Analysis of wear resistent weld materials in laboratory conditions

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Abstract

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The aim of the study was the evaluation of the suitability of using filler surfacing materials in abrasion resistant layers according to their material and tribology features. Laboratory analysis of the selected materials consisted of the tests of hardness, microstructure and wear resistance determination. The abrasive wear resistance was defined according to the standard STN 01 5084. On the basis of the results obtained, we can state that using the hard-facing for the background is tenable for the purpose of wear amount decrement where the abrasive wear prevails.

Keywords: abrasive wear; relative resistance; laboratory analysis; abrasion resistant layers; Fluxofilcord 58; Fluxofilcord 59

Material properties can be evaluated from the point of view of abrasive wear resistance by tests in laboratory conditions and on the basis of the results obtained in tests in operational conditions. Common methods of wear amount testing allow determining the relative material wear resistance by several quantitative methods (Kotus, Drahoš 2010).

One of the tribological test methods is the determination of the metal material abrasive wear resistance on a device with grinding fabric according to the standard STN 01 5084 (1973). Relative abrasive wear resistance ($\psi_{abr.}$) is an elemental criterion for the material evaluation in laboratory conditions (Balla 1989).

On the basis of the indicators defined (hardness, microstructure) in laboratory conditions, we can evaluate also the suitability of filler materials for forming abrasion resistant layers, which are abrasive wear resistant (Kotus 2009).

On the basis of the laboratory analysis, the object of this study was the evaluation of mechanical properties of filler materials Fluxofilcord 58 and Fluxofilcord 59 (Air Liquide Welding, Lužianky, Slovak Republic) suitability of their use in abrasion resistant layers formation. The formation of abrasion resistant layers by surfacing with filler materials is a possible way of resistance enhancement in functional machine parts.

MATERIAL AND METHODS

The analysis of the filler materials was done in the laboratories of the Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra. The test

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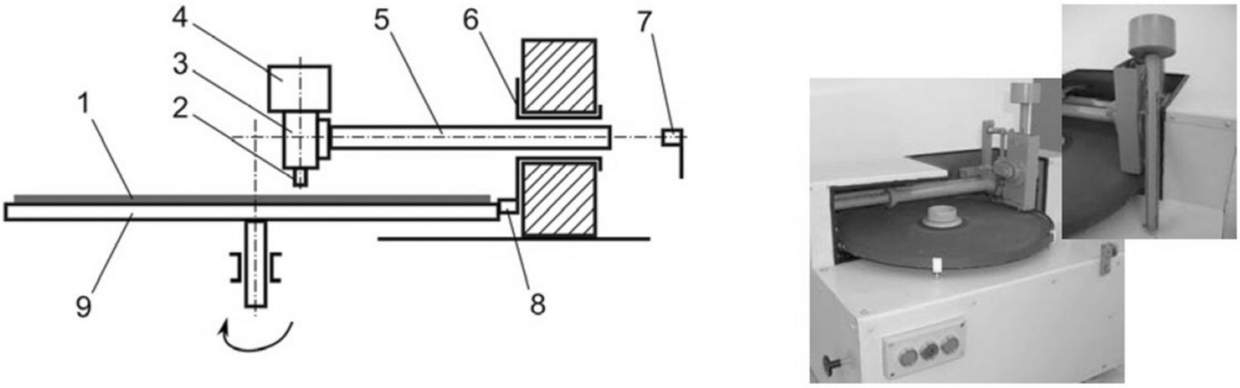

Fig. 1. Test device with grinding fabric
1 – grinding fabric, 2 – sample, 3 – holder, 4 – weight, 5 – moving screw, 6 – rotary matrix, 7 – limit switch, 8 – stopper, 9 – rotary horizontal panel

device (Fig. 1) for the determination of metal material abrasive wear resistance on the grinding fabric meets all conditions defined by the standard STN 01 5084 (1973).

The parameters of the samples, as well as the procedures and conditions which need to be met in the test for reproducible and comparable results, are given in the standard. The comparative sample tested according to the standard STN 41 2014 (1993) was steel 12014.20 with the range of hardness HV = 95 to 105. The weight loss with precision of 1×10^{-4} g was computed from the measured weights of the samples before and after the test. Minimum of four tested samples were obtained from each material. The comparative etalon sample was regularly alternated by the tested material in the order 1-2-1-2-1.

