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Improving the wear resistance of hoe blades by modifying of restoration coatings

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Abstract

The possibility of using a non-magnetic fraction of a detonation charge with a diamond fraction from the disposal of ammunition to modify the restoration coatings of a natural product – clay and secondary raw materials — was studied. Four different coating variants were investigated. For this, a T-620 electrode was used with its additional modification by coating with bentonite clay, as well as with a non-magnetic fraction of the detonation charge and applying it in the form of a slip coating on the cutting surface of the cultivator. It is shown that the use of such additives allows to increase the resistance of the working tool of agricultural machines, reduces its tendency to damage due to the minimum penetration of the thin-walled product of the hoe blade and a decrease in the cross section of the transition layer and the level of stress. Each modifier makes changes to increase the microhardness to varying degrees. An increase in microhardness is observed on the surface of the coating and its gradual decrease to the transition layer. The surface coating with the additional introduction of bentonite clay in a liquid bath has the highest microhardness. Its microhardness varies from HV-50-1009.7 to HV-50-615.2. Similarly, the effect of the modifying additive of the detonation charge, the microhardness varies from HV-50-969.6 to HV-50-633.26. When clay or a mixture is introduced into the restoration coating, the wear resistance increases by 1.3 - 2 times with respect to the deposited surfacing only by the electrode and by 2 - 3 times to the initial material of the cultivator. It was found that the lowest coefficient is characteristic for dry friction, as well as for hydroabrasive, for samples with additional modification with clay or a detonation charge.

Key words: wear resistance, restoration, hoe blades, bentonite clay, detonation charge, modifier, wear and friction coefficients, microhardness.

Introduction

Currently, in agriculture, a large number of tillage tools (cultivators, sowing complexes, seeders, soil rippers etc.) are used for tillage, with widely used working bodies, which include arrow-shaped cultivator blades. The cultivator blade is one of the most consumable part in agriculture during cultivation. The arrow-shaped cultivator blades are operated under direct exposure to abrasive particles and therefore wear out intensively with the corresponding structural degradation of the metal and a change in geometric dimensions that determine the main parameters of the process efficiency [1]. Worn cultivator blades significantly reduce the efficiency and quality of the work. Their use leads to non-compliance with the agrotechnical terms of tillage. In addition, the tillage equipment is idle due to the replacement of worn cultivator blades. All of the above at times increases the cost of tillage and significantly reduces the amount of gross output obtained. As a result, in order to maintain tillage implements in working condition, enterprises producing spare parts for agricultural machinery produce a large number of new cultivator blades as spare parts. At the same time, a significant amount of expensive alloy steel is consumed. In this regard, increasing wear resistance and durability of the arrow-shaped cultivator blades of tillage tools during their operation is one of the important scientific problems.

There are a large number of methods for restoring the operability of the cultivator blades. The most demanded is their restoration with coating by hardfacing. For this, the most commonly used electrodes are T-590, T-620 [2 - 4]. To improve the restoration quality and wear resistance, various methods of modifying the metal of the restoration coating are also used. Most often, an additional modifier is introduced in the form of an electrode coating or a slip coating [5].

The aim of the work was to increase the wear resistance of the restoration hardening of the coating during the operation of cultivator blades. The objective of the study was to assess the wear resistance of the coating when adding an additional modifier to the liquid bath during hardfacing.

