin, 2008). Given the contradictory nature of the information about the effect of the sliding angle and cutting speed on the energy performance of the grinding process, it is necessary to conduct additional studies of the influence of the above factors on the specific work of cutting.

An important role in improving the means of mechanization for the production of feed is played by the development and creation of energy-saving, highly efficient grinding machines, with modernized working bodies. In this regard, the study and improvement of forage grinders and increasing the durability of their working bodies is an urgent and important task. It is important in the design of machines for the preparation of feed is the development of principles that reduce the energy consumption of grinding feed, since this indicator allows you to reduce the unit costs of feed production. Reducing the energy intensity of forage grinding is possible by taking into account the parameters of the grinding apparatus of forage preparation machines. These parameters include the thickness of the knife blade, the angle of sharpening of the knife, the sharpness of the knife blade, etc. (Kurdyumov, 2008b). The thickness of the knife is essential for the cutting process and energy consumption in particular. It has been experimentally established that with an increase in the thickness of the knife, the effort and work of cutting plant material increase (Ayugin, 2016). The most optimal knife thickness for cutting feed is 5 ... 8 mm.

From the point of view of reducing the specific work of cutting, the sliding angle of the knife for cutting stalk feed should be at least 65 ... 70˚. At the same time, some authors point to the optimal sliding angle 35˚ (Ayugin, 2016).

The angle of sharpening of the blade is chosen such that the knife blade remains sufficiently resistant to breakage, retains its sharpness for a long time, and the cutting force remains minimal. The most optimal knife sharpening angle for cutting stalk feed is 45˚, although some sources indicate a value of 18 ... 25 ° (Ayugin, 2016).

Often, different indications of the authors when conducting tests in similar conditions are mainly associated with the kinematic transformation of the angle of sharpening of the blade. The angle of sharpening is determined based on the usual concept of the geometry of the blade in a static state. It is easy to make sure that in the process of oblique cutting and sliding cutting, the sharpening angle in the cutting direction (working movement of the blade) changes its value - it decreases depending on the angle of inclination of the blade or the sliding angle. In other words, passing from the idea of the static geometry of the blade to the idea of its kinematic geometry, we encounter the phenomenon of transformation of the sharpening angle.

An equally important parameter is the sharpness of the knife blade. This is due to the importance of this parameter in the force interaction of the blade with the material, as well as its influence on the cut quality.

Some scientists argue that with an increase in the speed of the knife, the cutting force decreases, others point to the independence of the specific cutting pressure of plant materials from the speed of the action of the cutting tool, and some determine the optimal speeds for each individual case in relation to a specific grinder design.

Since the thickness of the knife blade is limited by the strength characteristics of the material from which the knife is made, an additional reserve for reducing the energy intensity of

chopping is to maintain the optimal sharpness of the knife blade throughout its entire service life due to the use of surface hardening methods in order to achieve the effect of self-sharpening of the knife.

When manufacturing the working bodies of feed preparation machines (shredders), one should take into account the peculiarities of their operation, in particular, the resulting increased dynamic loads, rapid wear of the working bodies. Improving the reliability of the developed designs of the working bodies of shredders is an important task, since this will ensure a stable fractional composition of the crushed feed, reduce the costs of operation and repair of the grinders. The indicators of the longevity of the grinders are linked to the increase in the efficiency of their working bodies.

The knives of existing shredders are significantly worn out and destroyed, which leads to their frequent replacement (repair). A productive way to achieve a high level of durability of shredder knives is to harden them at the manufacturing stage, which in many cases is more justified than refurbishment or replacement.

One of the most effective and resource-saving methods of hardening is electromechanical processing (EMP) of parts of agricultural machines (Zhiganov, Halimov & Smirnova, 2010; Zhiganov & Halimov, 2013). Electromechanical hardening (EMH) has the following advantages: low consumption of electrical energy, high productivity, increased wear resistance, fatigue strength and impact strength of the treated surfaces of parts. However, previously, EMH was not previously used to strengthen knives of a complex shape (helical profile) of feed preparation machines (Halimov, 2018).

