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Investigation of the process of surfacing and vibration deformation during the restoration of plowshares and discs of tillage machines

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Abstract

The analysis of ploughshare wear is given in the article and the characteristic requirements to the technological process of restoration of their worn surfaces are established. The choice of restoration technology was justified taking into account the nature of defects and the degree of wear of the working surfaces of cutting elements, their material, hardness, design parameters, accuracy of processing and cost of repairs. Quantitative and qualitative assessment of the reliability of the cutting elements of the plowshares of tillage machines, restored by different methods, was carried out by comparison with the same indicators of the new ones. Analysis of the condition of restored and new plowshares was carried out on their wear in the process of laboratory and operational tests. Laboratory researches on strengthening of plowshares by a method of vibration deformation were carried out on the specially made installation consisting of the following main knots: vibroexciter IV-105 with adjustable unbalance; hydraulic lifting systems; auxiliary equipment. The deformation rate was regulated by a V-belt double-circuit variator of the pump drive. To study the effect of normal and vibration load on the strength characteristics of the processed material, the study was performed on samples-models, and then - on the details. The samples were new plowshares, experimental studies on which provided the identity of the nature of the course of wear of their cutting elements. It is experimentally established that the hardness of the material on the surface of the blade, depending on the technological process of restoration was: restored by welding tires of steel 45 with surmaite surfacing and vibration hardening - 71-74 HRC; new plowshares made of L-53 steel, subjected to vibration hardening 66-68 HRC; new from 65G steel and strengthened by vibration deformation 57-59 HRC.

Key words: surfacing, vibration deformation, wear resistance, tillage machines, ploughshare restoration, disk hardening, durability, sormite.

Introduction

The operation of plow plows on sandy, loamy and loamy soils is associated with intensive wear of the working bodies, which leads to limited failure. The most significant defect is the wear of the ploughshare sock, which has a radial shape, the recurrence coefficient of which is 0.84; while 30% of the parts retain a geometric shape that satisfies the technical conditions. Meanwhile, technological processes to eliminate this defect are ineffective. Therefore, it is necessary to conduct research aimed at developing methods for restoring plowshares that provide increased post-repair life.

Increasing the durability of plowshares is possible with the use of technologies that combine restoration and strengthening, preventing intense abrasive wear [1].

At the same time, the use of methods of eliminating radial wear should not affect the appearance of bends, destruction, distortion, wear in other parts of the part during their further operation. It is necessary to withstand the geometry of the restored ploughshare, which meets the agronomic requirements.

Restoration is usually reduced to the deposition of wear with special electrode materials that provide sufficient wear resistance of the surface, without taking into account the possibility of other defects in the process.

Sormite surfacing and vibration hardening have wide possibilities in this respect, where the intermediate layer has increased elastic and plastic properties, in comparison with a wear-resistant surface coating.

However, research on the creation of such technologies in relation to the working bodies of tillage machines is not enough, so the work is relevant.

Literature review

Restoration of worn parts allows you to reuse, sometimes reuse depleted parts and assembly units.

Technical and economic indicators of a number of agricultural machines are still very low due to short service life and poor performance of responsible parts (especially working bodies), forced downtime with their periodic replacements, the cost of additional funds for the restoration of parts and more. Tillage machines and implements suffer the most from such shortcomings, they perform a very large amount of work in agricultural production [2].

Rapid wear of plowshares, cultivator tines and other tillage machines and implements prevent the increase of labor productivity in agriculture.

The working bodies of plows include a ploughshare, a dump, a disk knife and a field board. The ploughshare is intended for cutting of a soil layer from below and together with a dump of its separation from the party (from a furrow wall). There are trapezoidal and chisel-shaped plowshares. They are made of special ploughshare steel L-53 or L-56. The lower part (blade) with a width of 50…60 mm is hardened to a hardness of HB 444 ... 500 [3].