Abrasive wear relative resistance ($\psi_{abr.}$) was calculated by the following adapted equation:

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

where:

W_{hE} – average weight loss of etalon sample body (g)
W_h – average weight loss of samples of tested material (g)

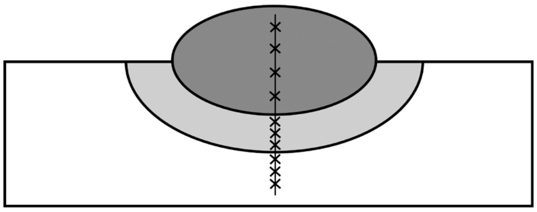

Fig. 2. Scheme of plane and location of hardness measurement HV 10: 4× surfacing metal (SM), 3× heat affected zone (HAZ), 3× parent material (PM)

The set parameters of the test device were the following:

- frictional speed – max. 0.5 m/s
- transverse feed per rev – 3 mm
- diameter of rotary panel – 480 mm
- length of frictional track – 50 m
- amount of contact pressure – 0.32 MPa
- grinding fabric – Globus 100
- sample length – 50 mm with diameter 10 mm

Vickers's method was used for the evaluation of the hardness measurement by crossing the parent material through the heat affected area into the surfacing metal. Vickers's test of hardness is given by the standard STN ISO 6507-1 (2006) using the load of 98 N, this means marking HV 10. The location punctures of the hardness measurement HV 10 are illustrated in Fig. 2. The location punctures were at the distance of 1.25 mm from the surface of the material in the surfacing metal. The distance of the location punctures was 0.50 mm in the heat affected zone as well as in the parent material.

The microstructure of the surfacing metal was evaluated on the basis of the image obtained by measuring chain consisting of microscope Epityp 2 (Carl Zeiss Jena GmbH, Jena, Germany), a camera and a computer. Filler materials Fluxofilcord 58 and Fluxofilcord 59 (ø 1.6 mm) are basic pipe wires for surfacing of resilient and abrasion resistant layers on machine parts. The surfacing metal shows high toughness and impact resistance. They are used for parts of the tools exposed to heavy abrasive wear such as components of dredgers, excavators, grabs, conveyors, drills, jaw crushers.

Chemical composition and hardness HV 10 (given by the producer) of surfacing filler materials are shown in Table 1.

Table 1. Initial chemical composition and hardness HV 10 of the filler materials

Surfacing material	Hardness HV 10	Elemental contents (%)					
		C	Mn	Ni	Cr	Mo	W
Fluxofilcord 58	615–655	0.5	1.5	–	5.5	0.6	–
Fluxofilcord 59	596–675	0.4	1.0	1.0	5.0	0.8	2.0

Table 2. Average values of material weight loss in tests on grinding fabric

Material	Weight loss (g)	Standard deviation (g)	Relative wear resistance ($\Psi_{abr.}$)	Standard deviation (g)
Fluxofilcord 58	0.1783	0.007597	2.10	0.110799
Fluxofilcord 59	0.1698	0.005808	2.21	0.092966
Etalon 12 014.20	0.3750	0.005199	1	–

Welding power source Optipuls 500i W (Air Liquide Welding, Lužianky, Slovak Republic) with stepless welding current and voltage was used for surfacing the samples. MIG surfacing was used as a method of filler material application on the parent material in protective atmosphere of mixed gas [MIG – GMAW – marking 131 according to ČSN EN ISO 4063 (2011)]. The following are the parameters of surfacing: welding voltage $U = 26$ V, welding current $I = 133$ A, welding speed 0.30 m/min, wire feed speed 2.0 m/min, shielding gas Ferroline C18 (Messer Tatragas, Šaľa, Slovak Republic) in the amount of 12 l/min.

RESULTS AND DISCUSSION

The weight values measured before and after the test as well as the calculated weight loss and relative wear resistance are shown in Table 2. Graphical evaluation is given in Fig. 3.

The measured values of the hardness of the parent material, heat affected area and surfacing metal are shown in Table 3. Graphical evaluation is given in Fig. 4.

The microstructure reached of the filler materials used is shown in Fig. 5.

