napryazhennosty Resistance and path smyatyya soil for raznыh uh layers.

Soil, Glubokoryhlitel, mechanics-matematycheskaya model napryazhennoe STATUS, smyatye.

Received mechanical-mathematical model of interaction of working body subsoilers with ground. The values of intensity and path collapsing soil for its various layers.

Soil, deep, mechanical-mathematical model, stress, collapse.

UDC 631.31: 621,891

Wear-resistant coatings FOR WORKING OF AGRICULTURAL MACHINES

MI Denisenko, Ph.D.
National University of Life and Environmental Sciences of Ukraine
KO Sidorenko, Chief Technologist
DKTB Paton. EO Paton

In this paper, an analysis of modern methods of strengthening the work of tillage machines discussed their advantages and disadvantages. It is shown that the most effective method of strengthening working surfaces of tillage machines are strengthening point arc spot welding flux cored wire.

Abrasive wear, disc harrow, cultivator paw, ploughshare plow, wear-resistant coating durability.

Problem. One of the urgent problem of Mechanical Engineering is working to increase durability of tillage machines. The nature and intensity of wear of the working bodies tillage machines depends on the physical properties of the soil. Thus, the sandy soil wear parts in thickness, on a clay loam and width. Thus on sandy soil in parts wear out 8-10

faster than clay. Ploughshare plow is one of the fastest irrigation working bodies. The main reason - accelerated abrasive wear caused by the interaction of solid (NV 8-11 GPa) mineral particles contained in the soil. Analysis of the causes of culling serial plowshares showed that more than half of plowshares that a substantial margin nespratsovanoho metal width, discarded because of premature wear socks. Currently, for the

primary tillage - plowing job of used parts, structural parameters were designed 40 ... 50 years ago. Given that today significantly increased weight harvesters, and this has led to an increase in the density of the soil, the load on the working bodies of arable units increased about 4 times, although the working bodies have not changed either by design or material science.

Numerous test series of working groups blade plows indicate that the average time between failures dolotopodibnyh plowshares P-702 depending on the types of soils and their physical condition ranges from 5 to 20 ha, sternum shelves from 10 to 100 hectares wings shelves from 40 to 250 hectares , field boards from 20 to 60 hectares [1]. Limited resources are working bodies and other tillage machines: disc plows and disk harrows 8 ... 20 hectares, feet cultivators 7 ... 18 hectares. This indicates that the durability of working bodies tillage machines not sufficient. Therefore, research aimed at improving their life are important and are of great national importance.

Analysis of recent research. Great contribution to the study of the issue of wear working machines and develop measures to improve their work ability and durability have made foreign and domestic scholars: M. Tenenbaum, Khrushchev MM, MM Severnev, AS Rabinovich, KRAGELSKY IV, Kostecki BI, Tkachev VN, Bernstein D., V. Lorenz, Lvov PN, E Hrechkosiy and many others. Differential selection of materials and the development of working designs require high durability detailed classification of soils by wearing their ability. The main elements of the wear is hard (NV 7 ... 11 GPa) mineral particles of quartz and granite, which is approximately 36.6 ... 70.8% of the soil. Then the degree distribution are feldspar, mica and other materials (NV 6 ... 7.2 GPa). The higher number of particles have a rounded shape, but also present and particles with sharp edges and protrusions capable of warp and wear contact surfaces of working parts.

Methods to improve the durability of the working parts can be divided into the following groups: 1) the chemical composition and properties of the material; 2) heat treatment; 3) surface chemical and thermal strengthening; 4) surfacing hard alloys; 5) the use of metal materials [2, 3]. In the literature, there is little justification for the choice of these materials. Obviously, the main criterion for their use is strength in the dangerous section. In published studies focused on the improvement of thermal treatment plowshares and similar working bodies.

According to IN Ermakov [4] endurance iron plowshares 10-30% more than steel. Industrial use in our country is not found, although in the UK for the treatment of light soils used iron plowshares bleached bottom side for more than 150 years. The widespread use of technology renewal

and strengthening Ploughshares ceramic materials held high cost of making pottery and ceramics lack of technology to mount blade that provides the necessary grip ceramic plate with plowshare. Existing methods and materials for restoration and strengthening (freezing detonation spraying, plasma arc welding) do not meet the requirements for performance and physical and mechanical properties of the working parts (adhesion of coating base, wear resistance, hardness, impact strength, etc.). .

Analysis of modern ideas about the kinds of wear shows that working bodies tillage machines subject to the following types of wear:

- abrasive - by cutting or scratch which influence solids and particulates;
- fatigue - as a result of fatigue during repeated deformation micro surface layer friction sliding or rolling;
- oxidative - a chemical reaction with oxygen or material environment and mikroplastychnoyu deformation of the surface layer.

