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# INFLUENCE OF PLOUGHSHARE SURFACE LAYERS ON PLOUGHING EFFICIENCY

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The paper presents comparison between standard ploughshares made of manganese steel 50Mn7 and the authors' ploughshares hardfaced with a layer of C-Co-Cr-Ni-Si on the same steel. The research was carried out by using two tractors with two four-furrow plough of the same power in a total of 360 working hours, and a total of 180 hours of ploughing with each ploughshare. Ploughshares were used to measure hardness, to analyse the structure and wear.

*Key words:* alloy steel, ploughing, surface layer, wear, efficiency

## INTRODUCTION

Parts of ploughs, especially the ploughshares are exposed to wear during service. Those parts are worn because of the abrasive action of the soil particles, which depends on the soil moisture and composition [1, 2]. Ploughshares are less worn if used on moist clay and loam soils and if used on moist sandy soil, then the wear of ploughshares is greater [3]. During service, the first to become blunt is a ploughshare tip and then the blade [4, 5]. Also, the intensity of the ploughshare wear is increased along with the increase of sand content in the soil [6, 7, 8]. Because of the wear and bluntness, ploughshares need to be replaced with new ones, thus causing delays in service, increasing costs and lowering the efficiency of a tractor. Possible solution to this problem is in surfacing of ploughshares with a protective layer. The research aim is to determine the efficiency of ploughing by using standard and protected ploughshares.

## PLOUGHSHARE MATERIAL AND RESEARCH METHODS

The research was carried out by using two 4 WD tractors, both of 129 kW, and two reversible four-furrow ploughs of 120 cm working width. In order to study the resistance to wear during ploughing, the following ploughshares were used:

1. Standard non-surfaced ploughshares, made of manganese steel 50Mn7, specimens marked as „A",
2. Ploughshares made by authors, with protective layer of C-Cr-Co-Ni-Si hardfaced on the manganese steel 50Mn7, specimens marked as „B".

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### Material and preparation of specimens

Chemical analysis was performed on base materials of ploughshares. Composition of both steels matches the declared 50Mn7. The ploughshare tip is mostly exposed to wear during ploughing [6]. Furthermore, the ploughshare blade is also exposed to wear. In this research, the ploughshare tip was manually welded by C-Cr-Co-Ni-Si electrode by arc welding method, and a blade was protected by inductive melting of powder C-Cr-Co-Ni-Si, of declared composition ≈ (3,3 % C; 1,5 % Si; 24,3 % Cr; 3,1 % Ni and 3,2 % Co). The Figure 1 presents characteristic ploughshare dimensions. For this research, the authors obtained two sets of ploughshares, i.e. 8 ploughshares for each plough. One set of standard ploughshares (marked „A") was bought, and the other set of ploughshares marked „B" was made by the authors by surfacing the standard ones with filler material.

Before arc welding, the surface was brushed and degreased, and before inductive welding, it was milled prior to hardfacing. Ploughshares were welded inductively by using metallic powder, and arc welding was performed by using an electrode of ø 4,5 mm. The thickness of the filler material layer was approximately 3 mm. Inductive welding was used as it could provide uniformly distributed layer, of uniform thickness, as

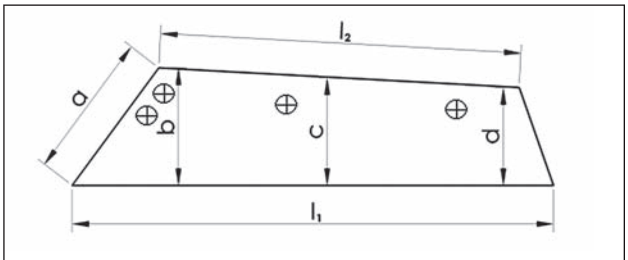
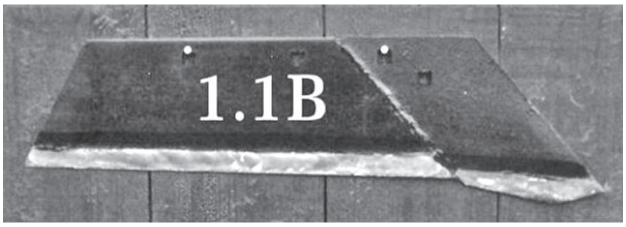



