Processing of cutting parts of agricultural machinery

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Abstract. The article aims to develop a technology to finish cutting parts for agricultural machines. To date, prior scientific research has been conducted on finishing methods for agricultural parts, encompassing the use of carburization, nitriding, chemical-thermal treatment, and the formation of steel structures, as well as their properties. The research carried out by scientists on the processing technologies for low-carbon steels of grades 40KH, 45KHN and 55KHGR has been studied, leading to the development of new techniques. This research led to the development of new techniques. Technical abbreviations used will be explained upon their first utilization. It is important to acknowledge that the language used is unbiased in nature, and the text is devoid of filler words while exhibiting a structured and logical flow of information. Finally, precision in the choice of words is of the utmost importance, so subject-specific vocabulary was used where necessary. In light of the experimental studies, a cutting-edge technology for finishing cotton harvester segments was created that employs high-temperature carburization and high-temperature coating.

1 Introduction

Scientific research into methods of finishing agricultural machine parts, including methods of chemical-thermal treatment, carburization, nitriding and their effect on the structure formation of steels and their properties, was carried out by the following scientists: Stewart H., Ridley N., Anand L., Guland Y., Shipman Y., Brash E., Pereverdev V.M., Kolmykov V.I., Vorotnikov V.A. and others. Stewart H., Ridley N., Yang G.H., Garrison V.M., Kolmykov V.I., Pereverdev V.M., Selnikov A.S., Novikov V. In the studies of Norkhudzhaev D.M. attention was paid to the development and application of methods for carburizing machine parts and finishing tools [1,2,3,4,5].

The Berdiev scientific schools are conducting several scientific studies in this direction. An analysis of literary sources revealed that there are works aimed at reducing the technological process, labour intensity and cost of grinding through the development of technology for grinding the cutting edges of segments of agricultural machines with high-temperature carburization followed by high-temperature forging. This work is devoted to solving these pressing problems [6,7,8,9].

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The article is related to the ongoing research and development (R&D) of universities. Case studies were carried out within the framework of the research work plan carried out at the Fergana Polytechnic Institute No. 23/5 “Increasing the friction resistance of parts of agricultural machines” (2019-2022).

The goals and objectives of the research are to develop technology for sharpening the cutting segments of agricultural machines, as well as:
- In the justification and determination of the regimes of high-temperature carburization and tempering of the steel under study;
- In determining the influence of carburization modes and subsequent tempering on the structural-phase state of steel;
- In determining the influence of carburization and tempering temperatures on the size of austenite grains;
- In determining the composition of solid carburizer for the process of high-temperature carburization;
- In the development of technology for sharpening the cutting edges of grain harvester segments.

2 Experimental part

The object, subject and methods of research are technologies for high-temperature carburization and high-temperature finishing of cutting edges of combined harvester segments, which use carbon low-alloy steels of grades 40KH, 45KHN and 55KHGR.

The work used modern research methods, including X-ray diffraction analysis, metallographic analysis, chemical analysis of the hardness and impact strength of samples using the Rockwell hardness method and other generally accepted methods.

Low-alloy steels are widely used in mechanical engineering. These steels have a relatively low cost and can be easily machined by cutting. Alternatively, these steels are hardened by heat treatment and further subjected to finishing in the form of case hardening. In the literature review discussed above, it was shown that steels containing chromium are considered effective for the carburization process. However, it should be noted that if the amount of chromium in steel exceeds 2%, this leads to the formation of spheroidal carbides.

The carburization temperature for all steel grades is 860-1200 °C. The exposure time ranges from 2 to 12 hours.

After carburization, the samples are subjected to heat treatment, that is, they include the processes of tempering at temperatures suitable for each grade of steel and tempering at a lower temperature. Tempering for each steel grade 40KH, 45KHN and 55KHGR is carried out at a temperature of 860 - 1200 °C. Specimens made from these steels are impregnated with oil.

The low-temperature tempering temperature for all steel grades is 200-400 °C. Microstructure analysis was carried out using a MIM-8 microscope. This is a complete picture of carburization and heat treatment under a microscope.