The working bodies of cultivators include paws. Depending on the purpose, they are divided into the following types: floor or flat-cut (one-sided or arrow); universal (arrow-shaped), designed for pruning weeds and crushing the soil; loosening - chisel-shaped, reversible and spear-shaped. On soils prone to wind erosion, cultivators are used - cultivators-deep cultivators, the working body of which is a ploughshare [4].

Wear of plowshares, cultivator paws, knives and other cutting parts is manifested mainly in the deterioration of agronomic and to a lesser extent energy performance.

Worn-out working bodies of tillage machines (plowshares, cultivator paws, flat cutters knives) are characterized by blunting and change of the basic sizes: thickness of a blade, width of an occipital chamfer. The ploughshare in the process of work forms an occipital chamfer with a width S at an angle α to the loose soil layer [5].

When defecting plowshares and cultivator paws, you can use three ways to detect defects [6]:

- external inspection (obvious defects are revealed - breakages, cracks, chips);
- knocking (reveal hidden defects, weakening of bolts, rivets, cracks, etc.);
- measurement of wear is determined by universal means (calipers) and templates.

Improving the quality of machine repair while reducing its cost is the main problem of repair production. In the structure of the cost of overhaul of machines 60… 70% of the costs are the purchase of spare parts, which in market conditions remain in short supply in the event of rising prices. The main way to reduce the cost of repairing machines - reducing the cost of spare parts. This can be achieved in part through careful and competent disassembly of parts. However, the main reserve is the restoration and reuse of worn parts, as the cost of restoring most parts is usually absorbed in 20… 60% of the price of new parts [7].

The blades of the ploughshare are sharpened when blunting the working side to a thickness of 1 ... 1.5 mm with a chamfer width of 5 ... 7 mm and sharpening angles of 25 ... 40 °. After wear to a width of less than 108 mm (check the template), the ploughshare is restored by forging to a normal profile (with a deviation in width of not more than 5 mm and a length of not more than 10 mm) due to the metal back (shop). Plowshares should be held no more than four times.

To delay the ploughshare is heated in furnaces or a blacksmith's furnace to a temperature of 900 ... 1200 ° C along its entire length and pulled on a pneumatic hammer. The surface of the extended ploughshare should be smooth, without cracks. Deviation of its back from flatness is allowed a little more than 2 mm, blades (convexity of a working surface) - to 4 mm.

After stretching the ploughshare is sharpened on the front side, then heated to 700 ... 820 ° C and hardened along its entire length to a width of 20 ... 45 mm in salt water at a temperature of 40 ° C (time 5 ... 6 s) on the side blades to a hardness of 444 ... 650 HB. Then released while heating to 350 ° C with air cooling.

More effective isothermal hardening, when the ploughshare is heated to a temperature of 880 ... 920 ° C and the blade is cooled to 350 ° C for 3.0 ... 3.5 s in heated to 30 ... 40 ° C 10% saline water. After that it is cooled in air. To increase the wear resistance of the ploughshare blade is made self-sharpening by surfacing its back side with a hard alloy. Before surfacing, a strip 25 ... 30 mm wide is pulled from the ploughshare on the blade side and a section 55 ... 65 mm wide is pulled into the sock of the chisel-shaped ploughshare.

The thickness of the surfacing layer should be 1.4-2.0 mm. Surfacing is carried out on the installation of HDTV alloy sormite № 1, acetylene-oxygen flame with a rod 0 6 mm from sormite № 1, electrodes brand T-590 and powder darts. When worn to a width of less than 92 mm, the ploughshare is restored by welding the strip, making it also self-sharpening.

Crushing of the knife blade is allowed in no more than three places up to 1.5 ... 2.0 mm deep and up to 15 mm long. Disc warping is allowed a little more than 3 mm. Damaged discs are ruled on the stove in a cold state. They are sharpened to a blade thickness of 0.5 mm on the installation OP-6112 for sharpening disc knives and on devices for the lathe cutters with plates of hard alloys T15K6 and others. Axial and radial beating of the disk is allowed no more than 3 mm.