The purpose of research is to increase the longevity and durability of working bodies tillage machines by providing samozahostryuvannya (for example, Ploughshares) by arc spot welding and the formation of the operation toothed blade.

Results. Spot strengthening, which is used to improve wear resistance of tillage machines based on mikrovkraplenni hard metal in the structure of surfaces exposed to abrasion wear [5-6]. The process is carried out by technology developed in cooperation with scientists from the Institute of Electric them. EO Paton.

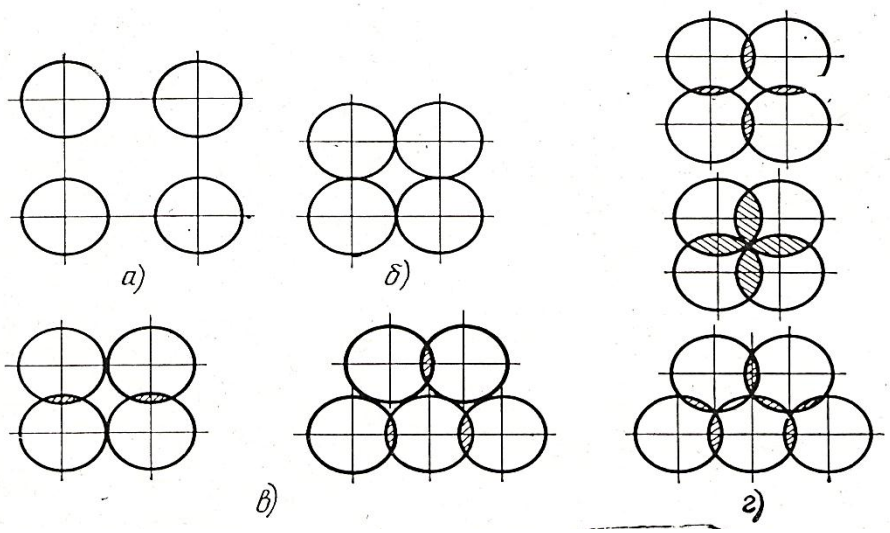

Fig. 1. Plans point location strengthening: *and* - Domestic; *to* - Conjugated; *to* - Conjugated compatible; *g* - Compatible.

Its essence is a point arc welding (TPA) on the surfaces of local, conjugated or compatible by up to 1/5 $D_{\text{Categories}}$ - Diameter carbide cone penetration fundamentals - strengthening points (Fig.1.).

TPA difference from conventional welding and elektrozaklepkamy is to change speed $\upsilon_{Section}$ cored wire feeding during periods: t_1 - Excitation curves, t_2 - Penetration of the base metal to form a crater and filling it melt, t_3 - Head formation points (Fig. 2). Each wire feed speed correspond to a welding current $And_{s\ in}$ and voltage U_d the arc.

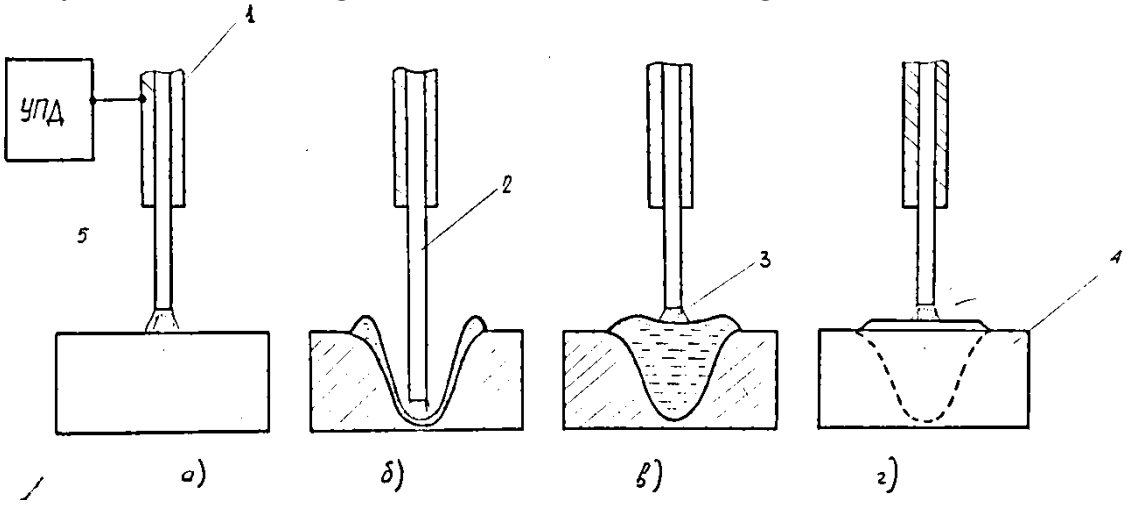

Fig. 2. The process of arc spot welding (spot-strengthening) cored wire PP - AN170M 1 - cored wire 2 - fusible electrode; 3 - arch 4 - substrate (base metal).

