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Research of weight and linear wear from resource indicators of cultivator paws hardened by combined method

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Abstract. The article presents the results of theoretical and experimental studies of weight and linear wear from resource indicators of cultivator paws hardened by the combined method.It is established that in order to achieve an increased resource of cultivator legs, world manufacturers use special alloying materials, design features and technological methods of hardening, namely heat treatment, application of wear-resistant materials. The most commonly used methods for strengthening the working surfaces of parts are conventional hardening of medium-carbon, high-carbon and alloy steels. The hardness of the metal can be obtained in the range of 45 HRC for steel 45 and up to 65 HRC for steel 65G and alloy steels. To determine the change in the geometric parameters of the blades of cultivator legs during production tests recorded linear wear, weight wear and the radius of rounding of the cutting edge of the working bodies with an operating time of 8, 23, 42 and 54 ha. According to the results of linear wear of the wings of experimental cultivator paws during production tests, the materials that provide the best performance against abrasive wear were determined. As a result of the analysis of cultivator paws with a yield of 54 ha, it was found that the working bodies do not have visible damage and extreme wear and are suitable for further use. At the same time, measurements showed that the amount of wear on the width of the blade is 5.3–11.9 mm.

1. Introduction

In the agricultural production[1], along with domestic tillage equipment [2], a significant amount of tillage equipment of foreign production has been accumulated [3], which is widely used [4]. The experience of using this technique indicates its advantages in reliability [5] and durability compared to domestic [6], in particular the operation of working bodies [7]. This is achieved by leading foreign companies through the use of new technologies in manufacturing [8]. It is established that in order to achieve an increased resource of working bodies [9], modern manufacturers use special alloying materials [10], design features [11] and technological methods of strengthening (heat treatment [12], application of wear-resistant materials [13]). The cost of such parts is quite high [14]. Therefore, there is a need to provide the agricultural consumer with relatively inexpensive spare parts for tillage equipment with high wear resistance [15].The decision of this question is possible by creation of competitive technologies of strengthening of details of domestic and foreign agricultural machinery at their restoration [16] and manufacturing for increase in a resource of these details several times and introduction of the given developments at the enterprises [17] and at the repair enterprises of agricultural machinery [18].Improving the performance of working bodies [19], in particular cultivator legs, is an urgent task in agricultural production [20]. This can be achieved by creating new technologies for manufacturing [21] and strengthening the working bodies [22], the use of new materials [23]. In particular, the development of technologies with the use of powder materials to strengthen the cutting edge is promising [24], which allows to increase the physical [25] and mechanical properties of the applied layers [26].The most commonly used methods for strengthening the working surfaces of parts are conventional hardening of medium-carbon [27], high-carbon [28] and alloy steels [29]. The hardness of the metal can be obtained in the range of 45 HRC for steel 45 [30] and up to 65 HRC for steel 65G [31] and alloy steels [32]. The wear resistance of such working bodies is lower in comparison with other [33], strengthened special materials [34].To locally strengthen the surface of the part in places of probable wear [35], it is advisable to use other methods [36], namely [37], electric arc surfacing with artificial electrodes [38] or flux-cored wires [39], surfacing with powder materials on microwave units [40], plasma [41] and gas-flame surfacing with powders, rods [42].Electric arc surfacing and artificial electrodes and wires can be both continuous over the entire surface and point [43]. Studies have shown that spot surfacing has proven itself better on the working side, while slightly increasing the resistance, which sufficiently protects against wear of the base layer of metal [44].

2. Purpose of research

The purpose of the research is to increase the resource performance of cultivator paws when using a combined method of hardening.

3. Materials and methods

One of the ways to solve this problem is to increase the life of cultivator paws due to the combined three-layer formation of their working surfaces, namely (figure 1): 1 – base is steel 65 G; 2 – hardened layer of steel 65 G to a thickness of 1.9–2.3 mm using the electrocontact method of sharpening and hardening, thus obtaining a solid layer of wear resistance of which is 3.48 relative to unhardened steel 65 G; 3 – additional hardening performed on top of the hardened layer with powder abrasive-resistant materials, which are deposited with a special electrode T-590 Ø5×450 mm, the wear resistance of this layer is 4.49 relative to unhardened steel 65 G.

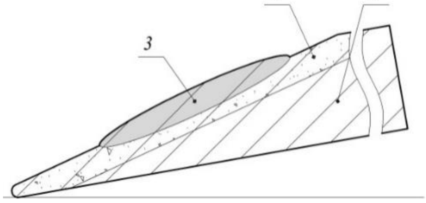

Figure 1. Scheme of electrocontact sharpening and strengthening of the blade of the cultivator paw: 1 – the base is steel 65 G; 2 – zone of electrocontact sharpening and strengthening; 3 – zone of strengthening by powder abrasive-resistant materials.

