Dynamics of wear of the knives that handled the deep cold

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Abstract. Among the measures that increase the efficiency of using agricultural and reclamation machines, there is an increase in the surface hardness of parts, the strength of materials, and wear resistance. With the introduction of high-speed machines in agricultural production, the wear of working surfaces has increased. Therefore, the issues of increasing the wear resistance of machine parts are currently being promoted to one of the first places in the complex of measures to extend their service life. We provide one of the methods to achieve this goal in this article.

1. Introduction
To increase the strength and wear resistance of machine parts, there is a whole system of well-developed methods: the use of alloying elements in metallurgy, blast molding, roller hardening, hydro jet molding, heat treatment, diffusion metallization, plasma dusting and high-temperature thermomechanical processing. Thermomechanical-magnetic treatment and surfacing with hard alloys improves the performance of a number of steels even better. However, most of these methods are very expensive and their application involves the use of complex and expensive equipment [1-4]. Outstanding scientists have developed a simpler and cheaper method of heat treatment - deep cold steel treatment method. The essence of cold treatment of hardened steels lies in the fact that cooling in the negative temperature range causes the resumption of the martensite transformation due the remaining austenite [5]. The increase in martensite increases the hardness and stabilizes the dimensions.

Studies of V.S. Zhmud performed in recent years have shown that the tool wear resistance increases significantly (5-10 times) after treatment with liquid nitrogen. The reason for the increase in wear resistance has not yet been disclosed. But the fact of a significant increase in tool wear resistance during such processing is firmly proven, and deep cold processing is increasingly being implemented in practice [6-13].

An analysis of published works on increasing the strength and wear resistance of agricultural machinery parts has shown that cold treatment is not yet applied and research in this area has not been developed.

2. Materials and methods
At the Department of materials resistance, research was carried out on the processing of segments of knives of snares and knives of tobacco cutting machines of TB with a deep cold. The knives were
treated with deep cold under laboratory conditions. The knife segments were placed in liquid nitrogen and kept in it until the temperature of the knives became equal to the temperature of liquid nitrogen. It was then removed and heated at room temperature for four hours. The change in the hardness of the knives before and after processing was carried out in two points on the press Brinel. The first is in the middle of the hardened part of the knife blade, and the second is in the non-hardened part.

To determine the print diameter of the press shaft a clock projector (PE), an optical measuring device that serves for accurate research of measurements and control of various small-sized parts, was used in the studied parts. It provides magnification of 10, 20, 50 and 100 times. Screen size: 560x450 mm.

To measure the diameter of the prints, tracing paper was fixed on the glass table of the projector screen, and the part with the print was placed on a slide. Using reflected light at a twenty-fold magnification, the print was projected onto tracing paper, and then its diameter was measured with a sheet of paper with an accuracy of 1 mm, which ensured the accuracy of measuring the print diameter to 0.05 mm.

To measure the sharpness of the knife blade, lead plates with a thickness of 1.5 mm, a width of 20 mm and a length of 40 mm were used, on which three blade impressions were made from different places of the knife. Using transmitted light, at twenty-fold magnification, a profile of the impression was drawn on the tracing paper of the screen.

The cold-treated and non-cold-treated knife blades were fingerprinted before starting work and after the KUF-1.8 mower had worked out 250 ha.

At the same magnification, prints were taken on the map and compared with the initial value of the blade sharpening angle. The actual sharpness of the blade could be seen from the rounded radius of the increased contour of the blade. The results of processing segments are shown in the table 1.

| Value       | The hardness of the blade at Brinel kg/mm² | The hardness of the blade at Brinel kg/mm² |
|-------------|------------------------------------------|------------------------------------------|
|             | Before treatment                         | After treatment                          | Before processing | After processing |
| Among.      | 464                                      | 407                                      | 181               | 164              |
| Max.        | 534                                      | 565                                      | 173               | 170              |
| Min.        | 393                                      | 388                                      | 152               | 152              |
| Among.      | 462                                      | 527                                      | 142               | 164              |
| Max.        | 514                                      | 565                                      | 170               | 170              |
| Min.        | 352                                      | 405                                      | 150               | 150              |

From the above research results, it can be seen that the processing of mower knife segments significantly increases the hardness of the hardened part of the blade on average by 5-12%, or by 25-50 HB units, and almost does not change the hardness of the non-hardened part of the segment. Moreover, it is noted that the increase in hardness of blades with lower initial hardness is significantly greater.

