International Journal of Agriculture and Forestry 2015, 5(6): 318-322
DOI: 10.5923/j.ijaf.20150506.03

Increased Wear Resistance of the Cultivator Plowshares by Laser Technology of Consolidation

Victor Aulin[1], Warouma Arifa[2,*], Sergei Lysenko[1]

[1]National Technical University of Kirovograd, Ukraine
[2]Dan Dicko Dan Koulodo University of Maradi, Niger Republic

Abstract Working parts of plowing machinery do not reach their expected life because of abrasive wear intensity of their work surfaces in contact with the ground. It is therefore necessary to improve the reliability of these parts. The technical equipment consists of plowshares made of steel 65G, consolidated by different processing technologies, mounted on the cultivator KPS-4.0 hitched to tractor MTZ-80. The technological operation consisted in plowing in order to determine the different parameters of performance of these plowshares. The laser heat treatment allow to reduce the wear of the plowshares tip of the cultivator from 1.3 to 1.4 times in comparison with the volumetric heat treatment, while the thermal recharging laser of mixture PS-14-60 + 6% B_4C allows to reduce the wear from 1.7 to 1.8 times relative to the core technology by induction. The lifetime of the consolidated plowshares by reloading laser of mixture PS-14-60 + 6% B_4C in areas of the plowshares tip is greater than 1.5 to 1.6 times when compared to the conventional induction welding. The tensile strength of the plowshares recharged with laser decrease to 2.6% comparing with its initial value while for those resulting from volumetric heat treatment it increase to 14.6%.

Keywords Cultivator plowshare, Wear, Laser technology, Consolidation, Tensile strength, Lifetime

1. Introduction

The work of the agricultural soil is done by working parts arranged on the oars of plowing machinery (Sisolin and Pogorelyi, 2005; Sisolin et *al.* 2001.). The working parts of plowing machinery (WPPM) do not reach their expected lifetime because of abrasive wear intensity of their work surfaces in contact with the soil (Severn et *al.*, 2011; Aulin et *al.*, 2012.). The uneven wear causes the loss of their initial forms which is necessary to a good technological tillage operation. This leads to the increase of the tensile strength wich provok the increase of fuel and lubricant consumption. Thus, the additional need of sharpening or replacement of worn away parts is necessary. All these factors lead to a reduction in the profitability of using work machines and the rising cost of agricultural production (Kushnarev et al., 1989; Aulin et *al.*, 2014).

Improving the reliability of WPPM and the choice of optimal technology for their hardening require careful study of the abrasive wear mechanism, which is rather complicated and to date remains a topical issue.

Among the WPPM, the cultivator plowshares are the most commonly used in agricultural work. The degree of the cultivator blades' wear in different lands vary from 2.2 to 2.5 times higher than the wings of plowshares (Aulin and Bobritsky, 2004). The more going away from the tip of the plowshare, the more the intensity of the edge wear decreased.

The technological methods of consolidation used in the case of the WPPM, is often the heat treatment and the formation of the consolidation coatings (Zenkin and Kopylov, 2002). During the manufacture of WPPM more than 90% of all recharging works are done by induction (Golovin and Zimin, 1990; Vihrova et *al.*, 2007).

During recent years, the most common used method is the technological process of consolidation based on the use of concentrated energy flux (CEF) (Aulin et *al.*, 2002; Aulin, 2007) including the technological process using laser. These methods allow effectively the increase of surface layers of parts performance and labor productivity; the reduction of the consumption in energy and metal, and the use of deficit raw materials (Devoyko and Kardapolova, 2003; Delone, 1989; Vedenov and Gladouch, 1985).

Laser technologies have evident practical and scientific interest (Aulin, 1989; Aulin et *al.*, 2004; Aulin, 2003). However, the laser processing effect on the working surface of the WPPM and the use of the local aspect of the treatment in accordance with the nature of the wear require theoretical and experimental studies.

