HARDFACING ELECTRODES RESISTANCE IN LABORATORY CONDITIONS

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Abstract
The article describes abrasive wear resistance determination of selected electrodes. Produced welds has been tested in laboratory conditions for hardness and relative resistance according to the standard (ČSN 01 5084). Achieved results confirmed the increase of welds abrasive wear resistance. Selected electrodes are suitable for a creation of abrasion resistant layers, which can lead to extension of working life cycle of agricultural machinery.

Key words: *tribology; abrasive wear; relative resistance; filler materials.*

INTRODUCTION

The area of the functional parts of agricultural machinery life extension is always up to date. Latest researches results allow solve this problem by application of expensive materials and technologies. Working parts of the machines in agricultural production are subjected to the intensive wear, particularly due to presence of abrasive particles in soil. During the motion of the active parts in the soil, the metal is heavily worn and thereby rapidly changing tool dimension and reducing its life. Improving of the working life cycle of machinery is related to the abrasive wear principles research in laboratory and/or operating conditions.

There are various possibilities of solving this problem in maintenance practice now. A modern solution is to produce active parts using new wear resistant materials (*Votava, & Kumbár, 2014; Bednár et al., 2013*). The main advantage is simple replacement of worn part by new one. Abrasive resistance can be also achieved by mechanical and heat treatment or chemical heat treatment (*Kováč et al., 2014; Mikuš et al., 2012)*. The solution with a future is the creation of abrasive resistant layer on the surface of active parts by harfacing (*Šoška et al., 2014; Müller et al., 2018)*.

A success of the creation the wear resistant layer depends not only on the quality and properties of used materials, but on the type of the application technology as well. Higher hardness and wear resistance, improved fatigue strength and corrosion resistance increase can be achieved by selection of proper material and technology.

The aim of this article is to assess the resistance of selected hardfacing materials to abrasive wear. For comparison we will use two electrodes applicable in agricultural industry with a focus on extending the working life of machinery parts. The difference between electrodes will be in the directional chemical composition. We assume that by increasing the carbon & chromium content it possible to reach a very hard surface already with the first layer. We determine the resistance of used weld deposits by testing in laboratory conditions with measuring hardness & determining the relative wear resistance.

MATERIALS AND METHODS

The abrasive resistance of filler materials is determined using electrodes of WELCO Ltd., Uherský Brod. They are used in renovation to get hardfaced surfaces for small & middle-sized businesses. The hardfacing process was carried out using a common welding supply according the manufacturer recommended technological process.

Short characteristics of selected materials declared by the manufacturer:

- Welco 1701s designed on chromium-carbide basis is used for abrasive wear at moderate impact stress. In comparison to similar types of electrodes, it is characterized mainly by improved control of the weld pool. The deposit is flat with easily removable slag. It is suitable for worn machinery parts used in the coal, earth, gravel, sand mining, for hardfacing welds of dredges, conveyor screws and machine parts with operation temperature up to 200° C.

- Welco 1707s is universal hardfacing electrode. It is applicable for the tools from steel, cast steels and hard Mn-steels worn due to simultaneous shock, pressure and abrasion wear. An application is easy with well removable slag, with very small spraying, no undercuts and with yield of 120%. It is suitable for worn parts of excavators, cylinders, chains, constructions and road machinery and cold cutting tools.

Table 1 describes the chemical composition of additive materials and hardness defined by manufacturer HV30. The hardness of HV30 has been achieved with the welding of first layer.

Tab. 1 Indicative chemical composition of electrodes and hardness HV30

Material	C	Mn	Si	Cr	Mo	V	Nb	W	Fe	Hardness HV30
Welco 1701s	4.3	1.3	-	38	0.8	0.5	0.03	1.3	rest	650-700
Welco 1707s	0.4	0.3	0.8	8	1	0.6	-	-	rest	515-690

Wear resistance and HV30 hardness has been determined in the laboratory of the Department of Quality and Engineering Technologies FE SUA in Nitra. The test instrument has been calibrated and meets relevant standards requirements as well. The hardness test has been carried out according to the standard STN EN ISO 6507 – Vickers hardness test. The penetrating pin is a diamond pyramid with a load of 294 N. To determine the wear resistance standard ČSN 01 5084 – Determination of abrasion resistance of metal materials on abrasive cloth has been used. The standard describes the procedure which has been followed. During the test, weight loss of both welded and standard samples have been measured. Standard test material for comparison has been steel 12014.20 with hardness range HV=95÷105.
As an assessment criterion abrasive wear relative resistance ($\Psi_{abr.}$) has been defined:

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

W_{hE} stands for average weight loss of standard (g), W_h stands for average weight loss of test materials (g).