The segments treated with liquid nitrogen were placed on a KUF-1.8 mower at the kolkhoz named after V.I. Shishkin. Lenin square in Korenovsky district in the Krasnodar region and participated in the work on the preparation of hay flour. The mower mowed 250 hectares of various grasses. As a result of inspection and measurement of the sharpening angles of the segment blades, it was found that the segments treated with liquid nitrogen also showed less wear. The processed segments were not painted. The sharpness of the blade in these segments is significantly higher than in the untreated ones.

The skins of tobacco cutting machines work in difficult conditions and usually after 7-12 minutes, they have to be removed for re-cutting. This has a significant impact on the performance of the
machine. Therefore, in order to reduce the loss of time for redrawing knives, improve the quality of cutting, it is necessary to significantly increase the wear resistance of knife blades. Our task was to check how the wear resistance of knife blades changes after processing them with liquid nitrogen. Taking into account that the removal of knives for reloading is determined by the worker according to subjective indicators, whether special experiments were conducted to study the dynamics of wear of knife blades treated with liquid nitrogen and not treated.

The knives were treated with liquid nitrogen in special foam baths measuring 600x500x100 mm by immersing the knives in liquid nitrogen poured into them. The knives were kept in liquid nitrogen until the entire knife was completely cooled (-190°C).

To determine the dynamics of wear of the cutting edge, a risk was applied on its surface parallel to the cutting edge at a distance of 5 mm (figure 1). A thread of marks was applied on the risk with an interval of 70 mm by the core. Blade wear was measured using a 24-fold magnification MPB-2 reference microscope with a reading accuracy of up to 0.06 mm.

![Figure 1. The point of measurement of the wear of the knives.](image)

Having experimentally established the average duration of knife operation (18-20 minutes), we took the interval of time between sharpening 4 minutes of machine operation (18-20 minutes). The test procedure was as follows. After drawing the drawings and marks, the distances from the center of each mark to the blades were measured and the knife was installed on the machine. After four minutes of operation, the machine was stopped, the knife was removed, and measurements were made again from the center of each mark to the blade. The difference in displays gave wear against each label. The knife was placed back on the machine and all operations were repeated until the knife was blunted. The experimental results are shown in figure 2.

4. Discussion

The values of each point are shown in the graphs (figure 2). There is also a graph of the wear dynamics of a knife that has not been treated with liquid nitrogen. The graphs show that knives that have not been treated with liquid nitrogen wear out more intensively. Moreover, wear increases faster as the knife becomes blunt, and it is different at different points. At the extreme points, the blade of the knife wears out largely than in the Central ones. It is more obvious that this occurs due to the unequal deformation of the toe during its sharpening. For example, at point 5 in the middle, the blade wear in 4 minutes was 0.4 mm, and in the center, it was only 0.27 mm.

Wear of knives also occurs when they are redrawn. With the help of a BCH-2 microscope, the wear of knives was studied during re-cutting of their blades. Wear was measured at three points (table 2 and figure 3).
Figure 2. Graphs and results of experiment.

Table 2. Wear of knives when re-cutting their blades at 3 points, mm.

| Sharpening number | Knife 1 | Knife 2 | Knife 3 |
|-------------------|---------|---------|---------|
|                   | 1       | 2       | 3       | 1       | 2       | 3       | 1       | 2       | 3       |
| 1                 | 1.30    | 2.05    | 0.15    | 1.95    | 2.05    | 0.70    | 0.90    | 1.33    | 0.10    |
| 2                 | 1.00    | 1.53    | 0.60    | 0.35    | 1.25    | 0.65    | 2.00    | 1.45    | 0.50    |
| Average           | 1.15    | 1.80    | 0.375   | 1.15    | 1.80    | 0.875   | 1.45    | 1.39    | 0.58    |

It can be seen from the table that intensive wear of knives is observed when the blades are redrawn. Moreover, more material is worn off in the Central part of the knives than at the extreme points of the blade. This is, on the one hand, an advantage down to a smaller wear of the blades in the Central part of the knife during work, and on the other hand, apparently, when grinding the extreme from the center point more is cooled, by a lower wear of the blade at these points. Since the knife wears out significantly more when the blades are re-edged than during operation, it is necessary to re-sharpen the
knives as little as possible. When reloading, you should try to better center and secure the knives to ensure that the metal is removed evenly.

![Figure 3. The point of measuring the hardness of knives.](image)

Treatment of knives with liquid nitrogen significantly increases the wear resistance of knives of tobacco cutting machines and reduces the intensity of their wear.

5. Conclusion
As a result of the performed studies, it was established that:

- Processing parts with liquid nitrogen increases the hardness in the hardened part of the segment by an average of 12%;
- Machine parts treated with liquid nitrogen have greater wear resistance and better sharpness of the blades;
- Discoloration of the blades and breakage of the segments were not observed

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