* Corresponding author:
warouma@yahoo.com (Warouma Arifa)
Published online at http://journal.sapub.org/ijaf

2. Material and Method

2.1. Material

The technical equipment consists of:

- Eighteen (18) cultivator plowshares made of steel 65G, consolidated by different technologies and mounted on the cultivator KPS 4.0 hitched to tractor MTZ-80;
- A laser processing module ‘'Komet-2";
- An alloy PS-14-60 and a mixture of alloy PS-14-60 + 6% B4C used for charging the laser;
- A device for determining the linear wear and changing the geometrical form of the working bodies of machines and implements,
- A dynamograph for determining the tensile strength of the WPPM.

2.2. Method

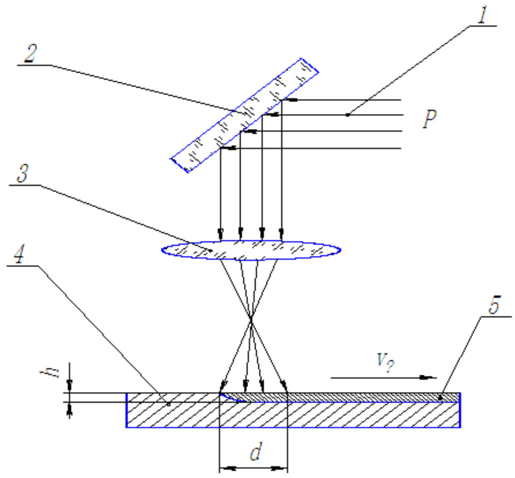
The thermal laser treatment and the reloading of WPPM work surfaces were carried out on the laser line "KOMET-2" in a radiation regime continuously generated (λ = 10.6 microns). Figure 1 shows the general view of the laser processing module "Komet-2" and the installation diagram of the laser treatment.

a)

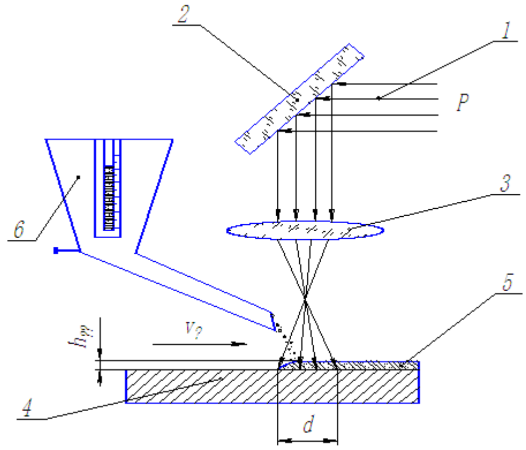
b)

Figure 1. Module of laser processing technology "Comet 2": a- post laser treatment, b - power supply and gas station

Sample processing was carried out according to the technological scheme presented in figure 2.



a)



b)

Figure 2. Technological diagrams of thermal laser treatment (a) and that of reloading laser sharp cultivator plowshares (b). 1 - laser beam, 2 - mirror, 3 - lens, 4 – part, 5 - consolidated layer, 6 - hopper, d- laser beam diameter, va -- forward speed, h - thickness of the heated metal, hei- thickness of the coating, p - radiation power

The alloys laser reloading (Figure 2b) was performed with the same working regimes as heat treatment laser. For reloading laser, a hopper was used for supplying powdered material.

Linear wear of WPPM was determined by the special device proposed. Its diagram is represented in Figure 3.

Linear wear value and the respective geometric shape of WPPM were determined using software which takes into account the difference of the distance between the initial and final contours.

For the field experimental, a total of eighteen (18) plowshares resulting from different technologies have been installed on the cultivator KPS-4.0 that was hitched to tractor MTZ-80 (Figure 4). Thus, the wear resistance, the average lifetme, the tensile strength and the dynamics of forms’ change in the process of exploitation of WPPM were taken each 5 hectares unit of operation per plowshare.