Points strengthen formed during the rapid introduction of metal parts such as heat, which is necessary for penetration cone crater filling it with molten base metal and hard metal head formation and consolidation point. The wide bowl-shaped crater cone geometry facilitates the rapid removal of heat from surfacing bath in the base metal and the environment, so cool points at high speed and in a short time.

Resistance TPA and strengthening basic parameters point - form depth $h_2$penetration, height and diameter Dn h1 surfacing weld depend on the current And_{SV}, Voltage U_d arc diameter d_{th} and speed $\upsilon_{Section}$ wire feed, TPA regimes, as well as on the brand and type of heat treatment of metal thickness H details and strengthening current polarity (Fig. 3).

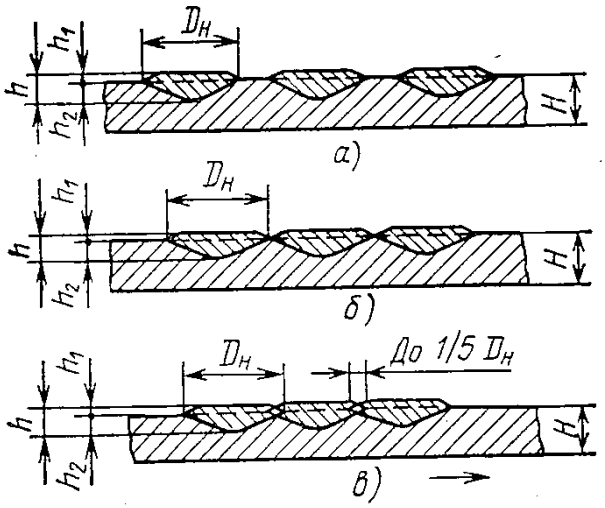

Fig. 3. Parameters strengthening points: *and* - Local; *to* - Compatible; *to* - Conjugate.

Direct current polarity reduces resistance arc process leads to the formation of spray reduces the depth of penetration and increases the height of the head in terms of strengthening. Therefore TPA regimes practiced in reverse polarity. The depth of penetration should provide reliable permanent connection point strengthening of the base metal at its abrasion and exposure to hard metal point where rejection criterion will be achieved by working body wear. The required depth h_2 penetration, as well as other parameters consolidation point ($D_{Categories}$,h_1) Is achieved by changing the strength of the weld current, voltage and time of the arc. Welded current has the biggest impact on shaping consolidation point: it generates a growth increase depth h_2 penetration and diameter $D_{Categories}$ head point and reduce height h_1 surfacing. Thus, with increasing weld current from 400 to 650 A in diameter $D_{Categories}$ increased from 14.5 to 31 mm, h_2 - From 2.3 to 4.3 mm; h_1 surfacing is reduced from 3.5 to 1.2 mm.

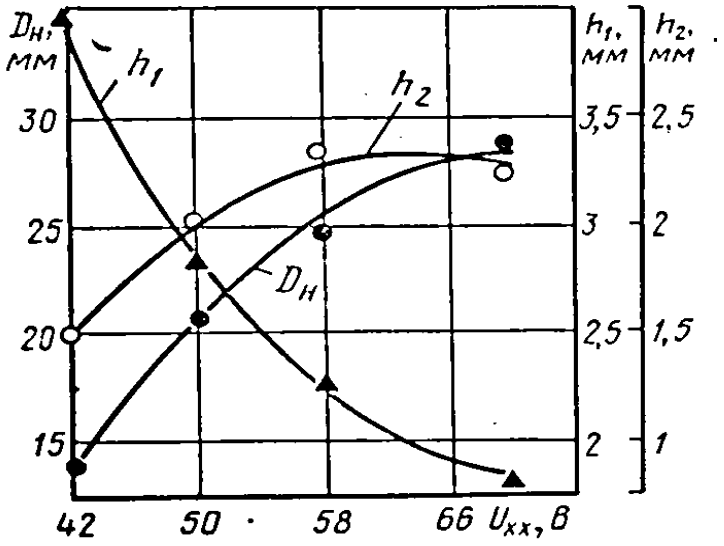

Fig. 4. The dependence of the geometrical parameters of voltage points strengthening idle pace U_{xx} power source.