The evaluation of the relative abrasive wear resistance shows a greater wear with the hard-facing Fluxofilcord 58. A lower weight loss and thus a lower wear by about 5% were reached with the filler material Fluxofilcord 59.

The wear resistance is not an internal property of the material like e.g. some of its mechanical or physical properties. The comparison of the material hardness and relative resistance shows that the relative resistance increases by the increments of hardness and thus the amount of wear decreases.

The values of hardness of the net overlay corresponded to those specified by the manufacturer of both used filler materials. The surfacing metal hardness decreases towards the parent material

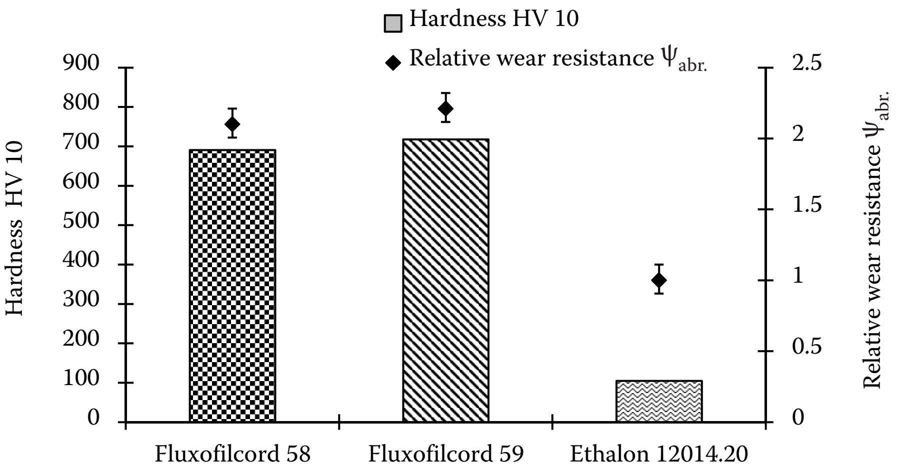

Fig. 3. Hardness HV 10 and relative wear resistance of the materials tested

Table 3. Average values of hardness HV 10 of the materials tested

Material/Hardness HV 10	Surfacing metal				Heat affected area			Parent material		
	1	2	3	4	5	6	7	8	9	10
Fluxofilcord 58	691	670	630	604	340	291	268	195	205	218
Fluxofilcord 59	718	689	702	673	327	284	270	233	214	199

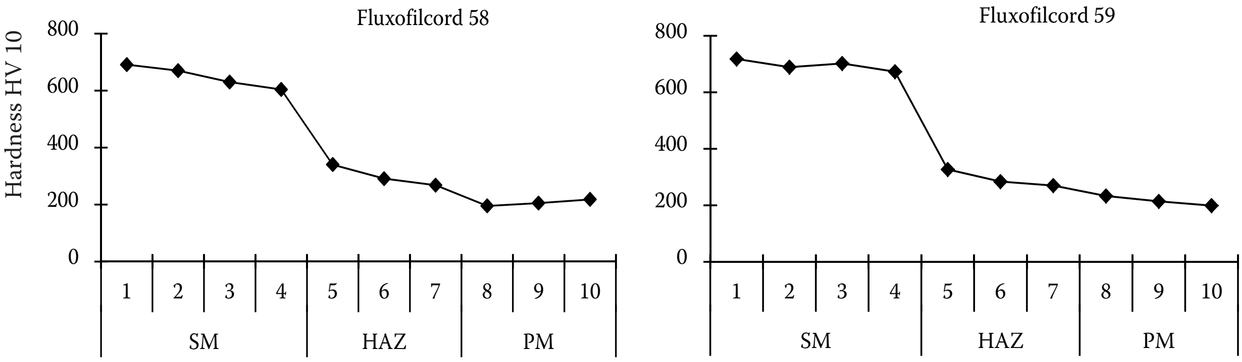

Fig. 4. Behaviour of hardness HV 10 of the materials tested
SM – surfacing metal, HAZ – heat affected zone , PM – parent material

as shown by gradual measurement of hardness. Fluxofilcord 58 caused a more significant decrease of hardness than Fluxofilcorde 59. The difference of the hardness reduction of Fluxofilcord 58 was 87 HV 10 and of Fluxofilcord 59 only 45 HV 10, which is double value.