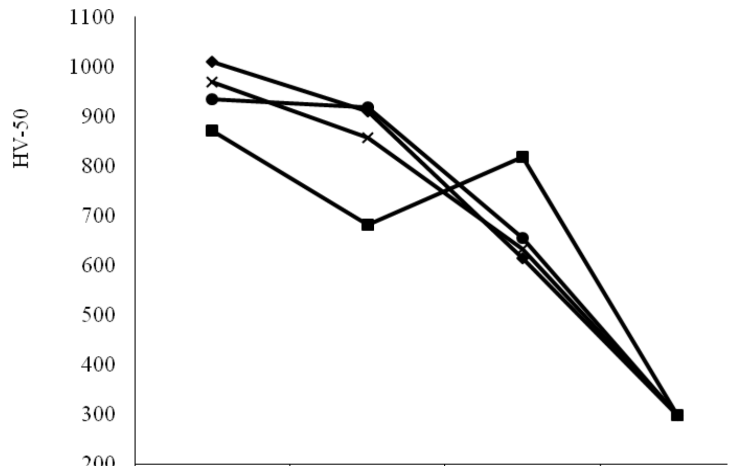
Materials and Tools

To solve this problem, restoration hardfacing on a cultivator blade of steel 65G was carried out with a T-620 electrode. Bentonite clay was used as a modifying additive, as well as a non-magnetic fraction of the detonation charge from the disposal of ammunition with a diamond fraction. The choice of these components is due to the fact that the use of clay as a modifier, which contains oxides of silicon and aluminum, can well withstand and resist wear to similar materials that make up the soil. The detonation charge, including nano- and dispersed diamonds, can also increase the wear resistance of the coating. As a result, four different coating options were investigated. For this, a T-620 electrode was used with its additional modification by coating with bentonite clay, as well as with a non-magnetic fraction of the detonation charge [6] and applying it in the form of a slip coating on the cutting surface of the cultivator. The chemical composition of the electrode used, %: 3.0 C, 2.2 Si, 1.2 Mn, 22.5 Cr, 0.7 Ti, 0.8 V, 0.03 S. Bentonite clay contains components such as %: 1.65 Fe, 0.25 K, 0.15 Ca, 0.06 S, 0.2 Mg, 54.88 Si, 32.42 Al, 0.3 Na. The mixture, according to chemical analysis, includes nano- and dispersed diamonds of 3.37-3.43% C, as well as copper up to 3.14% and iron up to 2.9% as the main components, and the rest is a small fraction of various modifying additives and their compounds.

Discussion of the results

At the first stage, the microhardness of the obtained coatings was evaluated (Fig. 1). It is seen that each modifier makes changes to increase the microhardness in various degrees. Microhardness grows on the surface and gradually decreases to the transition layer. During hardfacing only with an electrode, the microhardness throughout the entire depth varies within the limits of HV-50-681.2 – 871.2.

The highest microhardness of the transition layer is characteristic of the variant without the introduction of a modifying additive, which is associated with a high level of tension formation. When modifying additives are introduced - clay or detonation (depending on their fraction), the temperature of the liquid bath can be reduced up to ~ 300 °C, which allows to reduce the level of tension and the size of the transition zone.



	surface of the coating	middle of the coating	transition zone	basic metal
electrode	871,4	681,2	818,1	298,8
electrode with detonation charge modifyng	969,6	856,4	633,26	298,8
electrode with clay modifying	1009,7	909,8	615,2	298,8
electrode with detonation charge slip coating	935,1	918,2	655,3	298,8

Fig. 1. Average microhardness values for various coating options

The highest microhardness is the surface of the coating with the additional introduction of bentonite clay in a liquid bath. The microhardness varies from HV-50-1009.7 to HV-50-615.2. The effect of the modifying additive of the detonation charge is similar. In this case, the microhardness varies from HV-50-969.6 to HV-50-633.26. Slip hardfacing also makes a difference in microhardness. Since the thickness of the new cultivator is 6 mm, and worn to 5 mm, this method, due to the uneven distribution in the liquid bath of the additive, melts the base metal to a greater extent and increases the length and stress of the transition zone.

To assess the effect of modifying additives when applying reconditioning coatings, they were tested for wear. Bench wear tests were carried out on a friction machine SMT-1. The relative wear resistance of various methods of restoring and hardening the surface of the parts was carried out and evaluated according to five options: 1 - the starting material of the cultivator blade - steel 65G; 2 - by coating with a T-620 electrode with additional modification by a non-magnetic fraction of the detonation charge by the electrode coating; 3 - hardfacing by electrode T-620 using molten slip coating of a non-magnetic fraction of a detonation charge; 4 - coating electrode T-620; 5 - hardfacing with a T-620 electrode with its clay coating. Tests were carried out according to the "block-on-disk" scheme. The test design and sample size are shown in Fig. 2.

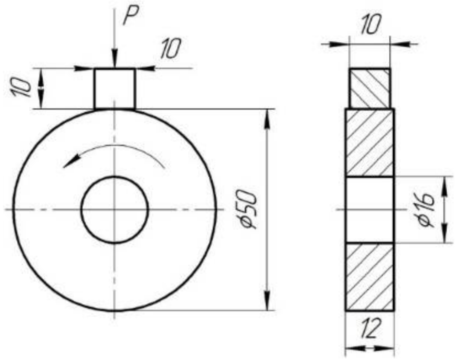


Fig. 2. Test design and sample sizes for bench wear tests

Testing of the samples was carried out in the abrasive environment of quartz sand without lubrication and was carried out according to the Brinell scheme. Samples of 10 × 10 mm in size, cut from the coated zone and processed on a surface grinding machine at a load of 5 kg, were tested. Ftoroplast was used like a counterbody (PTFE-4). In this test, ftoroplast was used as the body to hold the abrasive in the area of friction. The sand of the Staroverovsky deposit (Ukraine) with a fraction of 0.25 - 0.4 mm was used as an abrasive. Before testing, the prepared samples (bloks, disks) were washed, marked, and weighed on a WA-200 balance. The results of preliminary tests Table 1 shows. The friction path was 100 m.