Collection control. The plow after repair in the unit with a tractor is established for check on the control stand platform. It is made on a reinforced concrete base with a variable (for different tractors) track of channels with stops for the tractor and the control plate with a stencil, which marks the position of the working bodies, wheel supports and other control points of the plow. The completeness of the plow, the correct installation of its working bodies, the rigidity of fastening parts and other parameters are checked on the stand-platform.

When working in a properly assembled plow, the plowshares, the ends of the field boards, the heel of the rear field board, the furrow and the rear wheels must lie in the same plane. Deviations from the parallel field edges of dumps and plowshares are allowed only in the direction of the furrow, but not more than 10 mm. Socks and heels must lie on one straight line with a deviation of not more than ± 5 mm.

The distance between the inner edge of the furrow wheel and the heel of the ploughshare of the first case is allowed 50 ± 5 mm. Displacement of the rear wheel from the straight line passing through the field edge of the ploughshare of the last case is allowed a little more than 5 mm. The plane of the rear wheel disc must have an inclination of 6 ... 10 ° from the vertical towards the plowed field. The clearance between the heel heel or the rear edge of the field board and the plane of the control plate is allowed up to 10 mm.

The location of the plow sock above the heel or field board is not allowed. The blade and the ploughshare must fit snugly together, and the ploughshare must protrude no more than 1 mm above the blade surface at the joint. It is not allowed for the surface and the field edge of the blade to protrude above the surface and the edge of the ploughshare. The screw mechanisms of the plow must rotate freely if the steering wheel is applied with a force of not more than 150 ... 200 N.

The technology of repair of mounted and trailed plows is similar. Repaired plows for long-term storage paint, which work surfaces are covered with anti-corrosion composition.

The development and application of alternative energy-saving and efficient methods of ensuring the reliability of tillage implements by strengthening their surface treatment is relevant. An effective method is the technology of restoration and strengthening of the working bodies of tillage machines by means of vibration.

In this regard, research is particularly relevant to determine the technological parameters of the most responsible working bodies of tillage machines in their production and restoration, aimed at improving the reliability and durability. Therefore, the creation of technology for strengthening such bodies with the use of mechanical vibrations can be considered one of the important scientific, applied and promising tasks for the development of the agro-industrial complex of Ukraine.

Purpose

The purpose of the research is to increase the reliability of ploughshare working bodies of tillage machines by restoring them by the method of vibration hardening.

Research methodology

To study the effect of normal and vibration load on the strength characteristics of the processed material, the study was performed on samples-models, and then - on the details. The samples were new plowshares, experimental studies on which provided the identity of the nature of the course of wear of their cutting elements.

The thickness of the blade samples - plowshares during the tests varied within 2.0 ± 0.5 mm, the sharpening angle was 25 °, 30 ° and 35 °. The amplitude of oscillations of the processing tool was 0.25 - 0.75 mm, the frequency of oscillations 700 - 2100 min-1, hardening time - 10 - 30 s.

The levels of factors of the multifactorial experiment were determined by previous experimental studies [8].

Determination of stresses in the material of the samples, processing effort, the amount of deformation was performed by strain gauge using an oscilloscope, amplifier TUP-12, strain gauges type PD-5-200.

Studies of the microstructure were performed using a microscope MIM-8, hardness tester TK-2M, microhardness tester PMT-ZM; measurement of surface roughness of samples and parts was performed on a profilometer mod. 253 and profilographs of fashions 252.

Evaluation of changes in the macrostructure of the ploughshare blade along its generator was performed using the planimetric method, and evaluation of their reliability was determined by the probability of trouble-free operation, provided that the blade parameters do not exceed the limits.

The reliability of the results of experimental studies was evaluated in accordance with the accepted theoretical law of distribution, with a given value of confidence probability $\alpha = 0.95$.

Experimental studies of the wear resistance of plowshares, restored by various methods, were carried out on the stand - the soil channel, which adhered to the conditions of similarity of plowshares on the stand and during operation, ie preserved the nature of wear. The humidity of the working mixture (10-18%) was controlled using a moisture meter EV-2.

