THE EXTENSION OF THE LIFE OF COMBINED CULTIVATOR TEETH

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Abstract. The working elements of agricultural machines for the treatment of soil are exposed to the intensive wear during a run. It is possible to decrease the level of wear by using the proper technology. In this work, we concentrated on the possibility of increasing the wear resistance of surfacing. We tested the resistance of two kinds of surfacing materials in an operational test and compared them with the wear of the basic, untreated material. The comparison was carried out on the basis of lineal proportions and component weight measurements taken before and after the operational test and on laboratory tests of the hardness and metallography. The operational test was conducted on the teeth of a combined cultivator for pre-sowing soil preparation after ploughing or stubble ploughing.

Key words: renovation, surfacing, wear, operation tests, metallography

Introduction

Extending the life of the functional parts of soil treating machines is a crucial aspect of agricultural production.

The frequent replacement of worn-out tools in the agricultural machines leads to increased downtime of the machine in question and reduced efficiency, while rising repair costs mean that the economic efficiency of agricultural production declines.

The main cause of component functionality loss during the soil treatment is abrasive wear. However, it is possible to avoid this by the use of preventive surfacing on the new tools of agricultural machines, which are the most frequently manufactured using less wear-resistant materials. Heat treatment is most often used to prolong tool life, but this is has no capacity to prevent wear in a heavily abrasive environment.

With surfacing, a surface layer with special properties is acquired; these include high surface hardness, abrasion resistance and chemical resistance. Achieving the desired results iscontingent on the appropriate choice of additional material and the correct surfacing technology.

The functional parts of machines for pre-sow soil preparation number among the argricultural machine parts which are exposed to heavy, abrasive wear. This article aims to highlight the possibilities of extending the life the teeth of combined cultivators for pre-sow soil preparation by means of hard-surfacing material surfacing.

Material and Methods

For the operational tests, 10 teeth of the K 450 PS combined cultivator used for pre-sow soil preparation after ploughing or stubble ploughing were used.

Two types of surfacing electrodes, FIDUR 10/60 and FIDUR 4/60 were used for the surfacing.

Electrode FIDUR 10/60 characteristics:

This is a high-duty surfacing electrode for high abrasive-resistant surfacing, especially for high abrasive wear under humidity, such as, for example, excavators, and mixer blades. The surface has a maximum of two layers. Weld rust resistant ledeburitic metal can only be finished by cutting. The hardness, as stated by the manufacturer, is 57-60 HRC.

Table 1. Chemical composition of FIDUR 10/60 surfacing material

Element	C	Si	Mn	Cr
Percentage	3.8%	0.9%	0.4%	33%

Electrode FIDUR 4/60 characteristics:

This electrode is used for hard, high ductility abrasion-resistant surfacing. It is suitable for the armouring of the shear edges on low-alloyed steel tools, as well as for the repair of tools which work at high speed. The welded metal is extra-heavy, abrasive wear-resistant and impact-resistant. The hardness, as stated by the manufacturer, is 59-62 HRC.

Table 2. Chemical composition of FIDUR 4/60 surfacing material

Element	C	Si	Mn	Cr	Mo	W	V
Percentage	0,9%	0,3%	0,5%	4,5%	8,0%	2,0%	1,5%

The surfacings were applied in one layer, by hand, with an AW 200 thyristor welding machine. For two surfaces of one tooth, five electrodes with a diameter of d = 2,5 mm were necessary.

In total, six teeth were surfaced, three of them using the first type of weld material and the other three using the second type.

Surfacing was applied on the front side of two teeth and the rear side of one tooth from each set. By positioning the surfacing we were able to observe not only the weld materials' resistance, but also the self-sharpening effect developed by the gradual wear of the teeth.

The analysis covered both surfaced teeth and non-surfaced teeth; the latter were manufacturer's originals and served as a measurement standard. Before the operational tests, the linear dimensions and weights of the surfaced and non-surfaced teeth were measured.

Soil and research conditions:
- brown soil,
- humidity 14%,
- soil quality class: 15 and 16,
- operating width: 4500 mm,
- coulters' arrangement in the first row: 41 cm,
- machinery type: cultivation machine,
- coulter width: 300 mm.

Results and Discussion

Preparation of the teeth was carried out in the KKaST laboratories. The hardness, in accordance with Rockwell, was measured, as were the linear dimensions after surfacing, the weight of the teeth before and after surfacing and the microstructure of the surfacing after the operational tests.

Teeth 1,3 and 5 were surfaced using the FIDUR 10/60 material and teeth 6,8 and 10 using the FIDUR 4/60 material. Teeth 2,4,7,9 were left without surfacing.