RESULTS AND DISCUSSION

Evaluation criteria (relative resistance and hardness) are evaluated for one-, two- and three-layer deposits. All results obtained are average values of the measured samples. Table 2 shows measured values for weight loss and HV30 hardness measurements. Figure 1 shows the wear resistance.

Tab. 2 Values of measuring weight loss and hardness HV30

Material	Weight loss			Hardness HV30		
	1st layer	2nd layer	3rd layer	1st layer	2nd layer	3rd layer
Welco 1701s	0.1682	0.1404	0.1069	640	711	785
Welco 1707s	0.2133	0.1940	0.1801	500	577	679
Standard	0.3614			104		

Based on the results obtained, we do conclude that increase of the hardness means higher relative wear resistance. Increase of relative resistance leads to the cut of material loss and it results in improved life cycle of the parts of the machines. This relation has been achieved with both filler materials and with multiple deposit layers as well. Higher resistance to abrasive wear was observed for Welco 1701s electrode.
Increasing wear resistance can also be achieved by using tool steels. The authors *Votava, & Kumbár, 2014; Bednár et al., 2013* achieved the relative resistance in the range of $\psi_{abr.}$ = 1.91 ÷ 2.75.

They have proven their value in practice in laboratory and operational tests. The relation of increased hardness and improved increases wear resistance has also been confirmed by other authors (*Ťavodová et al., 2018; Votava, 2014; Pauliček et al., 2014*) in their research.

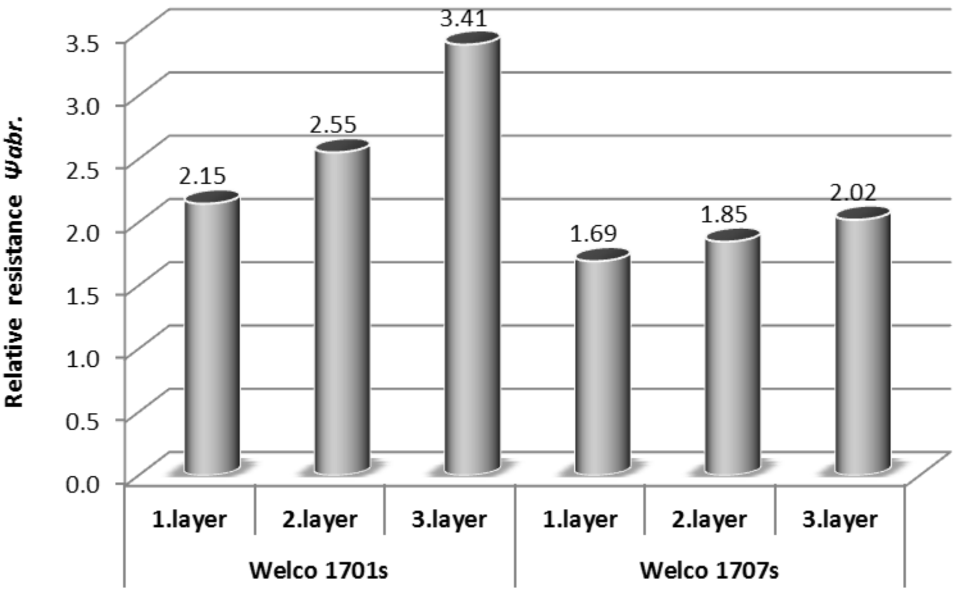

Fig. 1 Graphical representation of wear resistance $\Psi_{abr.}$.

Favourable results of deposit wear resistance can be achieved in testing of filler and powder materials in operation conditions (*Kováč et al., 2014; Mikuš et al., 2012; Müller et al., 2018*). These authors confirm the suitability for the application of such weld deposits on ploughs. Hardfacing deposits created on chisels (*Čičo & Bujna*, 2009; *Čičo & Bujna*, 2011) achieved reduced wear compared to the non-welded ones as well.

The wear resistant layer can also be created by chemical-heat treatment, e.g. with boron saturation. The authors (*Kováč et al., 2013*) state that increase in hardness and relative wear resistance in the range of $\psi_{abr.} = 1.2 \div 1.7$ can be obtained by controlling the diffusion processes. For wear resistance and hardness, it is necessary to ensure that the base metal matrix contains chromium carbides (*Vináš et al., 2013*). Laser application of powder filler material (*Kovaříková et al., 2011*) allow to achieve relative resistance $\psi_{abr.} = 3.2 \div 5.1$.