The impact of stress U_{xx} cold gait power source options to strengthen points shown in Fig. 4.

An increase to a limited extent arc voltage improves geometry point proplavlyannya depth varies slightly, 1.5-2 mm. With the lack of tension in the center of the arc surfacing formed deepening, and when excess - buhorok. This increases the electrode metal spray.

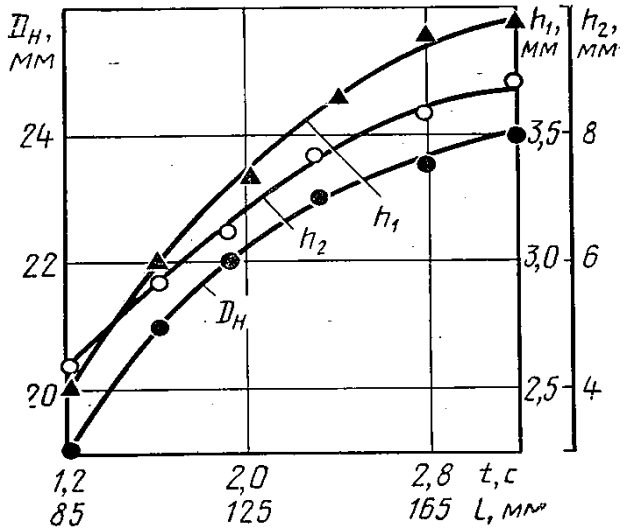

Fig. 5. The dependence of the geometrical parameters of time points to strengthen *t*surfacing and length *l* electrode wire.

Extending the surfacing leads to an increase in all three parameters - $D_{\text{Categories}}$,h_1,h_2 (Fig. 5), but the intensity of growth proplavlyannya much less depth.

The optimum height surfacing in terms of strengthening (head height) choose depending on the functional purpose of the working body. It must protect the base metal from abrasive wear Height consolidation point should be such as to defend the worn surface without creating significant additional resistance to the working body in the ground. In plowing blade, such as surfacing Blade height should not exceed 2 mm, and at loggerheads vineyard Engine - 0.5 mm, or increases traction resistance is sticky soil and agronomic requirements are not met by cutting weeds [7, 8] .

The diameter of the head consolidation points according to your choice of location, which is determined by the nature of the working body wear can be determined by height h_1 Head and depth h_2 proplavlyannya, set taking into account the thickness of parts and agronomic requirements diameter d_{th} and length *l* cored wire used to strengthen the movement points. Experiments show that the number of road vehicles

should be considered as the base metal and cored wire, forming a point of consolidation using appropriate coefficients k_m and $k_{Section}$Which reflect the ratio of primary and TC in total weld point.

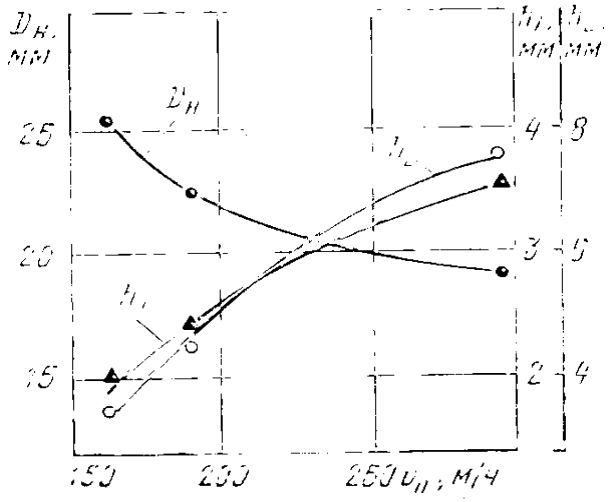

Fig. 6. Dependence of geometrical parameters on the rate of consolidation points $\upsilon_{Section}$ electrode wire feed.

Form the point of strengthening the sector represents a spherical volume:

$$V_{sf} = \pi (4 h_2^2 + D_н^2) h_1 / 6 \quad (1)$$

that fills the volume of melt

$$V_p = \pi k_m D_н^2 h_2 / 12 + \pi k_{Section} d_e^2 l / 4. \quad (2)$$

Conditions equity amounts to determine the diameter of the point of strengthening

$$D_{Categories} = [(3 k_{Section} d_e^2 l - 8 h_2^2 h_1) / (2 h_1 - k_m h_2)] 1/2. \quad (3)$$

Odds $k_{Section}$ and k_m TPA-mode, marks and surface condition strengthening the brand and type of cored wire.

In fact, in terms of strengthening the diameter somewhat larger settlement (25 mm) due to flowing over the edge of the crater alloy proplavlyannya.