Results and Discussions :

For the processing of three or more types of feed and the mechanization of performing household work, the industry produces machines for combined or universal purposes. Combined shredders come in several brands. Grinders DZK-1, IZK-1, KZE-1 are used for crushing grain and crushing root and tuber crops; grinders IKB-1, EKR-1, EKOR-1, I7-KU, IK-1 are intended for grinding coarse and succulent feed.

The intensity of grain supply for grinding is regulated by changing the opening of the loading window. The grain is crushed, falling under hammer blows and on the sharp edges of the holes of the cylindrical, welded three-section sieve. Holes with a diameter of 3 mm were drilled on one of the sections, 4 mm on the second and 5 mm on the third. Depending on the required degree of grain refinement, the sieve can be easily installed in a section with the appropriate hole diameter against the unloading mouth.

When combined shredders are in operation, root crops from the hopper fall on the knives of the knife disc and are thrown out in the crushed form along the tray. Root crops are pressed against the knife disk using a clamping device consisting of a handle and a clamp. The height of the knives when chopping root crops for pigs is 8-10 mm, for cattle - 10-15 mm.

The DZT-1 crusher is equipped with a grain hopper and a hopper for feeding grass for crushing. The raw material to be crushed is fed to a combined rotor located in the grinding chamber. Grain enters the section of the chamber with a hammer rotor, the grass in bunches - into the section of the chamber with a two-armed knife. Productivity when crushing grain 50-100 kg/h, when crushing grass 30 kg/h.

The root cutter-grain crusher KZE-T-1 consists of a structurally combined grain crusher and a root crop grinder. The grain crusher and the electric motor are located under the casing, the disc with knives for chopping root crops is closed with a casing, which can be opened for access to the working bodies.

When operating the root crop shredder, the casing is securely fixed with a lock handle. The organs for crushing grain and crushing root crops are located on one shaft, driven in rotation by an electric motor through the driving and driven pulleys connected by a V-belt.

In the body of the grain crusher there are working bodies grinding grain - a drum and a deck. The intensity of the grain supply for grinding is regulated by means of a gate. The crushed product is poured onto the pitched chute. A clearance of 0.5 mm between the drum and the deck is set during factory assembly.

With the wear of the working bodies, the gap increases. To adjust the specified gap, place appropriate spacers under the legs. Due to this, the body, in which the deck is fixed, rises up and the gap between the deck and the drum fixed on the shaft is reduced.

Root crops are fed for chopping through the throat and chopped with knives bolted to the disc. The crushed product falls down through the discharge chute. To sharpen the knives, the casing is opened, the drum is removed from the shaft, and the knives are removed from the drum. After sharpening, everything is put into place in the reverse order. When the motor is overloaded, a thermal relay is triggered.

Productivity of KZE-T-1 when crushing grain is 80 kg/h (modulus of grinding is not less than 2.6 mm); when chopping root crops 250 kg/h (the thickness of the shavings is regulated by extending the knives). Power consumption 0.7 kW, overall dimensions of the machine 870x730x430 mm, weight 66 kg.

Mounted aft crusher DKN-1 is driven from the power take-off shaft of the MB-1 walk-behind tractor using a V-belt drive. Equipped with two replaceable nozzles for crushing and for crushing root crops. A short shaft with a pulley at the end is installed in the center of the body.

To crush grain, a working body crushing the grain is fixed to the free end of the shaft and covered with a panel. In three places, the panel is securely fastened to the body by the forks using hinged screws with plastic handles. The cheek is equipped with a rail. A plate connected to the damper moves in the rail. With the help of the shutter, the width of the slot for feeding grain for crushing is regulated. In the desired position, the flap is fixed with a screw.

To grind root crops, the grain nozzle is removed, a disk with knives is attached to the free end of the shaft and covered with a panel.

Plugs are used for tight connection of the panel to the body with a screw. Productivity for grinding grain 300 kg/h, root crops 600 kg/h, overall dimensions of the grinder 680x640x1220 mm, weight 38 kg.

The HMS-1 also belongs to the universal class machines. It is intended for cutting roughage, crushing root crops, coarse grinding of grain, hulling corn, obtaining juice from fruits and vegetables. The machine is made on the basis of a straw chopper with a drive, on the side

wall of which replaceable attachments are mounted: a root cutter, a corn cutter, a mill, a juicer.

With the help of the MSB-1 machine, in addition to crushing the forage indicated in the table, it is possible to peel corn with a capacity of 40 kg / h, sharpen the tool, saw wood, and plan timber.