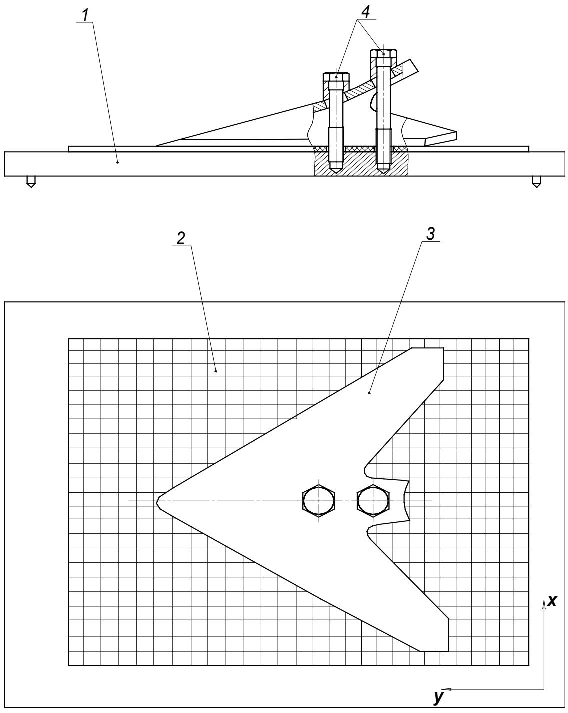


Figure 3. The scheme of the device for determining the linear wear and the change of the geometrical form of the Working parts of plowing machinery. 1 – base, 2 - cardboard sheet with grid, 3 - cultivator plowshare, 4 - bolts

Kirovograd, 2014

Figure 4. Overview of the aggregate for the determination of the tensile strength of the Working parts of plowing machinery

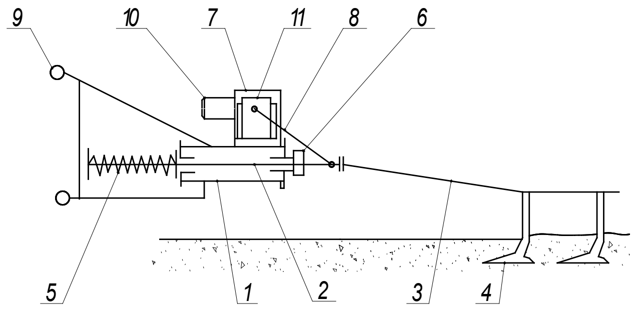


Figure 5. Diagram of the device for determining the tensile strength of the working parts of plowing machinery: 1 - body, 2 - stem, 3 - cultivator, 4 - plowshare, 5 - spring, 6 - stop mechanism, 7 - recording mechanism, 8 - lever system, 9 - the coupling device, 10- electric motor, 11- elastic device with a paper roll

The measurement of tensile strength (Figure 5) was performed by using the dynamograph of the traction, which was mounted between the tractor and the cultivator. The calibration of the instrument was carried out on a tensile testing machine. The average error of the instrument was 1.9%. The cultivator working width was of 4.0 m, the working speed was of 1.5 m / s and the working depth of the soil from 7 to 8 cm.

3. Results and Discussion

3.1. Results

The soil particles are greater than 0.01 mm and the moisture value varied between 10 and 25%. The results of the linear wear of cultivator plowshares are presented on Figure 6.