Table 1

Abrasion wear test

No.	Variant of hardening	Coefficient of wear, %
1	The original material of the cultivator blades steel 65G	1.0
2	Hardfacing with a T-620 electrode with the additional introduction of a detonation charge by a non-magnetic fraction	0.30
3	Hardfacing with a T-620 electrode over a slip coating of a non-magnetic fraction of a detonation charge	0.63
4	Hardfacing with T-620 electrode	0.62
5	Hardfacing with T-620 electrode with the additional introduction of clay	0.45

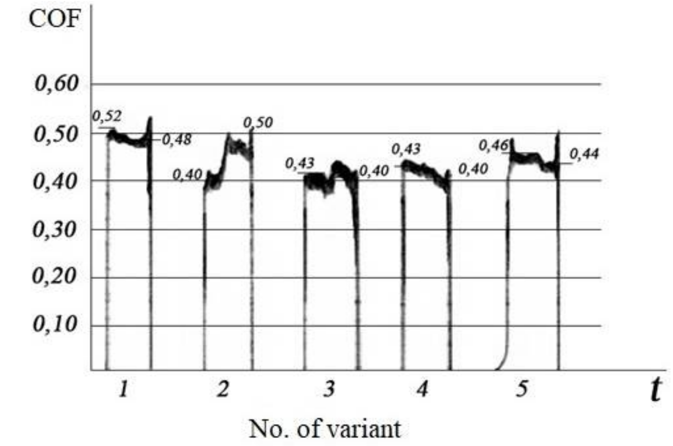
Table 2

Coating wear tests

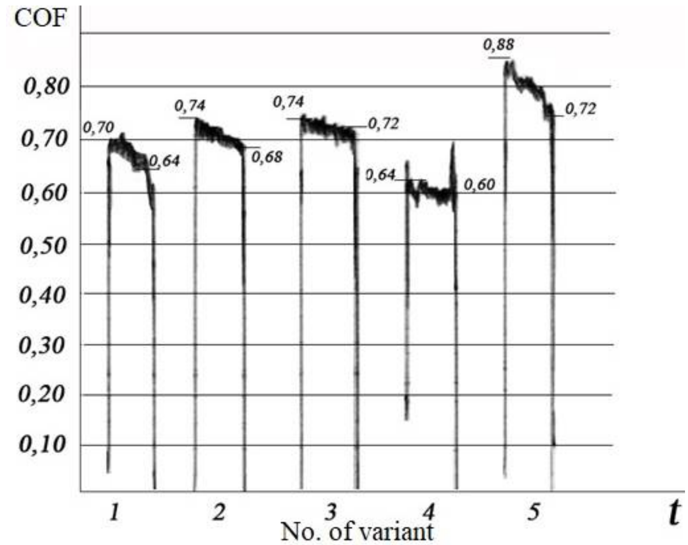
Option No.	Value of COF under test conditions		
	P = 50 H*	P =50 H**	P = 200 H***
1. The original material of the cultivator blades steel 65G	0.48 - 0.52	0.64 - 0.70	0.38 - 0.42
2. Hardfacing with a T-620 electrode with the additional introduction of a detonation charge by a non-magnetic fraction	0.40 - 0.50	0.68 - 0.74	0.38 - 0.42
3. Hardfacing with a T-620 electrode over a slip coating of a non-magnetic fraction of a detonation charge	0.40 - 0.43	0.72 - 0.74	0.34 - 0.38
4. Hardfacing with T-620 electrode	0.40 - 0.49	0.60 - 0.64	0.32 - 0.34
5. Hardfacing with T-620 electrode with the additional introduction of clay	0.44 - 0.46	0.72 - 0.83	0.34 - 0.36

Test conditions: *dry friction; **dry with a supply of quartz sand of 0.25 - 0.40 mm fraction; ***with a supply of quartz sand and water.

From the results of the analysis it follows that the best indications during the wear test were shown by samples with the additional introduction of clay and a non-magnetic fraction of the detonation charge with a diamond fraction. Hardfacing on a slip coating does not introduce significant changes and in terms of friction coefficient (COF) is on par with conventional hardfacing with an electrode.



a



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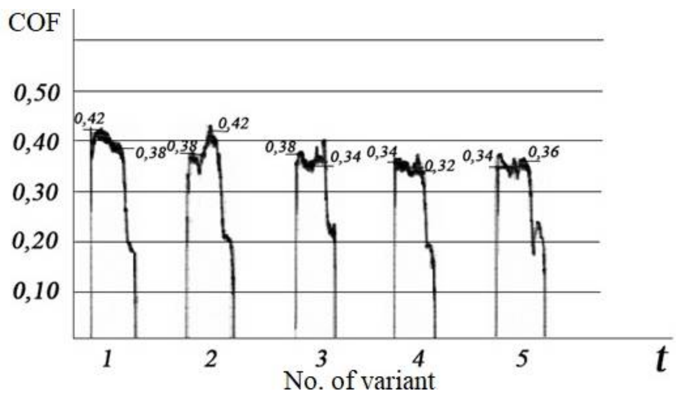

