Resistance of Coated Electrodes Suitable for Renovation of Tillage Tools

Odolnosť obalených elektród vhodných na renováciu pôduspracujúcich nástrojov

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Abstract

This article deals with the abrasive wear resistance of additional materials. The resistance of individual materials was figured out by determining a proportional wear resistance on a grinding fabric. Results of the experiment confirmed an increase in welds abrasive wear resistance. Chosen coated electrodes are suitable for the renovation of tillage tools of agricultural machines.

Keywords: manual surfacing, basic electrode, relative resistance, abrasive wear

Abstrakt

V príspevku sa zaoberáme odolnosťou prídavných materiálov proti abrazívnemu opotrebeniu. Odolnosť materiálov sme definovali na základe stanovenia pomernej odolnosti proti opotrebeniu na brúsnom plátne. Experimentálne výsledky potvrdili zvýšenú odolnosť návarov proti abrazívnemu opotrebeniu. Vybrané obalené elektródy sú vhodné na použitie pri renovácii pôduspracujúcich nástrojov poľnohospodárskych strojov.

Kľúčové slová: ručné naváranie, bázické elektródy, pomerná odolnosť, abrazívne opotrebenie

Introduction

In active usage, a tillage working tool is exposed to the dynamic load, abrasive wear and chemical activity of surroundings. The typical examples of active parts of agricultural machinery are ploughshares, digging blades, stub runners, etc.

In soil conditions, the friction angle is composed of the functional surface of the tool, arable land and environment. Hardness and structure, given by the chemical composition and condition, belong to the most important properties of the ploughshare. Soil properties are determined by its composition, structure, humidity and chemical activity.

Functional parts of agricultural machines are exposed to intense abrasive wear. It is possible to increase the wear resistance and thereby to extend the life of machine parts by welding renovation. The testing of renovated tillage tools is possible either in a field or in a laboratory.

The determination of material wear resistance in field conditions is time consuming and financially demanding. In laboratory conditions, it is necessary to determine the evaluation criteria of wear resistance.

The objective of this article is to test the abrasive wear resistance of chosen coated electrodes in the laboratory using a tribological test according to the standard ČSN 01 5084 – abrasive wear resistance of metals on a test device with grinding fabric.

Materials and Methods

Tribological tests enable us to determine the size of wear on the basis of weight losses of studied materials due to wear. In the laboratory, the main criterion for the wear resistance of individual materials is relative abrasive wear resistance $\psi_{abr.}$ defined as:

$$\varphi_{abr.} = \frac{W_{hE}}{W_h} \quad (1)$$

where:

W_{hE} – average weight loss of etalon sample body, g

W_h – average weight loss of samples of tested material, g

Laboratory conditions as well as the procedure of this test corresponded to the relevant standard. Average weight losses were calculated from weight losses of individual electrodes. Compared sample bodies are made of steel 12 014.20 according to the standard STN 41 2014, with a set range of hardness HV=95÷105.

The test device for measuring the resistance of metal materials to abrasive wear is shown in Figure 1.

Table 1 shows the hardness values HV10, labelling of electrodes listed by the manufacturer as well as the chemical composition of welding metal.

Table 1: Initial chemical composition and hardness HV10 of the additional materials

Electrode	Hardness HV10	Elemental contents, %						
		C	Mn	Cr	Mo	Si	V	B
E-502 B	340-350	0.09	0.9	3	-	0.9	-	-
E-503 B	445-455	0.2	0.9	2	0.5	0.4	0.5	-
E-508 B	580-655	0.4	0.7	6	0.6	0.4	-	-
E-511 B	515-545	0.2	0.6	13	-	0.3	-	-
E-518 B	650-660	3.5	<1.5	29	-	<1.5	-	-
E-519 B	670-698	3.5	1	25	-	2	-	0.2
E-520 B	595-665	3.5	0.8	25	-	0.8	1.3	-

The electrode E-502 B is suitable for welding of part's functional surfaces made of non-alloyed and low-alloyed steels in which there is a need to raise the resistance to wear, e.g. for welding of rails, cross switches, etc. It is also appropriate for welding of edges of simple tools for wood shaping etc.

The electrode E-503 B is suitable for welding of active parts of tools used in higher temperatures, resisting wear at temperatures over 400 °C, e.g. forging tools, pressing tools, rods, etc.

The electrode E-508 B is applicable for welding of active parts of agricultural and forest machines exposed to abrasion and impact.

The electrode E-511 B is suitable for welding of functional surfaces resisting wear under concurrently exerted pull and impact up to +400 °C (pressing tools, swages, gear wheel, cutting edges). Also, it is possible to use these welds for control and retaining valve seats and cones.