The household machine E-270 is also used for grinding various feeds and for processing wood.

Small-sized feed chopper IKM-T-0.8 allows you to chop grain, root crops, vegetable and fruit waste, melons, green and twig feed, straw, hay, acorns, reeds.

Universal feed choppers of the IKU type allow you to chop all types of feed, and the IKU-T-5 chopper can also be converted into a juicer and a device for sawing wood materials.

Reconstruction of small-sized universal machines for performing various operations is carried out by connecting replaceable units to a common drive shaft, replacing working bodies, switching the drive.

For the processing of several types of feed, the industry produces machines for combined or universal purposes.

Combined shredders are distinguished by several brands. Grinders DZK-1, IZK-1, KZE-1 are used for crushing grain and crushing root and tuber crops; grinders IKB-1, EKR-1, EKOR-1, I7-KU, IK-1 are intended for grinding coarse and succulent feed.

Grinder of grain and root crops DZK-1 is operated with an attachment for grinding grain. The intensity of grain supply for grinding is regulated by changing the lumen of the loading window 12 using the device 10. The grain is crushed, falling under the blows of hammers 3 and on the sharp edges of the sieve holes 14. The sieve is cylindrical, welded, three-section. On one of the sections, holes with a diameter of 3 mm were drilled, on the second - 4 mm and on the third - 5 mm. Depending on the required degree of grain fineness, the sieve is easily installed in a section with a corresponding hole diameter against the unloading neck 16.

Root crops from the bunker 5 fall on the knives of the knife disc 4 and are thrown out in the crushed form along the tray 14. The root crops are pressed to the knife disc using a clamping device consisting of a handle 8 and a clamp 10. The height of the knives overhang is set when chopping root crops for pigs at 8- 10 mm, for cattle - by 10-15 mm.

Grain and grass crusher DZT-1 is equipped with a grain hopper and a hopper for feeding grass for grinding. The raw material to be crushed is fed to a combined rotor placed in the grinding chamber: the grain enters the chamber section with a hammer rotor, the grass in bundles - into the chamber section with a two-armed knife. Productivity when crushing grain 50-100 kg/h, when crushing grass 30 kg/h, grain grinding module - no more than 2.6 mm, cut length of grass - up to 15 mm, electric motor power 0.6 kW, overall dimensions 630X592X1240 mm, weight 35 kg.