The teeth were used in the operational tests, after which, they were measured and evaluated. 380 ha of soil were treated. None of the teeth required replacement during the operational tests. The measurement results were converted into tables and graphs which visually demonstrate the tooth wear under the operational conditions. Tooth width and width loss are noticed at the most exposed tooth part, which is to say, at the edge.

Table 3. Tooth width before and after the test; width loss

Tooth number Material	Original Width [mm]	Post-Test Width [mm]	Width Loss [mm]
1/ 10-60	156,6	150,40	6.20
2 et.	156,3	133,00	23.30
3/ 10-60	157,8	142,50	15.30
4 et.	157,4	109,50	47.90
5 /10-60	156,5	132,30	24.20
6 / 4-60	158,1	130,60	27.50
7 et.	156,1	118,00	38.10
8 / 4-60	157	135,20	21.80
9 et.	158,6	132,20	26.40
10/ 4-60	158,6	140,50	18.10

Table 4. Tooth weight before and after the test; weight loss

Tooth number	Original weight[kg]	Post-Test Weight [kg]	Weight loss [kg]
1	1.07	0.929	0.141
2	1.02	0.742	0.278
3	1.08	0.890	0.190
4	1.01	0.597	0.413
5	1.08	0.850	0.230
6	1.07	0.820	0.250
7	0.98	0.646	0.334
8	1.05	0.856	0.194
9	1.00	0.730	0.270
10	1.08	0.910	0.170