**Figure 1** Dimensional characteristics of a ploughshare (a - length; b – height of front part; c – height of middle part; d – height of back part; $l_1$ – length of back part; $l_2$ – length of upper part)


a)




b)

**Figure 2** Ploughshares before ploughing
a) standard „A"; b) hardfaced „B"

well as because of its speed of hardfacing at such large surfaces (over 500 mm long).

Average surface hardness of standard ploughshares „A" was 44 HRC, while the hardfaced ploughshares „B" had average hardness of about 46 HRC. Characteristic appearance of standard ploughshares „A" and the authors' hardfaced ploughshares „B" is presented in the Figure 2.

## RESEARCH RESULTS

Characteristic structure of original ploughshares is presented on the Figure 3a, and the structure of ploughshares with protective layer of filler material C-Cr-Co-Ni-Si is shown in the Figure 3c. After ploughing, surfaces were examined and characteristic traces of wear were recorded. Characteristic traces of wear of standard ploughshares are shown in the Figure 3b, and the wear of hardfaced ploughshares is presented in the Figure 3d.

Diagrams in the Figure 4 present the flow of hardness HV1 at the ploughshare cross-section: "A" - standard, curve a; "B" - hardfaced, curve b.

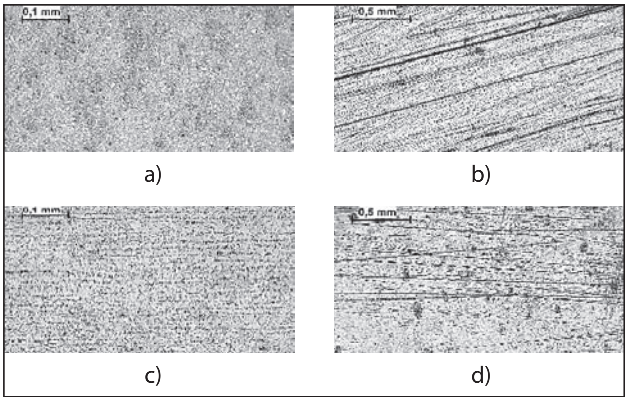



**Figure 3** Characteristic structures and traces of wear of ploughshare
a), b) standard ploughshares;
c), d) hardfaced ploughshares

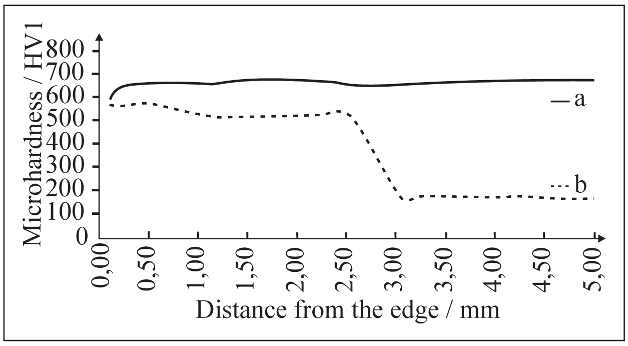



**Figure 4** Characteristic flow of hardness from the surface to the core of ploughshare
a) standard – curve a
b) hardfaced – curve b

The testing was performed on 15 agricultural plots with soil of silty-loam to silty-clay-loam texture [6]. Ploughing was done from 4 months. Average weight of standard ploughshares was about 3 930,00 g, and average weight of hardfaced ploughshares was about 4 330,00 g. The ploughshares were controlled for their weight reduce in three stages, i.e. after 120, 240 and 360 working hours. Since the research was performed on a reversible plough, each ploughshare was controlled after 60, 120 and 180 hours of service, Table 1.