Number of related or overlapping dots strengthening the length *L*or width *In the* protective surface of the body at a selected point diameter $D_{Categories}$ and overlap $\Delta D_{Categories}$ determined by the formula:

$$n = [L (In the) - D_{Categories}] / (D_{Categories} - \Delta D_{Categories}). \quad (4)$$

Estimated value is rounded to the nearest whole number.

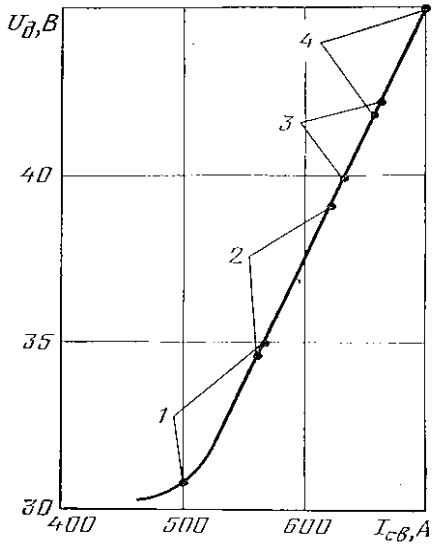

Fig. 7. The optimum voltage dependence U_d arc of current strength $And_{St.}$ for the electrode wire PE-CO-80H20RTZ-N-C 3.2 (GOST 26101-84); *1*,*2* - Toe blade and blade; *3* - Sidewall; *4* - Breast shelf.

To conjugate points of overlap $D_{Categories}$ = 0. If necessary $\Delta D_{Categories}$ changes in either direction depending on the functional purpose of working body. Great influence on the parameters of the points to strengthen provides speed $\upsilon_{Section}$ feed cored wire (Fig. 6). As you can see, with its diameter growth $D_{Categories}$ heads point decreases, which is associated with a reduction in time surfacing at the same flow wire. At that point the shape significantly affect heat dissipation to the sides of its borders, as well as the reduction of time surfacing this option in cross section smaller than the longitudinal, the melting occurs at a faster rate in the depth of the base metal than the party. This allows the entire proplavlyaty blade thickness, which is very important for samozahostryuvannya plowshares, as in the wear increases hardness difference between weld and weld areas and not in operation due samozahostryuvannya third kind is formed wavy-stepped blade (Fig. 8).

Technological parameters point to strengthen and TPA modes worked and standardized for these workers of tillage machines exposed strengthening (Table. 1): Ploughshares and plaskoriziv steel L53, field boards, side panels, steel bits cultivators 45, ripping legs and knives cultivators , chisel plows and naralnykiv baking powder, steel 65G, sternum shelves and shelves with a three-layer steel.

1. Profiles points surfacing strengthening.

Naymenu-tion details	Arson arc	Penetration	Formation head	$And_{St.}$And	Ud, B	*t*,*with*	Departure electrode rod, mm
	$t_{1,2,3,}$ mm / s	s /$v_{p1,2,3,}$					

Sides: PLZH 51.200U	0.5 / 17	2.1 / 96	0.4 / 21	620-660	38-43	3	27
PHTS 61.200U		1.6 / 44	0.4 / 21	650-700		2.5	27
PLYE 21,500	0.5 / 17				42-45		
Belly shelf		1.9 / 69	0.4 / 21	510-560		2.7	23
PLYE 21.401U		1.2 / 15.5	0.4 / 21	570-620		2	25
Ploughshare PNCHS 702U: toe blade	0.4 / 17	1.6 / 44	0.4 / 21	650-700	32-36	2.5	27
	0.4 / 17	2.1 / 96	0.4 / 18	620-640	35-39	3	27
		1.9 / 69	0.4 / 18	510-560		2.7	23
	0.4 / 17				42-45		
Knife KFH 06.070U	0.5 / 17				38-40		
Paws: KFH 00.070U 8.5 (GOST 1343-82)	0.4 / 17				32-36		

For welding points are used to strengthen tipped wire PP-NP-80H20R3T-N-C 3.2 (GOST 26101-84), which provides hardness 60-65 NRSe.

The length of cored wire spent on strengthening movement points, determined in accordance with TPA regime:

$$L = \upsilon_{P1} t1 + \upsilon_{P2} t_2 + \upsilon_{P3} t_3 \text{And} \quad (5)$$

where $\upsilon_{P1}, \upsilon_{P2}, \upsilon_{P3}$ cored wire feed speed for the three modes of road vehicles. When set modes TPA length of wire consumed is determined by the weight of costs *G* at a known diameter d_{th}:

$$l\,4 = G/ (\pi\, d_e^2\, \gamma), \quad (6)$$

where γ - Density of hard material cored wire.

