

Methods for Restoring the Working Surfaces of Various Types of Parts by Surfacing with Wear-Resistant Materials

I. U. Zhunaev

Senior Lecturer, Department of Technical Support, Institute of Ground Forces, University of Military Security and Defense of the Republic of Uzbekistan

S. Zh. Sultonov

Head of the Department of Technical Support, Institute of Ground Forces, University of Military Security and Defense of the Republic of Uzbekistan

Abstract: One of the perspective methods of the reconstruction worker to surfaces of the details of the different type is on melting wear-out steadfast material. For наплавке of the details of the type gross layer s on surfaces, possessing high wear-out by stability. In article is considered recovering the details of the type gross on melting wear-out steadfast metal on damaged worker of the surfaces and influence change the thickness to hardness of the gross after on swimming trunks.

Keywords: wear capability, on swimming trunks, reconstruction, thermal processing, remaining voltages, mechanical processing, rifts, stability, melting, warm-up voltages

INTRODUCTION

Modern mechanical engineering production is characterized not only by the use of fundamentally new materials and technologies but also by the improvement of existing technological processes. At the same time, the goal is to ensure high product quality, conserve resources, and utilize conventional raw materials and standard technological equipment. Ultimately, this leads to achieving the greatest economic efficiency[1].

One of the possible approaches to significantly improving the service properties of heat-treated products is the application of heat treatment with repeated phase recrystallization. Among such methods, cyclic heat treatment has been studied most extensively and has found practical application. It provides grain refinement and increases the yield strength and impact toughness of steel[2].

The essence of this method lies in repeated phase recrystallization through multiple heating and cooling cycles at the critical temperatures A1 or A3. Numerous thermocyclic treatment methods have been developed for various alloys. However, from a technological standpoint, heat treatment involving double phase recrystallization is considered the most practical.

It has been established that double quenching of bearing steel, carried out using conventional technology, increases its service life several times. This improvement is primarily attributed to the refinement of the grain structure and secondary carbides in the steel. The results of studies on the formation of steel microstructure during heat treatment with double phase recrystallization are presented in the works cited in[3].

It has been demonstrated that there are optimal heat treatment regimes with double phase recrystallization that ensure the formation of structures with fine austenitic grains, a high degree of dispersion of excess phases, and maximum dislocation density. These regimes involve the first recrystallization with heating to extreme temperatures, which for carbon and low-alloy steels are within the range of 1100–1150°C. At these heating temperatures, not only does the carbide phase

dissolve, but the dissociation and initial dissolution of refractory phases are also observed[4].

The initial dissolution of these phases is also characterized by the chemical heterogeneity of the solid solution, while cooling from this state (by quenching or normalizing) leads to the formation of a high dislocation density in the α -phase.

One of the promising methods for restoring the working surfaces of various types of parts is surfacing with wear-resistant materials. During the surfacing of shaft-type parts, a layer with high wear resistance is formed on the surface[5].

However, considering that surfacing is performed on large surfaces made of high-alloy steels, which differ significantly in composition from the deposited layer, it is necessary to develop a special heat treatment technology to prevent the formation of significant residual stresses.

The following technology for shaft restoration was proposed: machining to remove heat-checking cracks, deposition of a soft intermediate layer using Sv-08 welding wire, followed by the deposition of a wear-resistant layer using PP-3Kh2V8F welding wire, and subsequent slow cooling[6].

RESEARCH METHODOLOGY

The study was conducted using an experimental approach. Shaft specimens made of 9Kh2MF steel were restored by surfacing with Sv-08 and 3Kh2V8F welding wires. Prior to surfacing, the specimens were preheated to 420°C , followed by isothermal holding at 550°C and controlled cooling. The deposited layers were examined using optical and electron microscopy, while hardness measurements were performed across the cross-section of the specimens. The obtained microstructural characteristics and hardness distribution were analyzed to evaluate the effectiveness of the proposed heat treatment and surfacing technology.

RESULTS AND DISCUSSION

Preliminary experiments showed that, in the absence of controlled preheating, when the shafts were heated with a gas burner prior to surfacing, cracks appeared on the shaft surfaces even after slow cooling in thermostatic chambers[7].