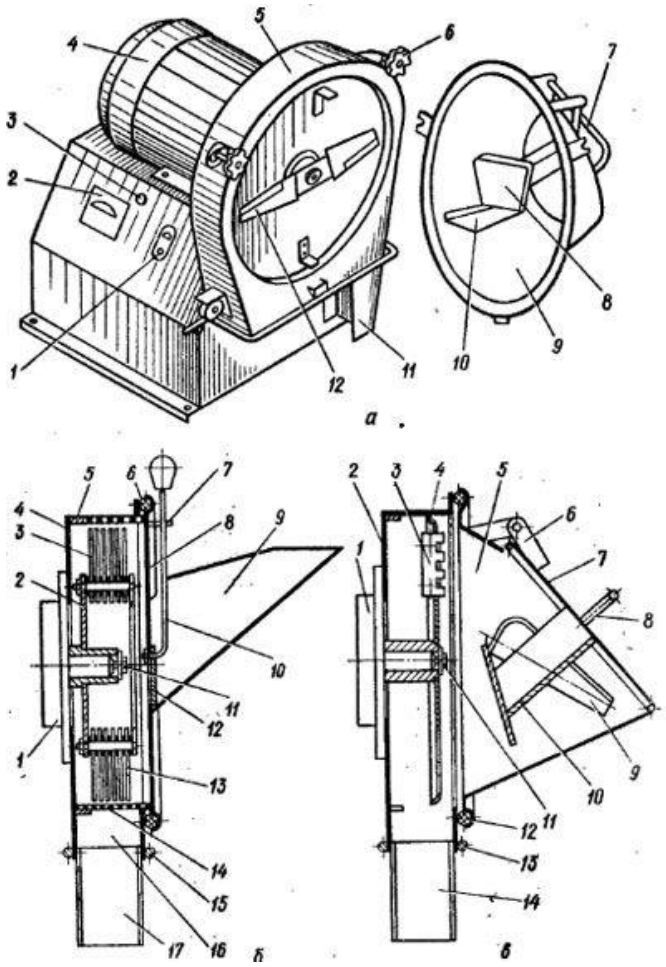

Figure 1 : Grinder of grain and root crops DZK-1: a-general view; 1-starting device; 2- load control ammeter; 3 - indicator; 4 - electric motor; 5 - body of the attachment for crushing root and tuber crops; 6 - handwheel; 7 - bunker cover; 8 - clamp; 9 - removable attachment hopper; 10- guide; I-tray; 12 - knife;

b - attachment for crushing grain: 1 - adapter flange; 2 - hammer rotor; 3, 13 - hammers; 4- box attachment; 5 - sieve stopper; 6 - housing cover seal; 7- retainer; 8 - removable cover; 9 - loading buffer zeria; 10 - grain feed adjustment device; 11 - rotor mount; 12 - loading window; 14 - cross-section sieve; 15 - ring; 16 - unloading neck; 17 - tray;

c - attachment for grinding root and tuber crops: 1 - adapter flange; 2 - attachment body; 3 - knife 4 - knife disk; 5 - bunker; 6 - loop; 7 - bunker cover; 8 - handle; 9 - emphasis; 10 - clamp; 11 - fastening of the rotor with a knife disc; 12 - housing cover seal; 13 - ring; 14 – tray.

The root cutter-grain crusher KZE-T-1 consists of a structurally combined grain crusher and a root crop grinder. The grain crusher and the electric motor are located under the casing, the disc with knives for chopping root crops is closed with a casing, which can be opened for access to the working bodies. When operating the root crop shredder, the casing is securely fixed with a lock handle. The organs for crushing grain and crushing root crops are located on one shaft, driven in rotation by an electric motor through the driving and driven pulleys connected by a V-belt.

In the body of the grain crusher there are working bodies grinding grain - a drum and a deck. The intensity of the grain supply for grinding is regulated by means of a gate. The crushed

product is poured onto the pitched chute. A clearance of 0.5 mm between the drum and the deck is set during factory assembly. With the wear of the working bodies, the gap increases. To adjust the specified gap, place appropriate spacers under the legs. Due to this, the body, in which the deck is fixed, rises up and the gap between the deck and the drum fixed on the shaft is reduced.

Root crops are fed for chopping through the throat 7 and chopped by knives 6, bolted to the disc 5. The chopped product falls down through the unloading chute 9. To sharpen the knives, the cover 8 is opened, the drum is removed from the shaft, and the knives are removed from the drum. After sharpening them, everything is put into place in the reverse order. When the motor is overloaded, a thermal relay is triggered.

Productivity of KZE-T-1 when crushing grain is 80 kg/h (modulus of grinding is not less than 2.6 mm); when crushing root crops 250 kg/h (the thickness of the shavings is regulated by extending the knives). Power consumption 0.7 kW, overall dimensions of the machine 870X730X430 mm, weight 66 kg.

Mounted feed crusher DNA-1 is driven from the power take-off shaft of the MB-1 walk-behind tractor using a V-belt drive. It is equipped with two replaceable nozzles for crushing grain (in Fig. 2 this nozzle is shown assembled) and for crushing root crops (the elements of the nozzle are shown in the figure below). A short shaft with a pulley at the end is installed in the center of the housing 11.

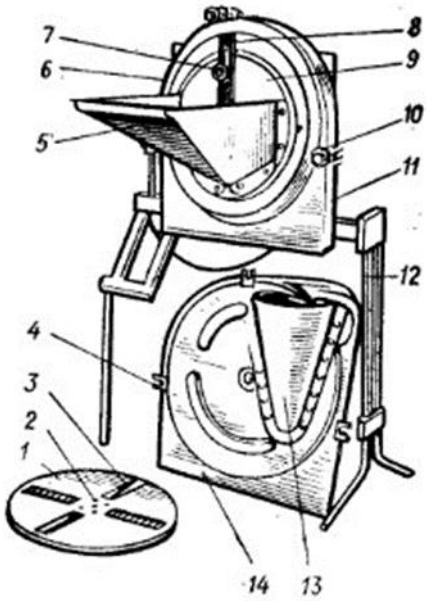

Figure 2. Crusher of grain and root crops DKN-1 mounted on a walk-behind tractor:

1 - disk; 2 - holes for mounting the dis-a. h - scabbard; 4 - plug; 5 - grain receiving hopper; 6 - nozzle panel for grain; 7 nozzle with a handwheel; 8 - rail; 9 - cheek 10 - hinged screw with a handwheel; 11 - case; 12- support; 13 - throat for feeding crushing of root crops; 14-panel root vegetable chopper.