As powder abrasive-resistant materials used powders PS-12NVK-01, PG-10K-01, sormite, FCB-1, PT-NA-01, PG-19M-01. According to the developed technology, a set of cultivator paws with a grip width of 420 mm was strengthened (figure 1). Manufactured and strengthened cultivator legs were installed on the cultivator QUANTUM-12 with a width of 12 m and were tested in production conditions (figure 2).To determine the change in the geometric parameters of the blades of cultivator legs during production tests recorded linear wear, weight wear and the radius of rounding of the cutting edge of the working bodies with an operating time of 8, 23, 42 and 54 ha.According to the results of linear wear of the wings of experimental cultivator paws during production tests, the materials that provide the best performance against abrasive wear have been identified.

Figure2. Cultivator with the strengthened paws.

4. Results and discussion

As a result of the analysis of cultivator paws with a yield of 54 ha, it was found that the working bodies do not have visible damage and extreme wear and are suitable for further use. At the same time, measurements showed that the amount of wear on the width of the blade is 5.3–11.9 mm (figure 3).

Figure3. Reinforced cultivator legs.

It is established that the best results of wear resistance showed powder material PS-12NVK-01 applied by arc surfacing with an electrode T-590 Ø5×450 mm and is described by the following dependence:

$$w_x = 0.085 \cdot t_l - 0.059, \quad (1)$$

where w_x – the amount of linear wear of the blade of the cultivator paw, mm; t_l–operating time per paw of the cultivator, ha.

The results of comparative tests of weight wear of reinforced and serial legs showed that for the production of 54 ha of reinforced legs, the average weight wear is 425 g.

After processing the results of production tests of the legs of the cultivator QUANTUM-12 received mathematical models of the process of weight wear of serial w_c and hardened y from the legs (figure 5), depending on the operating time t_l:

$$w_{cs} = 0.017 \cdot t_l^{1.47} \text{ and } w_{ct} = 0.003 \cdot t_l^{1.8}, \quad (2)$$

where w_{cs} and w_{ct} – respectively, the weight of worn material serial and hardened cultivator legs, kg.

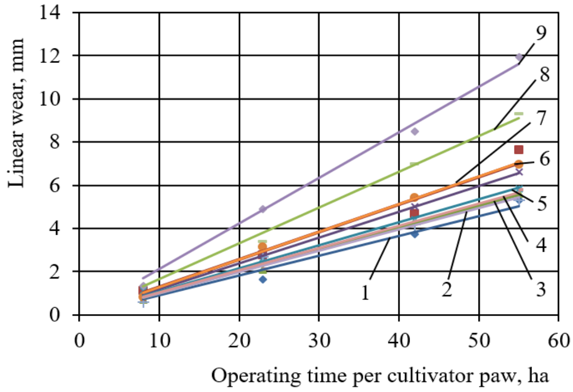

Figure4. Linear wear of the blade of the cultivator paw from the working time of the cultivator paw: 1 – PS-12NVK-01 + T-590; 2 – PG-10K-01 + T-590; 3 – FCB-1 + T-590; 4 – PG-10K-01 + Graphite; 5 – sormite + T-590; 6 – PS-12NVK-01 + graphite; 7 – FCB-1 + graphite; 8 – sormite + graphite; 9 – EDM treatment; 10 – serial cultivator paws KPE-410.

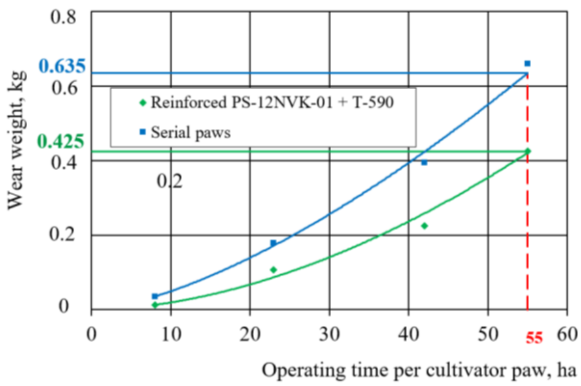

Figure5. Wear of cultivator legs by weight from operating time.

Mathematical models (2) allow to predict the amount of weight wear depending on the resource indicators of serial and harvested by the combined method of cultivator paws and found that when the weight wear reaches 635 g of hardened paws, their output will be 40% higher than serial. The proposed method of hardening allows to increase the resource of cultivator paws by 35–45%.

5. Conclusions

The best indicators of wear resistance showed powder material PS-12NVK-01 applied by the electrode T-590 after electrocontact treatment of the part, after 55 ha the amount of wear on the width of the blade is 5.3 mm, which is 43% less than electrocontact treatment.

The results of comparative tests of hardened and serial legs showed that for the production of 54 ha the average weight wear of serial legs is 635 g, and reinforced by the developed technology is 33% less and is 425 g. Achieving weight wear of 635 g of reinforced legs is will be 40% larger than serial.

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