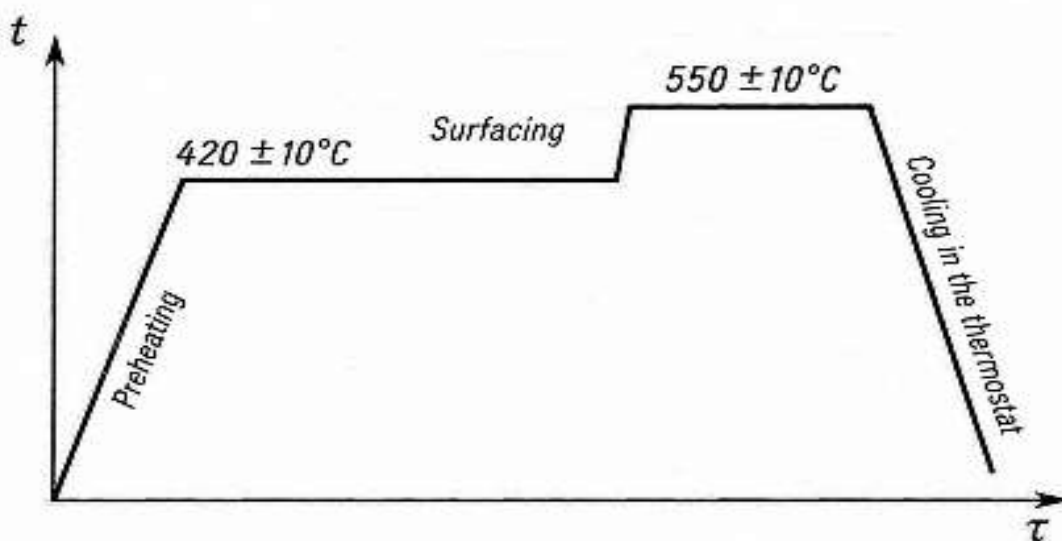


Fig. 1. Heat treatment scheme for shafts during surfacing

Apparently, the main causes of crack formation are thermal stresses arising from heating the metal to its melting point and the non-simultaneous occurrence of structural transformations during the $\gamma \rightarrow \alpha$ phase transformation. Therefore, to reduce these adverse effects, a preheating regime was developed in which the shafts were heated in a furnace before surfacing, followed by isothermal holding in the furnace and controlled cooling (Fig. 1)[8].

Considering the large volume of surfacing work, after machining, a soft intermediate layer was first deposited on the shaft using low-cost Sv-08 steel. This promoted stress relaxation both during the deposition of the wear-resistant 3Kh2V8F steel layer and during the subsequent service life of the shafts.

Isothermal holding was performed not only to slow the cooling process but also to eliminate unfavorable chain-like carbide precipitates along the grain boundaries (Fig. 2a). Such precipitates were observed only in the surface layer of the shaft that had been processed without isothermal holding[9].

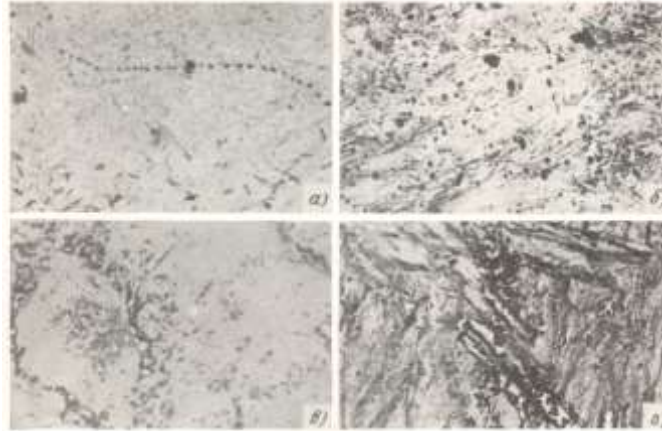


Fig. 2. Microstructure of the surfaced roll ($\times 4000$)

(a) Carbide precipitates in untreated rolls; (b) base metal at the interface with the intermediate layer; (c) intermediate layer of low-carbon steel; (d) wear-resistant layer.

The wear-resistant layer was deposited onto the rolls using a 3.2 mm diameter welding wire on a KZh-9704 surfacing unit at a wire feed rate of 136 m/h. The arc voltage was maintained at 32–34 V, and the welding current ranged from 340 to 360 A. The microstructure was examined on vertical specimens cut from the roll surface to the base metal[10].

Due to the differences in the steel grades used for the deposited layer and the roll material, particularly in the positions of their critical transformation temperatures, it was of interest to investigate the microstructure of the surfaced layers. For this purpose, both optical and electron microscopy were employed[11].

The results showed that preheating the roll to 420°C before depositing the first layers of Sv-08 steel caused changes in the microstructure of the base metal within a layer 3–5 mm thick. While the base metal originally had a highly dispersed tempered sorbite structure, the thin surface layer contained coarse globular MC-type carbides, which could have precipitated directly from the molten metal (Fig. 2b).