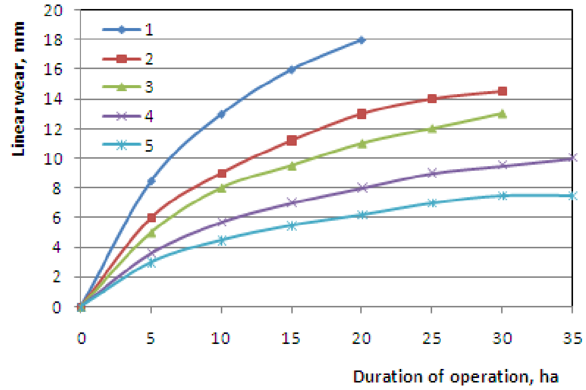


Figure 6. Dependence of linear wear of the plowshare tip in accordance with the duration of operation and consolidation method. 1 - volumetric heat treatment (Basic Technology), 2 - heat laser treatment, 3 - induction welding of alloy PS-14-60 (basic technology), 4 - Laser reloading of alloy PS-14 -60, 5 - Laser resurfacing of mixture PS-14-60 +6% B_4C

This Figure shows that the thermal laser treatment reduces the wear of the plowshares tip of the cultivator from 1.3 to 1.4 times in comparison with the volumetric heat treatment. While the use of reloading laser of alloy PS-14-60 with the addition of 6% of boron carbide can reduce it from 1.7 to 1.8 times in comparison with the induction welding.

The application of the consolidation of laser technology of mixture (alloy PS-14-60 + 6% of boron carbide) in the local areas, which are subjected to the greatest wear, allows substantially to equalize the wear characteristics of plowshares points all along the length of the cutting edge. And to keep during a long time the geometric shape of WPPM during the operation process (Figure 7).

The tensile strength of the cultivator has been measured to determine the shape-changing effect of the cultivator plowshares on the energy characteristics of the soil working process and to verify the effectiveness of the hardening proposed methods.

Figure 8 shows the experimental results of the tensile strength.

Figure 7. Cultivator plowshares after 25 ha of operation, consolidated by: a - reload laser of alloy PS-14-60 + 6% B_4C (proposed technology), b - induction welding of alloy PS-14-60 (basic technology)

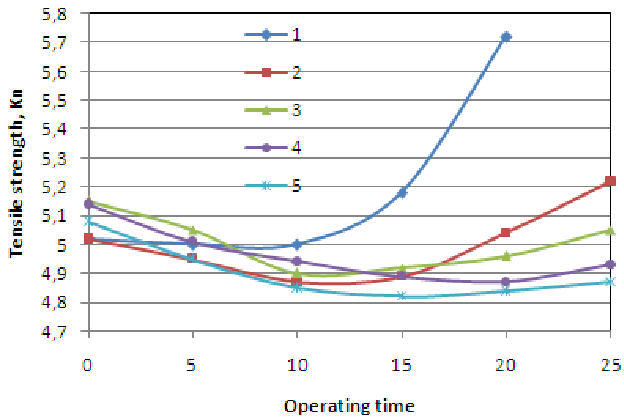


Figure 8. Dependence of the tensile strength of the cultivator KPS-4 in accordance with the operating time and the plowshare consolidation method. 1 - volumetric heat treatment (Basic Technology), 2 - laser heat treatment, 3 - induction welding of alloy PS-14-60 (basic technology), 4 - the laser reloading alloy PS-14-60, 5 - laser reloading alloy PS-14-60 + B_4C

In the beginning of the works, all plowshares had a slightly higher tensile strength. With the increase of the operating time, the tensile strength decreases and its optimum values corresponding to an operating time of 5 to 15ha for all consolidation methods. Except that of volumetric thermal treatment which optimum tensile strength values correspond to an operating time of 5 to 10 ha. Beyond that values, the use of the consolidated plowshares volumetric thermal treatment leads to the increase of the radius of curvature of the cutting edge and, consequently, to increase the tensile strength from 4,87 to 5,7 kN (corresponding to an increase of 14.6% from baseline after only 20 hectares of operation corresponding to their average lifetime). The consolidated plowshares by laser reloading, they are characterized by a decrease of the tensile strength from 5 kN to 4.87 kN (a decrease of 2.6%) and a stability of its values for an operating time of 25 ha and beyond.

The experiments were continued up to the sharp limits values reached, because the presence of the sharp flattening of WPPM excludes the quality of working soil and increases the technical and economic indicators of the exploitation of tillage machines.