Experimental tests were the final stage of research to determine the effectiveness of various methods of restoring the plowshares of tillage machines. Plowshares were tested in four versions: new steel 65G; restored by welding tires made of steel 45 with sormite surfacing and vibration hardening; new steel L-53, subjected to vibration hardening; new steel 65G, subjected to vibration hardening.

Tests of these variants of plowshares allowed to estimate their operational reliability.

Research results

The change in the shape of the ploughshare blade from technological (initial) to working (worn) occurs as a result of the action of forces on it, in its various planes (Fig. 1):

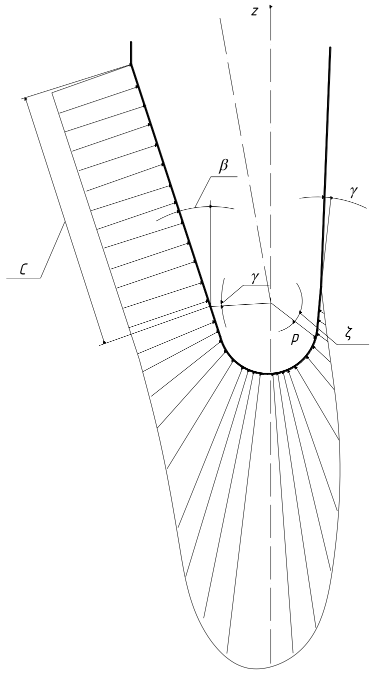

Fig. 1. Scheme of stress distribution in the cutting part of the ploughshare

The nature of the change in the force on the blade depending on the sharpening angle β is shown in Fig. 2.

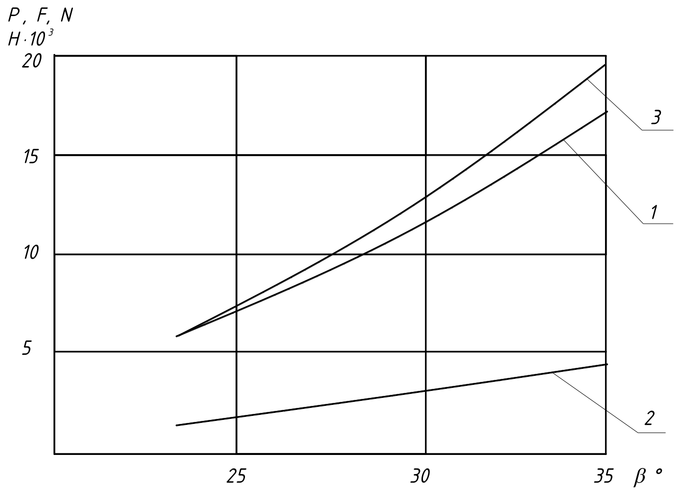

Fig. 2. Curves of changes of efforts on a blade depending on a sharpening angle:
1 - normal component of the cutting force; 2 - component directed along the generative; 3 - total cutting force

It was found that increasing the sharpening angle β from 30 ° to 35 ° causes an increase in mainly normal N and total P cutting force of 1.49 and 1.51 times, respectively.

It has been experimentally established that the criteria for the limiting state of plowshares can be considered as the wear values of the sock Δh and the thickness of the ploughshare wall. The amount of wear of the sock in plowshares, restored by welding tires made of steel 45 with sormite surfacing and vibration hardening, respectively, 1.2 and 1.1 times less than in plowshares made of steel L-53 and steel 65G, subjected to vibration hardening. Wear on the wall thickness of plowshares, restored by welding tires made of steel 45 with surmaite surfacing and vibration hardening, respectively, 1.54 and 1.2 times less compared to the wear of plowshares made of steel L-53 and steel 65G subjected to vibration hardening [9].

Based on the obtained equations for plowshares, restored by welding tires made of steel 45 with sormite surfacing, the surface dependence of the wear of the ploughshare blade thickness on the frequency and amplitude of oscillations of the working tool at a processing time of 20 s.