The Welco 1701s electrode contains significantly increased chromium content. Compared to the Welco 1707s electrode the content of carbon is increased and the electrode has a small fraction of niobium with tungsten. Chromium with carbon produces carbides increasing wear resistance. The hardness values obtained confirmed the influence of alloying elements on wear resistance increase. The hardness also increased with the number of layers, resulting from less mixing of the electrode material with the base materials.

The results of the tests showed that with increasing volume (number of layers) of the weld deposits, the relative resistance to abrasive wear increases. Wear of functional parts should be avoided in order to achieve proper operation of the functional parts. Wear reduction can be achieved by forming abrasion-resistant layers. The electrodes used meet the criteria for choosing lower weight-loss in abrasive wear.

CONCLUSIONS

The low life of the functional parts of the soil tillage machines requires new deposit alloy materials. Assessing the results of relative abrasion resistance and hardness of the tested materials, it is possible to conclude on the suitability of using the materials in soil conditions. However, we must not forget the impact of chemical effects of the soil on the machine functional parts.

For real application of electrodes it is also necessary to carry out operational tests, which also take into account the influence of real soil factors. We assume their decisive importance in the proper selection of wear resistant materials for specific soil conditions. It is necessary to comprehensively assess the service life of parts of agricultural machinery in the view of mechanical and chemical model of the wear.

The paper deals with the determination of abrasive wear resistance of selected electrodes. We have created deposits using filler materials that are commonly available at the market. Their advantage is the use of simple manual metal arc welding. Based on our results and in comparison with other authors we clearly state the suitability of the use of surfacing in abrasive wear conditions. The tested electrodes are suitable for use in practice in order to form abrasion-resistant layers. With the given electrodes we can increase the service life of some agricultural machines.

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REFERENCES

1. Bednár, R., Votava, J., Cervinka, & J., Fajman, M. (2013). Suitability of technical materials for machinery subsoilers for soil tillage. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 61*(2), 9-16.
2. Čičo, P. & Bujna, M. (2011). *Odolnosť tvrdonávarových materiálov v prevádzkových podmienkach* (monography), 119 p. SUA Nitra.
3. Čičo, P. & Bujna, M. (2009). Technical life of undermine chisels renovated of the hard surfacing. *Manufacturing engineering, 8*(4), 41-42.
4. Kotus, M., Pauliček, T., & Holota, T. (2013). Resistance of coated electrodes suitable for renovation of tillage tools. *Journal of Central European Agriculture, 14*(4), 1295-1302.
5. Kovaříková, I., Šimeková, B., Hodúlová, E., & Ulrich, K. (2011). Properties of composite wear resistant layers created by laser beam. *Annals of DAAAM and Proceedings of DAAAM Symposium, 22*(1). 1193-1194.
6. Kováč, I., Mikuš, R., Drlička, R., & Žitňanský, J. (2013). Boron effect on mechanical properties and structure of steel STN 41 5230 surface layer. *Materials, technologies and quality assurance*, *801*, 123-129.
7. Kováč, I., Vanko, N., & Vysočanská, M. (2014). Verification of the working life of a ploughshare renovated by surfacing and remelting in the operation. *Research in Agricultural Engineering, 60,* 98-103.
8. Mikuš, R., Kováč, I., Drlička, R., & Hudec, D. (2012). Tribological properties of duble layered hardfacing materials. In *Quality and Reliability of Technical System* (pp. 155-160). SUA Nitra.
9. Müller, M., Novák, P., Chotěborský, R., & Hrabě, P. (2018). Reduction of ploughshare wear by means of carbide overlay. *Manufacturing Technology, 18*(1), 72-78.
10. Pauliček, T., Votava, J., & Kotus, M. (2014). Abrasive resistance of filler metals in laboratory condi-tions. *Journal of Central European Agriculture, 15*(1), 208-213.
11. Ťavodová, M., Kalincová, D., & Slováková, I. (2018). Evaluation of some parameters of hard surfacing treatment of the functional surfaces of forestry tools. *Management Systems in Production Engineering, 26*(4), 222-226.
12. Viňáš, J., Brezinová, J., Guzanová, A., & Svetlík, J. (2013). Degradation of renovation layers deposited on continuous steel casting rollers by submerged arc welding. In *Proceedings of the Institution of Mechanical Engineers, 227*(12), 1841-1848.
13. Votava, J. (2014). Usage of abrasion-resistant materials in agriculture. *Journal of Central European Agriculture, 15*(2), 119-128.
14. Votava, J. & Kumbár, V. (2014). Use of tool st eels in soil processing to increase sugar beet production. *Listy Cukrovarnické a Řepařské, 130*(9-10), 292-296.

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