The results of the experiments of WPPM consolidated by different methods are shown on Figure 9.

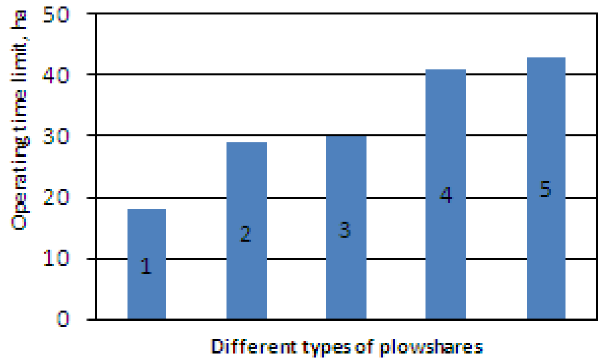


Figure 9. The durability of cultivator plowshares resulting from different consolidation methods. 1 - volumetric heat treatment (Basic technology), 2 - laser heat treatment, 3-induction welding alloy PS-14-60 (basic technology), 4 - reloading laser PS-14-60, 5 - reloading laser mixture PS-14-60 + B_4C

Figure 9 shows that the consolidated plowshares by reloading laser mixture PS-14-60 + B_4C have an average lifetime of 43 ha operating, while those resulting from the volumetric heat treatment have 18 ha.

3.2. Discussions

The results of the reload laser consolidation technology are better than other tested technologies.

In the early field work all plowshares have a slightly higher tensile strength. This can be explained by the fact that during the operation, the plowshares work surfaces are prone to sticking soil. With the increase of operating time, the tensile strength decreases and optimum values corresponding to an operating time from 5 to 10 ha for volumetric thermal processing technology and from 5 to 15 ha for all other technologies. This is explained by the fact that, during this period, the formation and the stabilization of the shape of the cutting edge are performed.

Unlike the other technologies, the proposed technology reloading laser alloys PS-14-60 + 6% B_4C, allows during a long period of use, to keep the original shape of the parts of WPPM. This is explained by the fact that the self sharpening phenomenon is well done with this technology.

The laser heat treatment can reduce the wear of the plowshare tip of the cultivator from 1,3 to 1,4 times relative to the volumetric heat treatment, while for reloading laser alloy PS-14-60 + 6% B_4C, the reduction is from 1.7 to 1.8 times relative to the basic technology (induction welding). These results confirm the works of Novikov and Belikov (2000), in which they are respectively in the range of 1.3 to 1.5 times and 1.7 to 1.9 times despite that the basic metal used is steel 45.

The application of the laser heat treatment in comparison with the classic volumetric heat treatment increases the lifetime of the blades from 1.5 to 2.2 times, and the laser consolidation from 1.5 to 1.6 times compared with the conventional induction welding. These results are higher than those of Repin et al., (2013) where the increase of the lifetime of the blades from the laser consolidation was from

1.3 to 1.4 times compared with the induction welding.

The consolidated plowshares by laser reloading are characterized by a decrease of tensile strength of 2.6% compared to its initial value, which is also positive in terms of fuel and lubricant economy.

4. Conclusions

Improving the reliability of the working parts of plowing machinery and the choice of optimal technology for their consolidation remains a topical issue.

It appears that laser reloading greatly improves the wear resistance, the durability, the tensile strength and the realization of the self-sharpening cutting edges of the Working parts of plowing machinery.

The proposed laser technologies can achieve both continuous and separated consolidation of the working parts of plowing machinery and mounting holes.

REFERENCES

[1] Sisolin P.V. and Pogorelyi L.V., 2005. Working Machinery soil and seedlings: History, engineering, construction. - K:. Phoenix.-264p.

[2] Sisolin P.V., Chernovol M.I., Salo V.M., Kropivniy V.M., 2001. Tillage machines, theoretical bases, projection. - K. - 384 p.