The fusion zone between Sv-08 steel and 9Kh2MF steel has no distinct boundary, and due to the mixing of metals with different carbon contents, the hardness decreases gradually (Fig. 3)[12].

The microstructure of the intermediate layer consists of ferrite with small pearlite regions located near the grain boundaries (Fig. 2c).

It should be noted that cementite plates approximately 0.1 μm thick were observed in the base metal, although the rolls were tempered at 550°C after surfacing. Apparently, the holding time at this temperature was insufficient to ensure complete spheroidization of cementite[13].

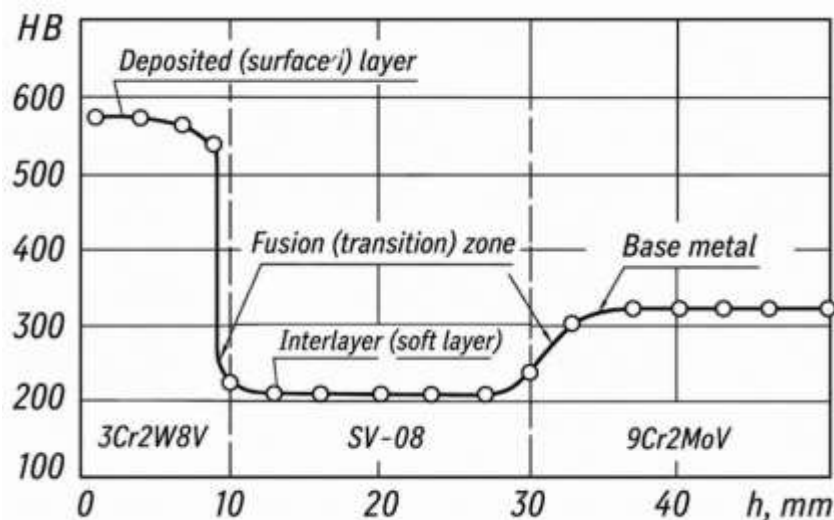


Fig. 3. Variation in shaft hardness after surfacing (h – distance from the surface).

The microstructure of the deposited wear-resistant working layer of 3Kh2V8F steel consists of bainite with a characteristic orientation, emphasized by special MC- and M2C-type carbides (Fig. 2d). The carbides have predominantly square or rectangular shapes and, less frequently, rounded shapes. The relatively large size of the carbides (about 0.5 μm) suggests that they precipitated during the cooling of the deposited 3Kh2V8F steel[14].

The boundary between the deposited wear-resistant layer and the intermediate layer is clearly defined, and the hardness changes much more abruptly than at the transition from the intermediate layer to the base metal (Fig. 3). At a depth of 8–10 mm from the surface, the hardness is approximately HB 550–570.

In our opinion, the causes of crack formation during roll surfacing are as follows. Initially, surfacing was carried out with preheating of the deposited surface using a gas burner to a shallow depth, while the core of the roll remained cold. Subsequent surfacing caused even greater localized heating of the surface (to a depth of no more than 20–30 mm) as the electrode moved. During cooling after surfacing, a non-uniform thermal stress field developed within the roll.

Cracks are likely to form at this stage when the stress state changes from compressive to tensile.

As the temperature of the roll surface decreases, structural transformations occur, accompanied by an increase in volume. As a result, the total stress level rises to a critical value. In addition, local concentrations of elastic energy develop within microvolumes of the metal where the grain boundaries are weakened by chains of carbide precipitates. When this localized elastic energy exceeds the energy required for crack initiation, and the overall stress level increases, fracture occurs [15].

Preheating the rolls in a furnace to 420°C reduces the thermal stress gradient, while subsequent isothermal holding at 550°C eliminates the possibility of martensitic transformation, since this temperature is above the Ms (martensite start) temperature.

Cooling under an improperly selected regime may lead to martensitic transformation, which is accompanied by an increase in volume. Since the stability of austenite and the position of the Ms temperature differ between 3Kh2V8F and 9Kh2MF steels, the corresponding volumetric changes occur at different rates, which is consistent with the findings reported in.

The increase in the hardness of the working layer after surfacing from HB 300 to HB 550–570, resulting from the formation of a bainitic microstructure containing chromium, tungsten, and vanadium carbides, promotes the refinement of austenitic grains and thereby improves the durability of the vertical rolls. The absence of cracks in the deposited layer indicates that the selected heat treatment regime is appropriate.