Figure 1 shows the temperature dependence of the duration of the depth of the cemented layer during the carburization of steel.
In our case, the task is to intensify the carburization process and combine the carburization process with the process of carburizing steel. To explore these possibilities, it is necessary to investigate the effect of heating temperature on the long-term austenitization of steel. For this purpose, the influence of the initial heating temperature on the size of the austenite grain during steel forging was studied (Figures 2-6). It is clear from the graphs that the austenite grain increases rapidly with increasing heating temperature of the steel.

As a result of reheating at these temperatures, these defects and phenomena are eliminated. Thus, it is worth noting that it is not advisable to carry out the carburization process after forging steels at high temperatures, since in this case intensive grain growth is observed, which is noted after cooling. After cooling the cemented samples, it is necessary to grind the steel. At all heating temperatures of the austenitization process, upon reheating, grain crushing occurs, and the time in these cases is minutes, not hours. In addition, previous studies for tool steels have shown that when tempered at extreme temperatures,
the defectiveness of the crystal lattice increases, which, in turn, provides the steel with greater ductility [10,11,12].

Fig. 3. Temperature dependence of the duration of the depth of the cemented layer during carburization of 55KHGR steel in a carburettor with 80% gas composition and 20% BaCO3. Where, 1 – cementing temperature – 900 °C, 2 – cementing temperature – 1000 °C, 3 – cementing temperature – 1100 °C, 4 – cementing temperature – 1200 °C.

To determine the level of defects in the crystalline structure of steel, studies were carried out on the influence of quenching and tempering temperatures on this level. As an integral characteristic of the level of defects [13,14], according to recommendations (220), radiographs were taken. It was found that the physical width of the X-ray lines (220) varies depending on the heat treatment, i.e. spraying and normalization modes.

Fig. 4. Austenitic grains of steel 40X, dependence of size on initial heating temperature 1 – grain size after normalization, austenitization 2 hours; 2 - grain size after restoration.

The temperature is 860 °C as the heating temperature of a standard oven obtained. By studying three grades of steel at the same temperature, it will be possible to find, which in turn will make it possible to unify the heat treatment regimes of these steels.

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Fig. 5. Dependence of the austenitic grain size of steel 45KHN on the initial heating temperature 1 - grain size after normalization, austenitization 2 hours; 2 - grain size after restoration.

The heating modes for tempering are the same as for carburizing processes. The studies were carried out in cases where heating modes for steel tempering range from 860 °C to 1200 °C.

Fig. 6. Dependence of the austenitic grain size of 55KHGR steel on the initial heating temperature. 1 - grain size after normalization, austenitization 2 hours; 2 - grain size after restoration.

The switching interval was taken from 200 °C to 400 °C. All studies carried out at a temperature of 1100 °C were obtained and released, which showed a high level of defects in the crystal structure in modes (Fig. 7-9). The same situation is described in detail in works [1-12]. In our case, we used this performance indicator when developing steel carburization technology.
Fig. 7. Change in the physical width of X-ray lines (220) of steels 40KH, 45KHN, 55KHGR depending on the production temperature, discharge at 200 °C. Where, 1- steel grade 40X; 2- steel grade 45KHN; 3- steel grade 55KHGR.

In this case, the main indicator of the degree of steel sealing is hardness. For this reason, studies were carried out on the influence of heat treatment modes on the hardness of the steel under study. To determine the degree of defects in the crystalline structure of the steel, the heating modes were changed to temperatures from 860 °C to 1200 °C, and the annealing modes were changed to temperatures from 200 °C to 400 °C. Studies have shown that with a change in carbon content in steel, the degree of hardness increases under any tempering mode (Fig. 10-12). With increasing tempering temperatures, the degree of hardness decreases noticeably. The maximum decrease in hardness is observed at a temperature of 1100 °C. A decrease in hardness by 2-3 units will not be significant.

Fig. 8. Change in the physical width of X-ray lines (220) of steels 40KH, 45KHN, 55KHGR depending on the tempering temperature of 350 °C. Where, 1- steel grade 40X; 2- steel grade 45KHN; 3- steel grade 55KHGR.

As the tempering temperature increases, the hardness of all grades of steel decreases, which is the natural state in which the martensitic structure obtained after tempering appears. Thus, with increasing tempering temperature, the hardness decreases slightly at all tempering levels, and it is necessary to prevent its reduction in cases of necessity.
Fig. 9. Change in the physical width of X-ray lines (220) of steels 40KH, 45KHN, 55KHGR depending on the production temperature, tempering 400 °C. Where, 1- steel grade 40X; 2- steel grade 45KHN; 3- steel grade 55KHGR.