The electrode E-518 B is suitable for welding of active surfaces resisting wear and concurrent impact (tillage machines, cutter bits, components of mills, sealing surfaces). Mentioned welds demonstrate good properties even at higher temperatures.

The electrode E-519 B is suitable for welding of active surfaces resisting high abrasive wear by soil and other mineral substances under concurrent pressure and impact. The electrode E-519 B is mainly used for welding of active parts and edges of earth machinery and tools, wheels of wheel mills, hammer and cement mills, screw conveyor edges, etc.

The electrode E-520 B is suitable for welds resisting strong abrasive wear under normal or increased temperatures (mine combines, earth machines or agricultural machinery).

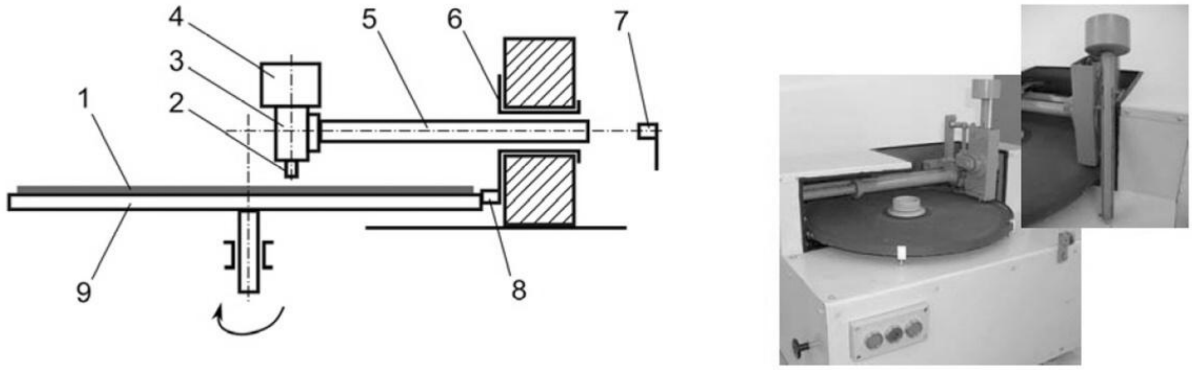

Figure 1: Test device with grinding fabric: 1- grinding fabric, 2 - sample, 3 - holder, 4 - weight, 5 - moving screw, 6 - rotary matrix, 7 - limit switch, 8 - stopper, 9 - rotary horizontal panel

The measurement of weight losses and hardness according to Vickers (HV10 according to the standard STN ISO 6507) were performed on devices and machines in laboratories of the Department of Quality and Engineering Technologies (Faculty of Engineering, Slovak University of Agriculture in Nitra).

Results and Discussion

Table 1 presents the results of measured weight losses when creating one-, two- or three-layer welds.

Figures 2, 3 and 4 show the graphic demonstration of relative abrasive wear resistance $\Psi_{abr.}$ as well as the achieved hardness HV10 in dependence on the used electrode in regard to the number of welds.

Table 2: Average weight losses of used electrodes and etalon

Electrode	Weight loss, g		
	One layer	Two layers	Three layers
E-502 B	0.2496	0.2423	0.2381
E-503 B	0.1970	0.1889	0.1827
E-508 B	0.1431	0.1129	0.1050
E-511 B	0.1585	0.1556	0.1541
E-518 B	0.1466	0.1226	0.1144
E-519 B	0.1027	0.1001	0.0982
E-520 B	0.1770	0.1166	0.1029
Steel 12 014.20 (etalon)	0.3655	-	-