As a result of the analysis of regression equations it can be stated that to increase the wear resistance of renewable plowshares vibration hardening should be carried out at an oscillation frequency of 1400 min-1, oscillation amplitude of 0.5 mm and hardening time of 20 s.

Studies of the microstructure of deformed specimens have shown that during vibrational deformation it is more fine-grained and uniform to a metal depth of 180-320 μm, which creates conditions that contribute to the strengthening of the treated surface (Fig. 3).

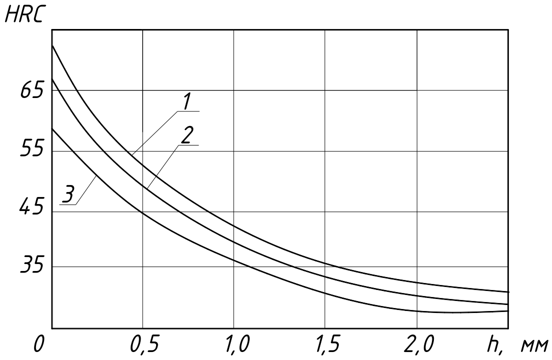

Fig. 3. Changes in the hardness of the depth of the plowshares depending from the recovery method: 1 - restored by welding tires made of steel 45 with sormite surfacing and vibration hardening, 2 - new plowshares made of L-53 steel subjected to vibration hardening, 3 - new plowshares made of steel 65G, strengthened by vibration deformation

It is experimentally established that the hardness of the material on the surface of the blade, depending on the technological process of recovery was: restored by welding tires of steel 45 with surfacing and vibration hardening - 71-74 HRC; new plowshares made of L-53 steel, subjected to vibration hardening 66-68 HRC; new from 65G steel and strengthened by vibration deformation 57-59 HRC.

The hardness of the ploughshare material, restored by welding 45 steel tires, surfacing and vibration hardening, is 1.23-1.35 times higher than the hardness of the 65G steel ploughshare material without hardening.

Studies have shown that during the restoration of plow plowshares by various methods in their material arise and redistribute significant residual stresses due to thermal effects on the parent metal during surfacing and various methods of hardening [10].

Compressive stresses increase as the layers are removed inwards and when strengthened with the amplitude of the machining tool A = 0.5 mm was at a depth of 0.08 - 0.15 mm: MPa; at strengthening of plowshares from steel L-53 and steel 65G accordingly 375 - 385 MPas and 420 - 435 MPas. At a depth of 0.22 - 0.32 mm, they turn into tensile stresses and at a depth of 0.40 - 0.48 mm, respectively, were: 460 - 470 MPa; 485 - 500 MPa; 530 - 540 MPa.

According to the obtained values of strain gauges, curves of changes of residual stresses along the depth of the ploughshare blade material are constructed (Fig. 4).

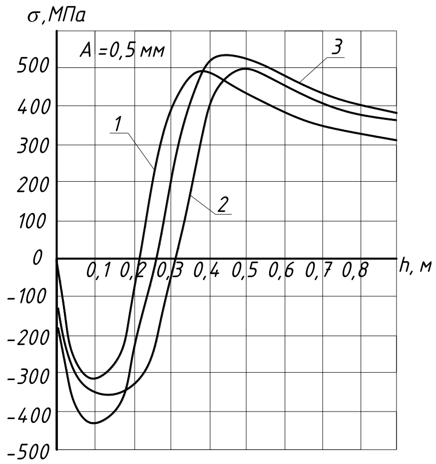

Fig. 4. Changes in residual stresses in depth depending on the method of plowing recovery, amplitude of oscillations of the processing tool and processing time t = 20 s: 1 - restored welded tires of steel 45 with surmaite surfacing and vibration hardening, 2 - new plowshares of steel L-53 subjected to vibration deformation, 3 - new plowshares made of steel 65G, strengthened by vibration deformation

Studies of the process of wear dynamics of cutting elements were carried out for plowshares: restored by welding tires made of steel 45 with surmite surfacing and vibration hardening; new plowshares made of L-53 steel, subjected to vibration deformation; new 65G steel plowshares reinforced by vibration deformation; new plowshares from steel 65G. The depth of the plowshares was 22-27 cm, and the speed was 1.4 m / s.