Before flux cored wire for removing moisture calcined at 200-250°C for 40 min, and parts cleaning corrosion, oil and dirt. The presence of normal layer after rolling scale does not affect the quality point of consolidation.

Spot on strengthening details perform a horizontal or near it positions.

Stability and performance arc excitation surfacing determine TPA regimes. Relatively stable arc excitation is provided at a current density of at least 150 A / mm2. At the same current density higher voltage power supply idle pace creates more favorable conditions for excitation and arcing. Experiments show that when surfacing between the end

point and the subsequent excitation curves are no more than 5-7 seconds, the end of the electrode does not have time to cool down and subsequent inflammation occurs easily. Great value for arson arc is the initial feed rate cored wire: at v_{P1} > 80 m / h. re-excitation of the arc is 1-2 times for 100 points strengthening at v_{P1} > 100 m / h. much less frequently. It was established that the optimal speed v_{P1} is in the range of 30-70 m / h.

The automatic application consolidation excitation points of the arc must be stable. For this purpose PWI them. EO Paton has developed a software device to change the speed BA prefix 1448 and RP-13, which provides punching air gap 1-1.5 mm. This principle is incorporated in the automated line U1062 spot strengthening plowshares.

At a point hardening of one of the main conditions that ensure consistent quality strengthening - coordination of welding current and arc voltage. This dependence wire PE-CO-80H20R3T-N-C-3.2 is shown in Fig. 7. The surfacing is recommended at the maximum current density. The average power at TPA efficiency power supply, which is 85%, ranging from 15 to 40 kW [9, 10].

Table. 1 shows the TPA regimes for some work of plows. Quality assurance is achieved by strengthening the control point at all stages of production. Check TPA regime carried out not less than three control samples detail. The depth of penetration is checked by section details the center point. If the selected mode is kept surfacing depth of penetration is determined from the measured diameters $D_{Categories}$ and height h_1 by the formula

$$h_2 = (h_{2\,max} + h_{2\,max}) / 2, \quad (7)$$

where $h_{2\,max,\,min} = \frac{k_m D_н^2}{16h_1} \pm \sqrt{\left(\frac{k_m D_н^2}{16h_1}\right)^2 + \frac{3k_п d_e^2 l}{8h_1} - \frac{D_н^2}{4}}$

(8)

The drawbacks of consolidation points can be clad layer pores, uneven head, burning parts without penetration, are easily detected by external examination. In clad points allowed some cracks without access to the base metal parts. The presence of TPA spray on the surfaces does not affect its functional properties.

Indirect no sign penetration - understated and unstable diameter point. To prevent phenomena need to control current and voltage. The sign of a good quality surfacing serve colors surfacing from the back side details.

Defects such as low head and single point of time, have no influence on the wear resistance of the workers. Illegal are defects that reduce the strength of the details (burning and crack in the base metal) and wear resistance (lack of penetration).

Tillage machines with working bodies strengthened TPA, were field tested in the 1983-1988 biennium. 2004-2011rr.u and various soil-climatic zones of the state. Spot strengthening compared with induction welding improve wear resistance of working in 1.5-3 times, while their production costs are reduced due to a significant reduction in power consumption
(5 times or more), 4-5 times increased productivity, significantly reduced production area.

Points surfacing act on a front surface detail on size 1 ... 3 mm and penetrate into the base metal to a depth of 4 ... 6 mm, forming a front surface details Carbide point diameter 18 ... 25 mm and hardness NRS 60 ... 66 (Fig. 8, Fig. 9).

Direct current polarity reduces the stability of the process leads to the formation of spray reduces the depth of penetration and increases the height of the point of consolidation.

So point parameters worked on strengthening reverse polarity. Welded current has the biggest impact on shaping the point of consolidation. For example, with increasing weld current from 400 to 650A in diameter in terms of strengthening increases from 14.5 to 31 mm, height of 2.3 to 4.3 mm; surfacing is reduced from 3.5 to 1.2 mm [7].