The comparison of the heat affected area showed lower values of hardness with the material Fluxofilcord 59. The decrease of the hardness values was less significant with this material compared with the parent material. It may have been caused by mixing of the surfacing metal with the parent material. A decrease of hardness was noted also in the final structure of the overlay, which confirmed more significant mixing of the parent material with the surfacing material Fluxofilcord 58.

The most important element, which gives hardness to the material, is carbon. The critical speed of cooling for the creation of martensitic structure decreases by increasing the carbon content. In the terms of the basic effect of elements on the microstructure and properties of an alloy, those creating special carbides such as e.g. Mn, Cr, Mo, are of greater importance. Fluxofilcord 59 contains more wolfram that increases the hardness and abrasion resistance. Apart from wolfram it also contains nickel that does not create carbide, is soluble in the basic matrix and increases the corrosion resistance.

Filler material Fluxofilcord 58 has a fine, pouring structure with a thick netting carbide phase. Segregation of the new phase in space between dendrite was noted with some samples. Filler ma-

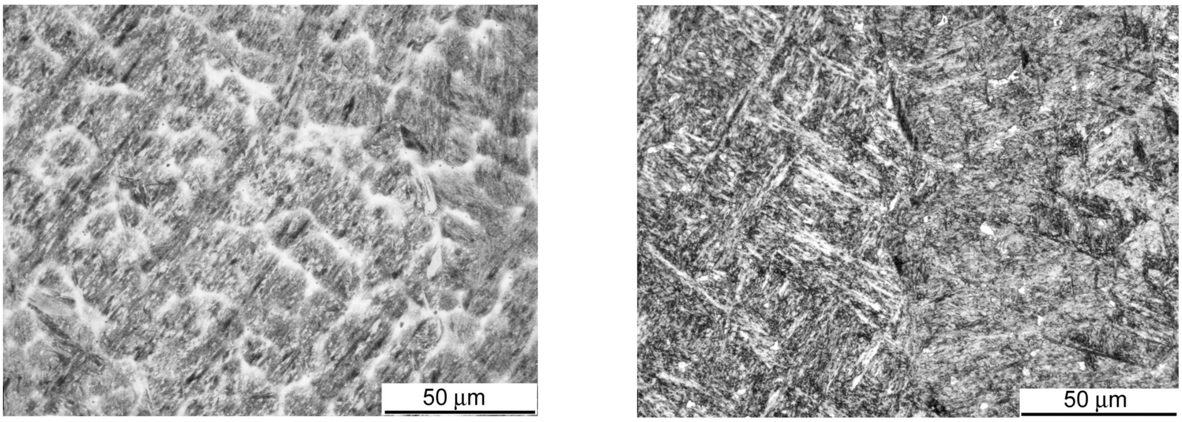

Fig. 5. Microstructure of the filler materials Fluxofilcord 58 (left) and Fluxofilcord 59 (right)

terial Fluxofilcord 59 has a pouring structure with a significantly lower amount of carbide netting. A fine acicular martensitic structure with a combination of primary and secondary carbide accretion is mostly observed here.

The results obtained suggest that the relative wear resistance increases with increasing hardness of the materials tested in defined conditions. However, hardness is not always the decisive factor that affects the wear resistance at the most. An important factor of the wear resistance is also the microstructure of the concrete overlay.

CONCLUSION

The lifetime of agricultural machines is significantly affected by the lifetime of the functional parts of the working tools, which are constantly worn out during the operation e.g. skives, shares, under-slinging skives, seeding base, etc. Their wear and tear adversely affects the quality of the work performance and energy consumption of the machine (Kotus 2007).

Soil as the abrasive background causes an intensive wear and tear by its specific properties and therefore decreases the lifetime of the functional parts of agricultural machines. The application of suitable hardfacing materials on the working surfaces of tools prolongs their lifetime (Hrabě, Chotěborský 2005).

On the basis of the tests carried out, we can state the suitability of the use of selected filler materials, which are resistant in conditions of abrasive wear.

The abrasion resistant materials can be one of the possibilities for surfacing when the wear and tear reduction is to be achieved.

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