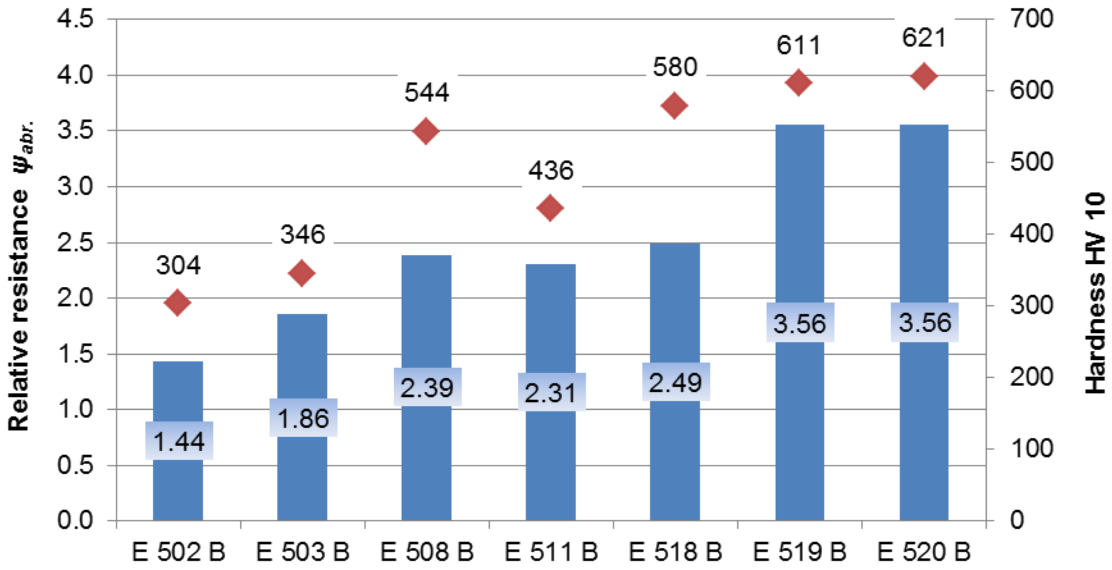

Figure 2: Obtained values of relative abrasive wear resistance $\Psi_{abr.}$ and hardness HV10 of electrodes, one-layer weld

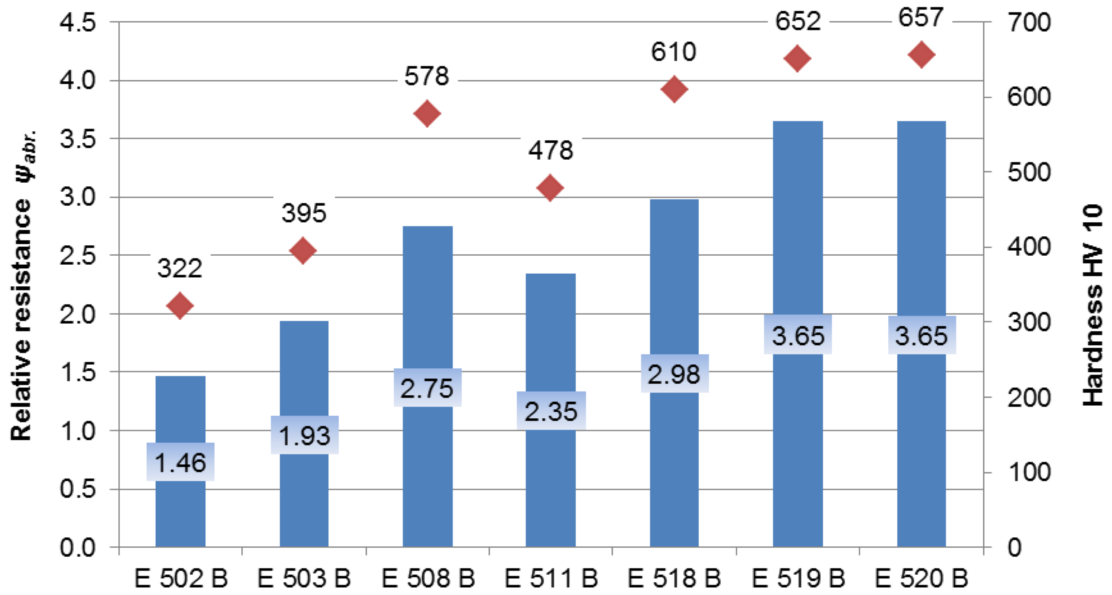

Figure 3: Obtained values of relative abrasive wear resistance $\Psi_{abr.}$ and hardness HV10 of electrodes, two-layer weld