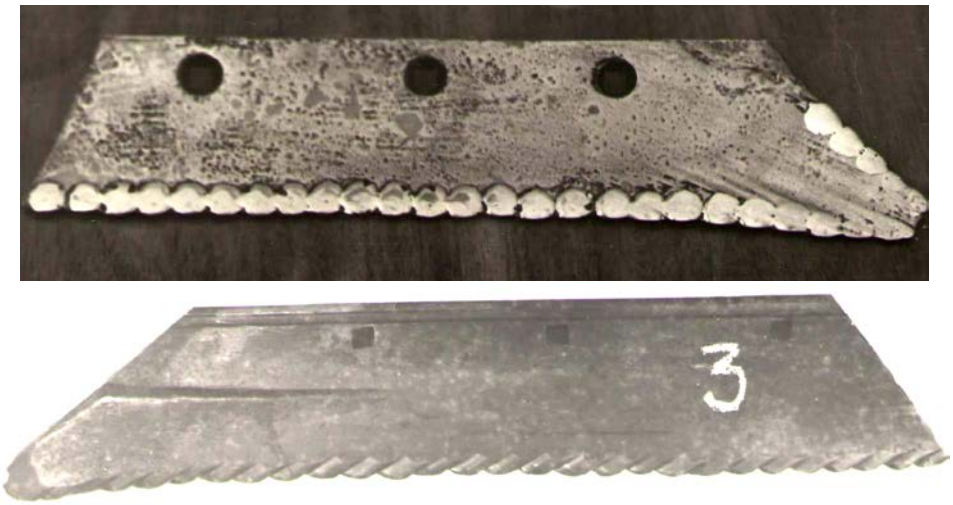

Fig. 8. ploughshare plow operating time after 49 ha.

Fig. 9. Geometric consolidation points.

The required depth of penetration as more options to strengthen achieved by changing spot weld strength of current, voltage and arc

length. Plowing was carried out at a depth of 25 ... 27 cm after harvesting crops. During the tests performed regularly measure the parameters of the job, determine the magnitude of wear. All working parts were the primary technical expertise labeled. Performance and quality of work conditions determined in accordance with GOST 20915-75 and OST.4.1-80.

Experimental plowshares strengthening of point blade and bow mounted on a batch plow PLN-5-35 that ahrehatuvavsya the tractor T-150K. Indicator of the quality of experimental plowshares depth processing and working width correspond to specifications. During the experimental trials plowshares sticking soil was observed. Experimental plowshares point of strengthening increased wear resistance (PNCHS-702U) meet the requirements for working the soil.

Resistivity PLN-5-35 with experimental blade at a speed of 2.08 m / s is 6.27 N / cm 2, which is 2.5% less (within the measurement error) than PLN-5-35 with serial blade . Since the difference of specific indicators within the measurement error, the value of specific indicators aggregates are compared, can be considered the same. By pulling power indicators tractor T-150K in the unit with PLN-5-35 with experimental blade ensures stable performance of the process, loading the engine when driving at a speed of 2.08 m / s was 94.6%.

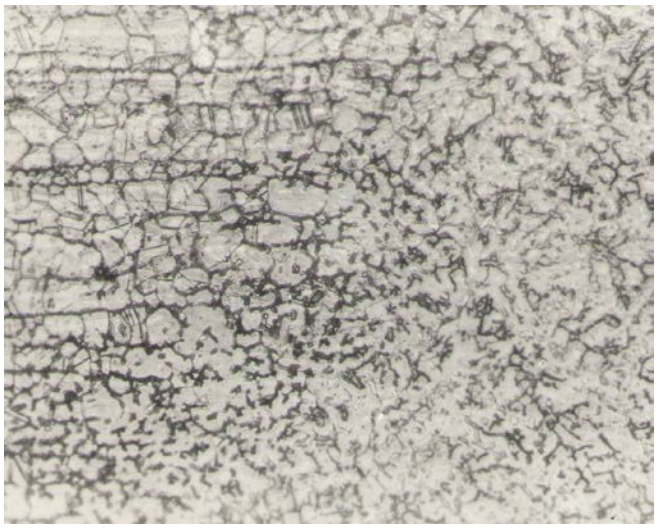

Fig. 10. Microstructure terms of strengthening Ploughshares, × 250.

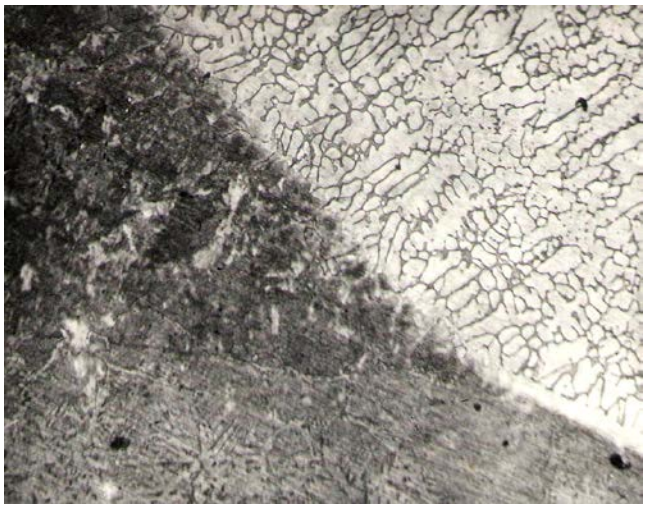

Fig. 11. Line fused to the upper and middle layer, × 250.

