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Improvement of wear resistance of working elements from gray iron for development of the ground

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Abstract. The question of increasing the wear resistance and resource of working elements for the development of soil through the use of sound technological methods of manufacturing them from inexpensive materials is considered. Increased tribological characteristics of the working elements are achieved by optimally structuring them into functional areas, depending on the perceived loads and peculiarities of the working conditions. According to the results of research, a promising material for the manufacture of chisel plows bits - gray cast iron is proposed. Gray cast iron SCh 20 with a bleached layer on the working surface with a thickness of about 2 mm has higher tribological characteristics as compared to rolled steel, as well as technological and economic advantages in production due to the use of casting technologies.

1. Introduction
Severe conditions of operation of the working elements of tillage machines predetermine unacceptably low lifespan. Time to failure when limiting wear is reached for the most loaded parts, such as, for example, a chisel plow chisel, does not exceed 5-20 ha [1, 2]. High consumption rates of bits, labor costs for frequent replacement in field conditions, increased fuel consumption due to an increase in traction resistance at blunting the cutting edge of the bit [3] significantly increase the cost of processing of closed soil and aggravate the relevance of improving the reliability of these working elements.

To increase the wear resistance of bits made of mild steel, cladding with sormite alloys is used. However, the deposited layer is prone to cracking and flaking under the action of friction forces and high contact pressures [4].

Recently, recommendations have been made to carry out the wear surfaces of heavily loaded parts of soil-cultivating tools made of Hardox steel from SSAB Oxelosund [5], which is distinguished by good weldability and wear resistance and has been successfully used in mining and mining equipment. However, the consistency of these recommendations did not confirm the results of field trials. In [6], it was shown that the time between failures of bits made of Hardox 450 steel was 4 hectares.

The purpose of this work is to ensure high tribotechnical properties of chisel plow bits by optimally structuring iron castings during heat treatment.

2. Theory of the Question
Bleached structures can be obtained both in the entire volume of the casting, and locally in the specified
zones [7, 8]. Using these features of iron casting, it is possible, through optimal zonal structuring, to create in castings such a complex set of properties that can drastically improve the performance of the chisel plow bits with the minimum cost of their production. [9-25]. A zonal structuring of the bit casting is proposed, providing high wear resistance and sharpness of the cutting edge due to the high hardness of the bleached layer and the realization of the self-sharpening effect during the plow operation.

3. Methods of conducting experiments, materials and methods of analysis

The study was conducted on heat-treated samples (castings) of cast iron SCH20, steel 45, 65G and Hardox 450 widely used for the manufacture of bits of tillage machines. The parameters of heat treatment are given in the Table 1.

| Sample number and material | Parameters of heat treatment                                      |
|----------------------------|------------------------------------------------------------------|
| No 1. Cast iron SCH20      | Regarding mode No. 2 + high frequency current quenching (HDTV) with work surface melting |
| No 2. Steel 65G            | Quenching from $t = 820 \degree C$, then cooled in oil and tempering at $t = 350 \degree C$ |
| No 3. Steel 45             | Normalization at $t = 880 \degree C$ for $\tau = 2$ hours, then air cooling |
| No 4. Steel Hardox 450     | Heat treatment from the manufacturer                              |

The structures obtained as a result of heat treatment were examined using a Neophot-21 metallographic microscope on microsections etched with 4% nital. The local hardness of the hardened zones and the individual structural components were determined using a PMT-3 instrument. The total Brinell and Rockwell hardness, as well as Charpy impact strength, were determined by standard methods according to GOST 9012-59, 9013-59 and 9454-78, respectively.

The method of research provided for comparative laboratory tests of the iron and steel under study, heat-treated in different modes, for abrasive wear resistance. The tests were carried out on the friction end machine in accordance with the requirements of GOST 17367-71.

When conducting comparative tests for wear resistance, this steel was used as a reference, its wear resistance was taken as 1.

4. Results and discussion

Hardening of the SCH20 sample by creating on its surface a bleached layer consisting of a cementite eutectic — ledeburite, was carried out during HDTV quenching (Sample No. 1). Under thermal action, the bulk of the metal remained cold. Therefore, after disconnecting the heat source, the thin molten surface layer, due to intensive heat removal to a large cold mass, solidified with a strong supercooling relative to the eutectic solidus with the formation of ledeburite (Figure 1).

The microhardness of the bleached ledeburite layer formed on the cast iron in sample No. 1 was equal to $H50 = 10210 \pm 1403$ MPa. The main difference was the thickness of the bleached layer. In the process of electric arc heating and HDTV the bleached layer was 1.2 mm or more.
Sample No. 2 of 65G steel after quenching and tempering had a microstructure of tempered medium needle martensite, the hardness was HRC 47 ± 1.8, and the impact toughness of KCU was 31 J/cm². The microstructure of sample 3 of steel 45, which is most widely used in the manufacture of chisel plow bits, is a relatively homogeneous mixture of ferrite and pearlite grains characteristic of the normalized state, the steel hardness is HB 185 ± 2.1.

![Microstructure of bleached layer](image)

**Figure 1.** Microstructure of the bleached layer, obtained as a result of the melting and rapid cooling of the surface of cast iron – Sch 20, HDTV (×500).

Hardox 450 steel (sample No. 4) was not subjected to heat treatment in the manufacture of the bit, since it is supplied in a heat-treated condition, the manufacturer does not disclose heat treatment modes. The microstructure of Hardox 450 steel is a highly dispersive reed sorbitol, hardness – HB 411±4.7.

The dynamics of weight loss by samples of experimental materials when testing for abrasive wear is shown in Figure 2.

![Weight loss graph](image)

**Figure 2.** Weight loss of samples of experimental materials when testing for abrasive wear resistance (Nos. 1-4, Table.).
The test results showed (Figure 2) that gray cast iron with a bleached working surface has the greatest wear resistance, exceeding the wear resistance of the other materials studied. So, for cast iron SCH20 after quenching with HDTV – $\varepsilon = 4.13$. Hardox 450 steel ($\varepsilon = 1.98$) showed resistance to wear, commensurate with the results of 65G steel ($\varepsilon = 2.05$), heat-treated to a hardness of similar magnitude.

5. Conclusion

Gray cast iron SCH 20 with a bleached layer on the working surface with a thickness of about 2 mm is the most promising material for the manufacture of working bodies of tillage tools for the development of soils having higher tribological characteristics as compared with rolled steel, as well as technological and economic advantages in production due to the use of foundry technology.

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