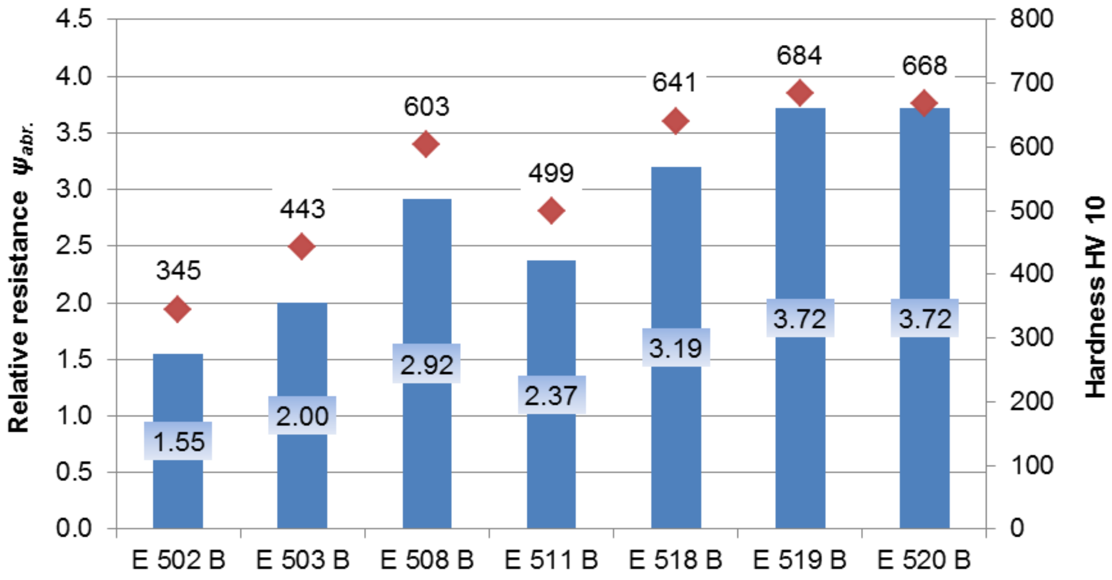

Figure 4: Obtained values of relative abrasive wear resistance $\Psi_{abr.}$ and hardness HV10 of electrodes, three-layer weld

According to the results of this test, it is possible to state that with increasing of weld hardness, we have also reached increased values of relative wear resistance. By this we confirmed that hardness as a mechanical characteristic of material positively influences the wear resistance. However, we must not forget that not only hardness is crucial in determination of abrasive wear but also the structure of welding metal.

Kalincová and Kuśmierczak (2011) claim that the structure of weld metal is influenced not only by the quality and characteristics of additional material but also by surfacing technology and process parameters. Kalincová (2012) states that the final structure of material is also affected by the heat treatment of steel, such as annealing and quenching.

Measured hardness values did not correspond to values presented by the manufacturer. The reason of this discrepancy can be caused by interfusion of weld metal into basic material. Manufacturers do not consider this alternative. When creating multi-layer welds, there is an assumption of creating a weld with a minimal content of base material.

Viňáš and Brezinová (2009) observed wear resistance of basic electrodes E-511B, E-518B and EW11 in field conditions (ploughshare – soil) and in laboratory conditions (corundum and stone chippings). One-layer and two-layer welds were used, and results did confirm elevated abrasive wear resistance of functional surfaces. Viňáš (2011) tested the same type of electrode in a powder abrasive environment on a laboratory device as well as on dipper teeth in field conditions. Both experiments confirmed the suitability of electrodes in terms of abrasive wear due to a higher content of hard carbide particles.

Votava et al. (2005, 2007) determined the relative wear resistance not only on grinding fabric but also in a field test when observing the wear of ploughshares in soil conditions. They tested soft annealed, normalized, hardened and quenched steel of grade 14 026.3. The structures of the steel thermally treated in this way were ferrite plus spheroidal pearlite, ferrite plus lamellar pearlite, sorbite, martensite. Relative abrasive wear resistance reached the value $\Psi_{abr.}$=1.1÷1.9. Furthermore, Votava (2012) states that the best resistance to corrosion is presented by surfaces with a higher share of Cr.

Kovaříková (2007) declares that today's welding materials are based on alloying Cr and C, by which welds obtain a large number of Cr carbides and therefore higher abrasive wear resistance.

We have used the electrodes with an increased share of beneficial elements like Mn and Si. The electrode E-503B contained also an increased proportion of alloying elements Mo and V. The highest share of V was in the electrode E-502B, where it formed very stable carbides with high hardness. E-519B contained the element B. Each electrode had an increased share of Cr. For example, the electrodes E-518B, E-519B and E-520B contained up to 25–29 % of Cr. An increased proportion of Cr causes a significant increase in hardness and wear resistance.

All of the tested coated electrodes reached higher wear resistance. The best results we observed when using the E-518B, E-519B and E-520B electrodes. The mentioned electrodes reached the highest level of hardness, too. The use of other electrodes in operation is also possible; however, we have to consider their use in terms of the cost and life of created layers. Total life can be determined by field tests, e.g. by creating welds on ploughshares.

Conclusion

The tillage tool of an agricultural machine must be characterized by a high technical level and be able to deliver high quality work. To fulfil this requirement, the active surface of the tool must be wear resistant. Increasing the endurance and wear resistance of active surface can be achieved by applying additional material that creates by its chemical composition a material structure able to withstand abrasive wear.

According to the test results, we can confirm that the use of additional materials is an option to reduce the size of wear. However, we have to point out that this issue should be addressed as the contemporary development of wear resistant layer technologies makes available constantly newer additional materials.

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