The wear intensity of the cutting edge thickness of plowshares, restored by welding tires made of 45 steel with surmite surfacing and vibration hardening, is 1.17 times less than that of new 65G steel plowshares. The change in the amount of blunting of the blades of plowshares made of 65G steel subjected to vibration hardening is 2.06 less compared to the new ones made of 65G steel without hardening [11].

The conducted bench tests allowed to determine the nature of the change in the shape of the ploughshare and the thickness of its cutting edge, as well as to choose a more efficient technological process of its restoration. Analysis of the obtained data allowed us to conclude that the wear resistance of the ploughshare depends largely on the type of processing during recovery, as well as on the combination of base and weld material.

As a result of bench tests the variant of restoration of a ploughshare by welding of tires from steel 45 with automatic surfacing of sormite and the subsequent vibration strengthening is offered. A lower rate of blade thickness reduction of 0.003 mm / ha compared to other variants was set.

The reliability of these plowshares was evaluated by the time of operation of the plow unit per unit of wear width, toe and thickness of the plow. The highest values of these parameters are 38.07 ha / mm; 8.13 ha / mm and 56.9 ha / mm had plowshares, restored according to the developed technology, and the smallest 31.24 ha / mm; 7.08 ha / mm and 46.67 ha / mm are the new 65G plowshares [12].

No plow failures were observed during operation.

These changes in the geometry parameters of plowshares and their wear were removed every 50 ha of work.

Operational studies of these variants of plowshares have confirmed full compliance with bench tests. More reliable are the plowshares restored by welding of tires from steel 45 with sormitic surfacing and vibration strengthening: speed of wear of width, a sock and plow thickness accordingly 1,29; 1.17 and 1.22 times less than the new 65G steel [13]. The average wear of these parameters was 9.56 mm, 43.20 mm, 6.56 mm, respectively (Fig. 5).

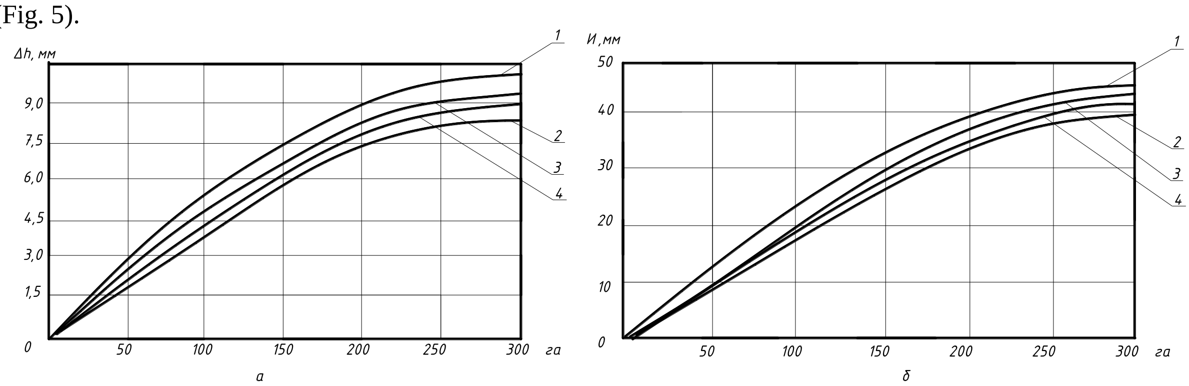

Fig. 5. Changes in wear of width (a) and sock (b) of a plow ploughshare depending on the operating time: 1 - new plowshares made of 65G steel, 2 - restored by welding tires made of steel 45 with sormite surfacing and vibration hardening, 3 - new plowshares made of L-53 steel, subjected to vibration hardening; 4 - new plowshares made of 65G steel, subjected to vibration hardening

An assessment of the reliability of tillage machines working with these working bodies, their performance and the coefficient of technical use [14].