Table 1 **Average weight reduce of standard and hardfaced ploughshares during service**

| Type of ploughshares | After 60 hours | |
|---|---|---|
| | Weight reduce | |
| | / g | / % |
| Standard „A" | 355 | 9,04 |
| Hardfaced „B" | 381,25 | 8,82 |
| Type of ploughshares | After 120 hours | |
| | Weight reduce | |
| | / g | / % |
| Standard „A" | 678,75 | 17,29 |
| Hardfaced „B" | 708,75 | 16,39 |
| Type of ploughshares | After 180 hours | |
| | Weight reduce | |
| | / g | / % |
| Standard „A" | 1 032,50 | 26,29 |
| Hardfaced „B" | 971,25 | 22,45 |

For all tests, the tractor speed was set at 7 km/h by an automatic transmission. The depth of ploughing was determined by a depth meter. The average depth of ploughing with standard ploughshares "A" was 29,1 cm, and with hardfaced ploughshares "B" it was 29,7 cm. In both cases, measurements were performed 30 times in three repetitions, i.e. 90 times. The efficiency of each tractor was based on the amount of fuel consumed per treated area (l/ha) and on the fuel consumption per hour (l/h), ploughed area and working hours of the tractor, Table 2.

## ANALYSIS OF RESULTS AND CONCLUSION

Structure of standard ploughshares is usually bainitic, while the hardfaced ploughshares contain Cr car-

Table 2 **Average fuel consumption**

| Standard ploughshares „A" | | | |
|---|---|---|---|
| Parameters | Working hours / h | | |
| | 120 | 240 | 360 |
| Amount of internal fuel / l | 3 491 | 3 208 | 3 023 |
| Treated area / ha | 119,2 | 110,2 | 101,8 |
| Working hours of tractor / h | 120 | 120 | 120 |
| Fuel consumption per area / l/ha | 29,3 | 29,1 | 29,7 |
| Tractor efficiency / ha/h | 0,99 | 0,92 | 0,85 |
| Hardfaced ploughshares „B" | | | |
| Parameters | Working hours / h | | |
| | 120 | 240 | 360 |
| Amount of internal fuel / l | 3 460 | 3 171 | 3 045 |
| Treated area / ha | 127,4 | 113,9 | 107,6 |
| Working hours of tractor / h | 120 | 120 | 120 |
| Fuel consumption per area / l/ha | 27,2 | 27,8 | 28,3 |
| Tractor efficiency / ha/h | 1,06 | 0,95 | 0,90 |

bides in their dendritic matrix. Wear of standard ploughshares is characterized by nearly parallel and continuous furrows, which occurred because of abrasive action, primarily of $SiO_2$ contained in soil. Surface of hardfaced ploughshares is characterized by furrows cut off at the point where abrasive particles (sand) met chromium carbides. Higher wear resistance of surfaced layers is assured by presence of Cr carbides, which are significantly harder than $SiO_2$ [9]. Average efficiency of the tractor during ploughing with different ploughshares „A" and „B" is shown in the Table 2. Hardfaced ploughshares „B" were used for ploughing at average depth of 29,7 cm, which was for 6 mm deeper than ploughing with standard ploughshares.

Greater tractor efficiency was achieved in ploughing with hardfaced ploughshares „B" (1,06 ha/h, 0,95 ha/h and 0,90 ha/h) than with standard ploughshares „A" (0,99 ha/h, 0,92 ha/h and 0,85 ha/h). In addition to better ploughing performance, longer service life of tillage machinery enables greater productivity. Furthermore, referring to fuel consumption (Table 2), there was 7 to 8 % less fuel needed when ploughing with hardfaced ploughshares. Based on these preliminary results, the advantage should be given to hardfaced ploughshares. Further research into influences of ploughshare surface layers shall determine the ratio of carbides in the toughest possible matrix to assure better service efficiency. Economic effects shall be also considered, as they include not only direct costs of new ploughshares and fuel, but also some indirect tribological "losses".

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