High wear resistance experimental plowshares abrasion wear implies the structure of the deposited layer of refractory metal carbides.

The formation of the carbide phase is mainly possible in two ways: through selective alloying elements carbide and carbon alloy weld or by doping the complex when administered ready carbide coating compound. The second method allows to simplify the control of the structure of the deposited metal. Microstructure point strengthening is boron carbide B4C (Fig. 10), boron is a part of the charge, in its pure form. At a point strengthening observe (Fig. 11) that Borides spread across grain boundaries, with no hardened structures and cracks. When using such materials operational load acts mainly on the inclusion of hard elastic-plastic matrix and stress relaxation occurs.

Conclusions

1. Point (arc spot welding) to create a technology that provides increased durability blade 1.5-3 times compared with induction welding when plowing in soils with different grain size and intensity of wear.

2. theoretically proved the possibility of formation samozahostryuvannya Ploughshares resulting spot formation and strengthening toothed blades during operation.

3. Production tests have shown that when wear it samozahostryuvannya blade is due to the difference of hardness stations substrate (base metal) and the blade working body.

References

1. *VS Novikov* Provision Durability workers organs soil-cultivating machines: Author. Thesis. on soys uchenoy Class doctor. Sc. sciences and technology spets.05.20.03 sredstva tehnycheskoho Maintenance in agricultural sector / *VS Novikov*. - M., 2008. - 43 p.

2. *Tkachev VN* Yznos Increase Durability and agricultural machines parts / *VN Tkachev.* - M .: Mashinostroenie, 1971. - 264 p.
3. *GI Kiselev* Abrazyvnыy yznos metal at temperatures DIFFERENT and Speed / *GI Kiselev.* - M., DAN USSR, 1952. - Vol XXXVII, №5. - P. 129.
4. *Rosenbaum AN* Yznashyvanye blades in the environment of pochvennoy / *AN Rosenbaum*. - M .: Mashhyz, 1960. - Sat. Increase Durability workers soil-cultivating machine parts. - P. 148.
5. *Klyuenko VN* Universal samozatachyvayuschyesya pluzhnыe Lemekh povышennoy yznosostoykosty / *VN Klyuenko*. - M .: Traktorы and selhozmashynы, 1986. - P. 31.
6. *Ermakov I. N.* Samozatachyvayuschyesya cast iron Lemekh / *I. N. Ermakov*. - M .: Mashhyz, 1956. - Sat. "Increase yznosostoykosty lemehov." - P. 204.
7. *Denisenko M.* Wear and increase the longevity of working farm machinery / *Mikhail Denisenko, A. Opalchuk*. - Ternopil: Ternopil Ivan Pul'uj National Technical University, 2011. - P. 201-210.
8. *Denisenko, MI* Strengthening and renovation of vehicles and agricultural machines using protective wear-resistant coatings / *Denisenko, MI Voytyuk VD, Rublev VI* // Herald KNTUA them. Peter Vasilenko. - H., 2010. - Vol. 101. - P. 93-103.
9. *Tereshchenko VI* Features arc tochechnoy quarrel plavyaschymsya Electrode / *Tereshchenko VI, Sharovolskyy AN, Sidorenko KA* // Automatic welding. - 1983. - № 9. - P. 51-53.
10. *Krahelskyy IV* Trenye and yznos / *IV Krahelskyy.* - M .: Mashhyz, 1962. - P. 142.

In the work given sovremennыh analysis methods uprochnenyya workers organs soil-cultivating machines rassmotrenы s Advantages and disadvantages. Shown something most эffektyvnым by uprochnenyya workers surfaces of parts soil-cultivating machines javljaetsja tochechnoe uprochnenye - Arc welding tochechnaya poroshkovoy provolokoy.

Abrazyvnoe yznashyvanye, tochechnoe uprochnenye, Lemekh plow, cultivator paw, boronы drive.

In paper present introduce the present method hardening working tool cultivation machine them advantage and defect Demonstrate what the greatest effective method hardening force surface part cultivation machine have-point hardening point consumable-electrode are welding flux cored electrode.

Abrasive wear, pointwise reinforcement, plough share, sweep, harrow disk.

UDC 681.513.5

RESEARCH AND ANALYSIS METHODS FOR OPTIMAL CONTROL OF DYNAMIC SYSTEMS

VS Loveykin, PhD