[3] Severn M.M., Podlekarev N.N., Sokhadze V.S, Kitikov V.O., 2011. Wear and corrosion of agricultural machinery. - Minsk: Belarus. Science. - 333 p.

[4] Kushnarev A.S., Kushnarev A.S., Kochev V.I., 1989. Mechanical and technological bases of working soil. - Kiev.: Harvest. -144 p.

[5] Aulin V.V., Bobritsky V.M., 2004. Character and wear intensity of working elements of tillage implements // Tribologic Problems. -Khmelnitsky: KSU. - №2- pp.107-112.

[6] Zenkin M.A., Kopylov V.I., 2002. Improving the performance of composite materials by optimizing the consolidation of technology: Monographie.- K. - 272 p.

[7] Golovin G.F., Zimin N.V., 1990. Heat treatment technology of metals with induction heating. - A:. Engineering. - 254 p.

[8] Vihrova L.G., Aulin V.V., Bisyuk V.A., 2007. Computerization of parts consolidation process with induction welding.: Visnik KNTUA. Flight. 57. Power Problems and energy saving in agriculture. Volume 2. Harkiv. - pp.213-219.

[9] Aulin V. V., Mazheyka O.Y., Solovykh E.K., 2002. Determination of technological parameters of laser machining parts with a beam of specific impact on building materials. // Bulletin of the Academy of Engineering Sciences. - №2. - pp. 30-25.

[10] Aulin V.V., 2007. Physics of structural reforms of the materials in the treatment area by concentrated flow of energy and friction and wear. // Tribologic Problems. - Khmelnitsky: KNU. - №2 (44) - pp. 57-59.

[11] Devoyko O.G., Kardapolova M.A., 2003. Creation of composite coatings based on mixtures by use of laser heating. Review of scientific work GUTP.-Novopolotsk.- pp.141-144.

[12] Delone N.B., 1989. Interaction of laser radiation with matter. - M:. Science, -280 p.

[13] Vedenov A.A., Gladouch G.G., 1985. Physical processes during laser treatment. - M:. Atomic Energy Review. - 207 p.

[14] Aulin V.V., 1989. Improvement of physical properties of the surface layers of some building materials by laser treatment: Doctoral thesis. -Science-Spec. 01.04.07 "solid state physics". - M:. MISA. - 24 p.

[15] Aulin V.V., Mahopets S.O., Mahopets A .S., Aulina T.M., Lisunov S.M., 2004. Laser treatment effect characteristics on the materials of agricultural machinery parts during their thermal treatment // Design, manufacture and operation of the Agricultural thecnique / Vol. 34. - Kirovograd: KNTU. - pp.229-233.

[16] Aulin V.V., 2003. Creation of consolidated composite coatings on parts of agricultural equipment by use of laser radiation // Conception, production and operation of agricultural machinery. - Vol. 33. - Kirovohrad, KDTU. - pp.310-316.

[17] Aulin V.V., Karpushin S.O., Tihii A.A., 2012. Self-sharpening machines working cutters of the soil and earth in terms of strengthening of their work surfaces // Review of the scientific work of the National University of automobile and road Kharkiv HNADU, Vol. 57 - pp. 188-194.

[18] Aulin V.V., Nastayachi V.A., Tihii A.A., 2014. Wear of selective parts of earthmoving machinery and implements, their interactions with soil particles / Scientific works of the National Academy of rail networks. - Vol. 148 - pp.25-33.

[19] Novikov A.V., Belikov I.A., 2000. Improvement of the reliability of the organs of tillage implements working bodies. // Proceedings of the Russian Academy of Engineering of Management and Agribusiness, number 2. RIA-M:. MA. pp. 124-128.

[20] Repin F.F., Glebov V.V., Prokhorov I.I., 2013. Laser consolidation of Agricultural machinery parts made of cast iron and steel. Coll. Articles "Testing of the Materials and Structures", Nizhny Novgorod, pp. 80-108.