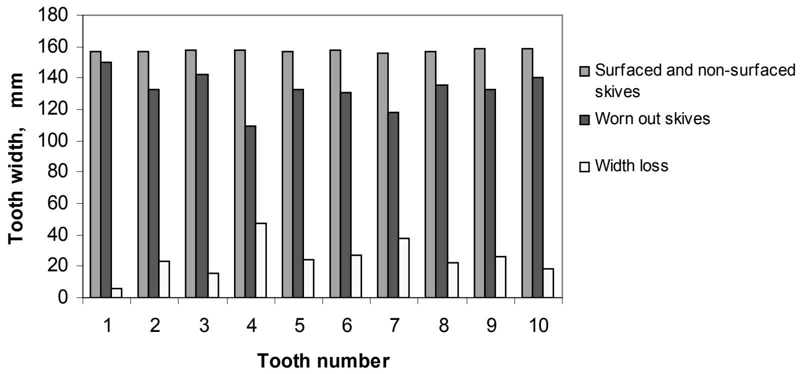

Fig. 1. Tooth width before and after the operational test; width loss

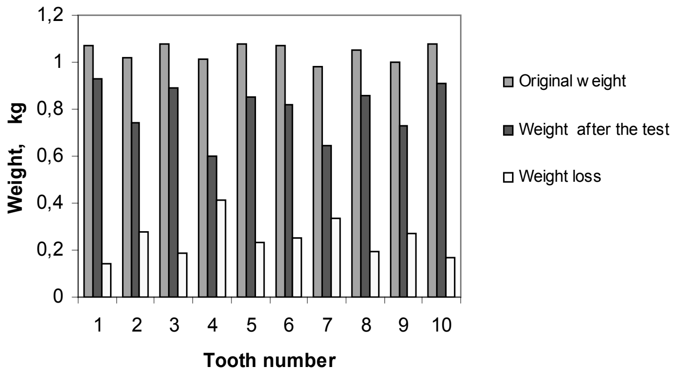

Fig. 2. Tooth weight before and after the operational test; weight loss

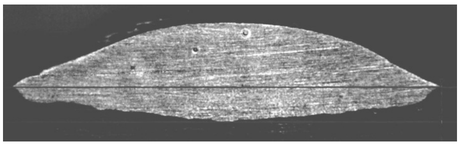

Fig. 3. Surfacing profile of the FIDUR 4/60 material

Fig. 4. Surfacing profile of the FIDUR 10/60 material

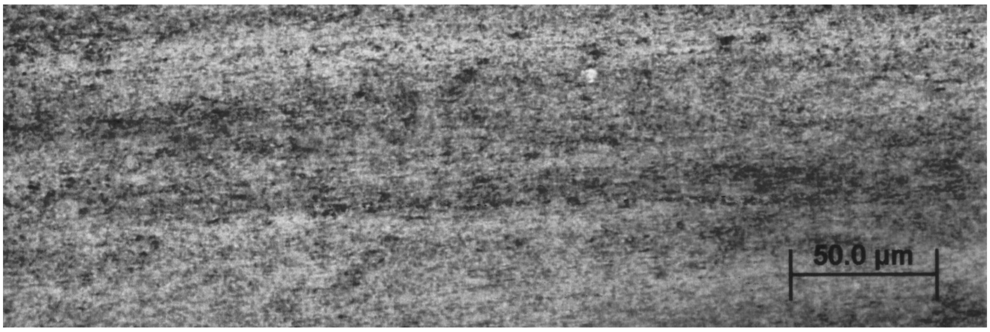

Fig. 5. FIDUR 4/60 surfacing material structure

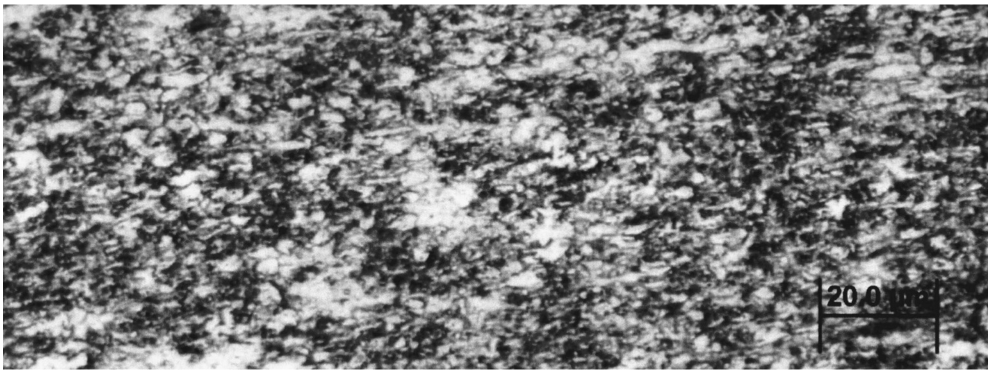

Fig. 6. FIDUR 10/60 surfacing material structure

From the results of the operational test it is obvious that the surfaced teeth show less wear in terms of both linear dimensions and weight than the non-surfaced teeth. The linear losses for the FIDUR 10/60 material represent 57.8 % and those for FIDUR 4/60, 63.2%. The weight loss ratio is approximately the same. The comparison of the two surfacing materials suggests that the FIDUR 10/60 material, which ademonstrates less wear, would seem to be the more suitable. The llower wear in this material was caused by the higher hardness of 725 HV, but we also suppose that it was primarily the structure of the material which reduced the intensity of wear. For FIDUR 10/60, the surfacing metal is ledeburitic cast iron with a high Cr concentration, which created Cr carbides (Fig. 6) that formed clusters distributed evenly in the basic material. With FIDUR 4/60, we can see (Figure 5), that W carbides and fewer C carbides were created and that the structure is finer. The mixing of the additional material with the basic material also plays an important role. In Fig. 3 and 4, we can also see that the depth of the welding for FIDUR 10/60 is less than at FIDUR 4/60, which could also cause less mixing and, hence, the better resistance.

Examination of the teeth demonstrated that surfacing on the front side is preferable, owing to the self-sharpening effect during operation. The teeth with the surfacing on the front side attained better sharpness. This, in turn, has an impact on better soil undercutting, as well as the destruction of plant residues in the soil.

Summary

1. The measurement results acquired are a contribution to, and, at the same time, an indication of, the possibility of increasing the abrasive wear-resistance of tools of soil treating machines.
2. Increasing the resistance of the functional parts of machines decreases repair costs and increases work quality, a factors in pre-sowing soil preparation in order to reach the required yield.

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PRZEDŁUŻENIE ŻYCIA ZĘBÓW KULTYWATORA

Streszczenie. Elementy robocze uprawowych maszyn rolniczych są narażone na intensywne zużycie w czasie pracy. Możliwe jest zmniejszenie poziomu zużycia przy zastosowaniu odpowiedniej technologii. W pracy skoncentrowano się na możliwości zwiększenia odporności na zużycie dla nawierzchni. Przetestowano rezystancje dwóch rodzajów nawierzchni w badaniach eksploatacyjnych i porównano je ze zużyciem materiału (nawierzchni) podstawowego, nie obrabianego. Porównanie zostało zrealizowane w oparciu o pomiar proporcji i wagi elementów przed i po badaniach eksploatacyjnych oraz w trakcie testów laboratoryjnych twardości i metalografii.
Badania eksploatacyjne przeprowadzono na zębach kultywatora przeznaczonego do przygotowania gleby przed siewem lub po orce.

Słowa kluczowe: renowacja, nawierzchnia, zużycie, badania eksploatacyjne, metalografia

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