CONCLUSIONS

To prevent crack formation during the surfacing of 9Kh2MF steel rolls, the rolls should be preheated in a furnace to 420°C, and after surfacing, an isothermal holding treatment should be carried out at 550°C.

As a result of surfacing, a wear-resistant layer 8–10 mm thick with a hardness exceeding HB 550 is formed on the roll surface. This layer has a bainitic microstructure containing special carbides.

The service life of rolls restored by surfacing exceeds that of conventionally heat-treated rolls by approximately 15%.

REFERENCES

- [1] M. A. Tylkin, *Handbook for Heat Treatment Specialists in Repair Services*. Moscow, Russia: Metallurgiya Publishers, 1981, 648 p.
- [2] S. Ya. Shekhter and A. Ya. Shvartser, *Surfacing of Metallurgical Equipment Components*. Moscow, Russia: Metallurgiya Publishers, 1981, 160 p.
- [3] Ya. Rakhimov and Z. Abdukakhkhorov, “Hot Deformation and Its Influence on the Properties of Carbon Steels,” in *Proceedings of the 53rd International Conference, Novosibirsk, Russia, Dec. 2015*, p. 115.
- [4] Ya. Rakhimov and Z. Abdukakhkhorov, “Factors Affecting Grain Size and Its Variation,” in *Proceedings of the 1st International Internet Conference, Astrakhan, Russia, Feb. 29, 2016*, p. 1345.
- [5] A. Qosimov and M. Atakhonova, “Substitution of Producing Wear-Resistant Steel from Secondary Raw Materials (Used in the Example of Excavator Shoe),” *Zenodo*, 2026, doi: 10.5281/zenodo.19557595
- [6] M. Atakhonova, “Detail Casting Using Secondary Metals in Foundry According to GOST Markings,” *Zenodo*, 2026, doi: 10.5281/zenodo.19557130.
- [7] S. Sadullaevich and Z. Zikirillaevich, “Technological Features of Wear-Resistant Surfacing of Metallic Components Alloyed with Carbon, Manganese, and Silicon Using Fused Fluxes,” *Zenodo*, 2026, doi: 10.5281/zenodo.18583517.
- [8] T. Rajak, D. Pagar, P. L. Menezes, et al., “Fiber-Reinforced Polymer Composites: Manufacturing, Properties, and Applications,” *Polymers*, vol. 11, no. 10, Art. no. 1667, 2019, doi: 10.3390/polym11101667.
- [9] A. Dudnikov, S. Gorbenko, O. Kelemesh, et al., “Improving the Technological Process of Restoring the Tillage Machine Working Parts,” *Eastern-European Journal of Enterprise Technologies*, vol. 2, no. 1(104), pp. 6–12, 2020, doi: 10.15587/1729-4061.2020.198962.
- [10] L. Lev, A. Anton, and A. Andrey, “Increasing the Reliability of Cylinder Liners of Marine Diesel Engines: Problems and Solutions,” *Marine Engineering and Technology*, 2018, doi: 10.5281/zenodo.1408233.
- [11] A. Dudnikov, O. Ivankova, S. Gorbenko, et al., “Effect of Vibration Treatment on

Increasing the Durability of Tillage Equipment Working Bodies,” Eastern-European Journal of Enterprise Technologies, vol. 3, no. 1(111), pp. 23–30, 2021, doi: 10.15587/1729-4061.2021.228606.

- [12] B. K. Tilabov, “Methods of Manufacturing Cast Details with a Solid-Alloy Coating and Heat Treatment,” Zenodo, 2024, doi: 10.5281/zenodo.14222745.
- [13] C. Bocchetta, D. Frattini, A. Ghosh, et al., “Soft Materials for Wearable/Flexible Electrochemical Energy Conversion, Storage, and Biosensor Devices,” *Materials*, vol. 13, no. 12, Art. no. 2733, 2020, doi: 10.3390/ma13122733.
- [14] O. Uzoma, P. Etim, C. Okonkwo, et al., “Recent Design Approaches, Adhesion Mechanisms, and Applications of Antibacterial Surfaces,” *Cleaner Engineering and Technology*, vol. 15, Art. no. 100563, 2023, doi: 10.1016/j.ceja.2023.100563
- [15] Y. Luo, X. Tan, and Z. Wen, “Recent Advances in Wearable Healthcare Devices: From Material to Application,” *Bioengineering*, vol. 11, no. 4, Art. no. 358, 2024, doi: 10.3390/bioengineering11040358