To crush the grain, a working body crushing the grain is fixed to the free end of the shaft and closed with a panel 6. In three places the panel is securely fastened by forks to the body 11 using hinged screws with plastic handles 10. Cheek 9 is equipped with a rail "8. A plate moves in the rail, connected to the shutter. The shutter adjusts the width of the slot for feeding grain for crushing. In the desired position, the shutter is fixed with a screw 7.

To grind root crops, the grain attachment is removed, a disk 1 with knives 3 is attached to the free end of the shaft and covered with a panel 14. Forks 4 are used to tightly attach the panel to the body 11 with a screw 10. Productivity when grinding grain 300 kg/h, root crops 600 kg/h, overall dimensions of the grinder 680X640X X1220 mm, weight 38 kg.

Universal feed grinders are designed for grinding three or more types of feed, mechanization of a number of other household operations. The machines of this class include the universal utility machine UHMS-1, which is produced by the Lvov plant "Elektrobyt-pribor". It is intended for cutting roughage, crushing root crops, coarse grinding of grain, hulling corn, obtaining juice from fruits and vegetables. The machine is made on the basis of a straw chopper with a drive, on the side wall of which replaceable attachments are mounted: a root cutter, a corn-cutter, a mill, a juicer. Electric motor power 1 kW, productivity, kg/h: straw cutters 130, root cutters 160, corn dealers PO, juicers 22.

Table 1. Technical characteristics of universal forage grinders.

Index	MSB-1	E-270	IKM-T-08	IKU-T-4	IKU-T-5
Productivity, kg/h, when grinding: straw green mass root crops grains	90 150 200 100	100 300 300 60	50 150 500 120	30 40- 400 120	50 300 300 350 40
Average particle size of					

the crushed product, mm: straw green mass root crops grains	15 1 5 6 1 , 4 - 2	10 - 15 1 5 - 35 5 - 10 1 , 2 - 1 , 8	2 - 15 1 5 5 1 , 5 - 2	30 - 50 30 - 50 6 1 , 1 - 1 , 8	30 - 50 30 - 50 5 - 10 1 , 4
Electric motor power, kW	0 , 6 - 1 , 1	1 , 1	1 , 1	1 , 1	1 , 1
Overall dimensions, mm: length width height	15 15 12 80 98 0	17 00 10 50 95 0	75 06 85 10 00	76 03 60 50 0	79 54 60 74 0
Weight, kg	25 0	20 5	72	60	12 0

With the help of the machine for rural life MSB-1, in addition to crushing the feeds indicated in the table, you can also peel corn with a capacity of 40 kg/h, sharpen tools, saw wood, and join timber.

The household machine E-270 is also used for grinding various feeds and for processing wood.

Small-sized feed chopper IKM-T-0.8 allows you to chop grain, root crops, vegetable and fruit waste, melons, green and twig feed, straw, hay, acorns, reeds.

Universal feed choppers of the IKU type allow you to chop all types of feed, and the IKU-T-5 chopper can also be converted into a juicer and a device for sawing wood materials.

Reconstruction of small-sized universal machines for performing various operations is carried out by connecting replaceable units to a common drive shaft, replacing working bodies, switching the drive.

Conclusions :

Thus, on the basis of the research carried out on the working process of the root and tuber grinder, it can be concluded that in order to reduce the specific energy consumption and increase the productivity of the installation, it is necessary to increase the number of horizontal knives and the cutting speed. Reducing the energy intensity of forage grinding is possible by taking into account the parameters of the grinding apparatus of forage preparation machines. To ensure the minimum energy consumption of the process of cutting root crops, it is advisable to choose the sliding angle = 35 °, and reduce the cutting speed to a value that ensures the specified throughput of the grinder.

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