It was found that the highest value of KTV = 0.992 were plow units working with plowshares, restored by welding tires made of steel 45 with sormite surfacing and vibration hardening, and the lowest KTV = 0.948 - with new plowshares made of steel 65G. The coefficient of technical use of plow units with plowshares, restored by the developed technology, is 1.05 times higher than that of plow units with new plowshares made of 65G steel.

Conclusions

It is established that during vibrational deformation a larger fine-grained and uniform metal microstructure is formed at a depth of 180-320 μm, conditions are created that ensure the accumulation of residual deformation and strengthening of the working layer of plowshares. Regularities of structure formation of the working layer within the limits of vibration processing parameters are revealed.

The hardness of the ploughshare material restored by welding 45 steel tires, grade surfacing and vibration hardening is 1.23-1.35 higher than the hardness of 65G steel ploughshare materials without hardening.

A computational-experimental method for determining the reliability of plow plowshares according to the main criteria, based on the use of measurement results obtained in the conditions of bench and operational tests, has been developed.

In plowshares, restored by welding tires made of steel 45 with automatic surfacing and vibration hardening, wear rate of width, sock and plow thickness in accordance with 1.29; 1.17 and 1.22 times less than the new 65G steel.

The estimation of reliability of plow plowshares of substantiation of processing machines for the coefficient of technical use is executed.

It is established that the coefficient of technical use of the plow unit with plowshares, restored by the developed technology in comparison with the new ones by 105 times.

The reliability of the plowshares of these options was evaluated by the operating time of the plow unit, which is per unit of wear width, toe and thickness of the plow. The highest value of these parameters is 38.07 ha / mm; 8.13 ha / mm and 56.9 ha / mm of small plowshares, restored according to the developed technology, and the smallest 31.24 ha / mm; 7.08 ha / mm and 46.67 ha / mm - new 65G steel plowshares.

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Марченко Д.Д., Матвєєва К.С. Дослідження процесу наплавлення і вібраційного деформування при відновленні лемешів і дисків ґрунтообробних машин.

В статті приведено аналіз зносу лемешів і встановлено характерні вимоги до технологічного процесу відновлення їх зношених поверхонь. Вибір технології відновлення обґрунтували з урахуванням характеру дефектів і ступеню зносу робочих поверхонь ріжучих елементів, їх матеріалу, твердості, конструктивних параметрів, точності обробки і собівартості ремонтних робіт. Кількісну та якісну оцінку надійності ріжучих елементів лемешів ґрунтообробних машин, відновлених різними методами, проводили порівнянням з такими ж показниками нових. Аналіз стану відновлених і нових лемешів проводили по їхньому зносу в процесі проведення лабораторних і експлуатаційних випробувань. Лабораторні дослідження по зміцненню лемешів методом вібраційного деформування проводили на спеціально виготовленій установці, що складається з наступних основних вузлів: вібр285збудника ІВ-105 з регульованим дебалансом; системи гідравлічного підйому; допоміжного обладнання. Швидкість деформування регулювали клинопасовим двоконтурним варіатором привода насоса. Для вивчення впливу звичайного і вібраційного виду навантаження на міцнісні характеристики оброблюваного матеріалу дослідженя проводили на зразках-моделях, а потім - на деталях. Зразками слугували нові лемеші, експериментальні дослідження на яких забезпечували ідентичність характеру протікання зношування їх ріжучих елементів. Експериментально встановлено, що твердість матеріалу на поверхні леза в залежності від технологічного процесу відновлення склала: відновлених приваркою шин зі сталі 45 з наплавленням сормайтом і вібраційним зміцненням - 71-74 HRC; нових лемешів зі сталі Л-53, підданих вібраційному зміцненню 66-68 HRC; нових зі сталі 65Г і зміцнених вібраційним деформуванням 57- 59 HRC.

Ключові слова: наплавлення, вібраційне деформування, зносостійкість, грунтообробні машини, відновлення лемеша, зміцнення диска, довговічність, сормайт