c

Fig. 3. Diagrams of wear tests of coatings in the dry friction (a), with the supply of quartz sand of 0.25-0.40 mm fraction (b) and in a hydroabrasive environment (c):
1 – the original material of the cultivator blade made of steel 65G;
2 – hardfacing with a T-620 electrode with additional modification by a non-magnetic fraction of the detonation charge;
3 – T-620 electrode with the slip coating is not a magnetic fraction of the detonation mixture;
4 – electrode T-620;
5 – electrode T-620 with the additional introduction of clay

When clay or a mixture is introduced into the restoration coating, the wear resistance increases by 1.3 - 2 times with respect to its application by the electrode without modification and by 2 - 3 times with the usual material of the cultivator blade.

For further analysis, we carried out additional comparative wear tests under various friction conditions (dry; dry with a supply of quartz sand of 0.25 - 0.40 mm fraction; with a supply of quartz sand and water) and evaluated the variability of the friction coefficients (Table 2 and Fig. 3). In these tests, the "disk" made of fluoroplastic Ø 50mm was also used, and the sliding speed was 0.78 m/s.

A slight decrease in the coefficient of friction when testing deposited samples without modification (Fig. 3, b No. 4) is associated with the grasp process, which reduced the test period.

From the data obtained it follows that the lowest coefficient is characteristic of dry friction, as well as hydroabrasive in samples with additional modification with clay and a detonation charge. When abrasive is applied, the friction coefficient decreases in samples that hardfaced by an electrode with a non-magnetic fraction of the detonation charge.

Based on the obtained test results, in order to increase the resistance of the cultivator blades in operation, it is recommended to use secondary raw materials for modifying restoration coatings and natural materials when applying restoration coatings, which will not only increase the resistance of the working tool of machines, but also reduce the tendency to damage due to the minimum penetration of the thin-walled product of the cultivator blade and reducing the cross section of the transition layer and the level of stress.

Conclusions

The possibility of using a non-magnetic fraction of a detonation charge with a diamond fraction from the disposal of ammunition to modify a natural product like clay and secondary raw materials is shown.

With the introduction of clay and the mixture into the coating by hardfacing, the wear resistance increases by 1.3 and 2 times with respect to the coating made only by the electrode, and also with respect to the original material of the cultivator blade 2 and 3 times, respectively.

To increase the service life of the cultivator blades in operation, it is recommended to restore them with deposition coating and additional modification with clay or a non-magnetic detonation charge with a diamond fraction.

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Т.С. Скобло, І.М. Рибалко, О.В. Тіхонов, Т.В. Мальцев Підвищення зносостійкості культиваторних лап модифікуванням відновлювальних покриттів.

Вивчено можливість використання для модифікування відновлювальних покриттів природного продукту - глини і вторинної сировини - немагнітної фракції детонаційної шихти з алмазною фракцією від утилізації боєприпасів. Дослідили чотири різні варіанти нанесення покриття. Для цього використовували електрод Т-620 з додатковим модифікуванням його обмазкою бентонітовою глиною, а також з немагнітної фракцією детонаційної шихти і нанесенням її у вигляді шлікерного покриття на ріжучу поверхню культиваторної лапи. Показано, що застосування таких домішок дозволяє підвищувати стійкість робочого інструмента сільськогосподарських машин, зменшує його схильність до пошкоджуваності завдяки мінімальному проплавленню тонкостінного виробу культиваторної лапи і зниження перетину перехідного шару і рівня напружень. Кожен модифікатор вносить зміни в підвищення мікротвердості в різному ступені. Підвищення мікротвердості спостерігається на поверхні покриття і плавне її зниження до перехідного шару. Найбільшу мікротвердість має поверхня покриття з додатковим введенням бентонітової глини в рідку ванну. Мікротвердість її змінюється від HV-50-1009,7 до HV-50-615,2. Аналогічний вплив і модифікуючої домішки детонаційної шихти, мікротвердість змінюється від HV-50-969,6 до HV-50-633,26. При введенні глини або шихти відновлювальне покриття підвищує зносостійкість в 1,3-2 рази по відношенню до нанесеного наплавленням тільки електродом і в 2-3 рази - до вихідного матеріалу культиваторною лапи. Встановлено, що найбільш низький коефіцієнт характерний для сухого тертя, а також - гідроабаразівного в зразках з додатковим модифікуванням глиною або детонаційною шихтою.

Ключові слова: зносостійкість, відновлення, культиваторна лапа, бентонітова глина, детонаційна шихта, модифікатор, коефіцієнти зносу і тертя, мікротвердість.