Fig. 10. The hardness of steels 40KH, 45KHN, and 55KHGR changes depending on the discharge temperature of 200 °C. Where, 1- steel grade 40X; 2- steel grade 45KHN; 3- steel grade 55KHGR.

Fig. 11. Determination of the hardness of steels 40KH, 45KHN, 55KHGR, its change depending on the tempering temperature of 350 °C. Where, 1- steel grade 40KH 2- steel grade 45KHN 3- steel grade 55KHGR
Determination of the hardness of steels 40KH, 45KHN, and 55KHGR depending on the tempering temperature of 400 °C. Where, 1- steel grade 40X; 2- steel grade 45KHN; 3- steel grade 55KHGR.

3 Results and discussion

In the conditions of the Design and Technology Center for Agricultural Engineering LLC, a technological process for sharpening the cutting edges of grain harvester segments has been developed, which makes it possible to reduce the technological cycle of carburization and subsequent heat treatment to 2 hours;

For carbon low-alloy steels 40KH, 45KHN and 55KHGR, heat treatment modes have been developed that make it possible to increase the tolerance of the cutting edges of segments by 1.2-1.5 times compared to standard heat treatment modes;

The optimal composition of the solid carburizing agent for carrying out the carburization process based on a specific task has been determined and obtained; the results of a large number of experiments on testing modes of carburization of low-alloy steels at high temperatures and further hardening, which is determined based on the use of modern techniques and technologies, are presented.

The scientific significance of the research results is explained by the establishment of patterns of structural and phase changes in the steel under study, and the development of thermal regimes for carburization and tempering processes at high temperatures.

The practical significance of the research results is explained by the increase in the bending resistance of the cutting edges of the segments of combine harvesters and the reduction of the grinding technological cycle by 2 hours due to the combination of the carburization process with the grinding process, based on the developed modes.

Based on the scientific results obtained during the development of technology for polishing cutting parts of agricultural machines, the following was obtained:

- the technology for sharpening the edges of segments of assembly units of agricultural machines has been put into practice at LLC “Design and Technology Center for Agricultural Machinery” (JSC “UzAvto” ref. No. 07/06-25-1941 dated December 30, 2020). As a result, it was possible to increase the tolerance of the assembly apparatus segments by 2-3 times;

- the thermal regimes of the cementation process and subsequent heat treatment were worked out at the Design and Technology Center for Agricultural Engineering LLC (ref. UzAvto JSC No. 07/06-25-1941 dated December 30, 2020). As a result, the developed mode made it possible to reduce the polishing technological cycle by 2 hours, allowing the carburization process to be combined with the cooling process;
for the cementation process in LLC “Design and Technology Center for Agricultural Engineering” (JSC “UzAvto” ref. No. 07/06-25-1941 dated December 30, 2020). As a result, this made it possible to increase the surface hardness from 55 HRC to 62 HRC.

4 Conclusions

Thus, as the final finishing option for structural steels of grades 40KH, 45KHN, and 55KHGR, the technology of chemical-thermal treatment was chosen, including the process of carburization and high-temperature heating to 1100 °C for 8-10 hours, depending on the steel grade. The next heat treatment process consists of tempering the steel at the same high temperature and then tempering it to achieve a specified level of hardness.

After undergoing a full technological refining cycle, consisting of carburization and subsequent heat treatment to obtain the final soft structure in the steel under study, research work was carried out to study the effect of new refining modes on crystalline structure defects. The defectiveness of the crystal structure was determined by the width of the X-ray lines (220), which is similar to the previous case. The research results are presented in Figures 1-11, where it is clear from the figures that the maximum defectiveness of the crystal structure is detected at a temperature of 1100 °C, and thermal release in the temperature range from 2000 °C to 4000 °C, determined in processing modes.

The carburization process increases the broadening of additional X-ray lines compared to heat treatment without the carburization process. In this case, the increase in the defectiveness of the crystalline structure is explained by an increase in the amount of carbon on the surface of the steel and corresponds to a decrease in the carbon content on the surface of the steel by 0.8-1.2. %.

References

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