Study of the Microstructure of 20 GL Steel Samples Cut From A Wedge-Shaped and Side Frame After Volumetric Surface Quenching

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ABSTRACT

This work is devoted to the topic " Study of the microstructure of 20 GL steel samples cut from a wedge-shaped and side frame after volumetric surface hardening".

Keywords: Volume-surface quenching (VSQ), quenching, wedge-shaped, truck bolster (or bolster).

Introduction. In this days, the railways of Asia and the Russian Federation are more than two dozen fractures of the side frames of trucks of freight cars every year. Each case is a potential source of an accident or crash. What's more, when carrying out scheduled repairs of freight cars, about a thousand side frames and truck bolsters are rejected.

At this time, it is believed that the main reason for the fractures of the side frames of the trolleys is poor-quality casting of these parts. In almost every broken side frame, one or another casting defect is found.

In this study, volume-surface quenching (VSQ) was used to improve the structure and mechanical properties of 20GL steel. The question of the possibility of evaluating the properties after VSQ on samples cut from the technological sample (wedge-shaped) is analyzed.

Research material. In this work, the microstructure and mechanical properties of samples of fragments of side frames made of 20GL steel after normalization (950 ° C, air cooling) and VSQ (945 ° C, 3 min cooling) were studied. The chemical composition of the steel fragments of the side frames is shown in Table 1.

Table 1-Chemical composition of the studied steel fragments of side frames

Steel Grade	Element content, % weight							
	C	Si	Mn	V	Al	S	P	Other impurities

20GL	0,22	0,45	1,2	0,04	0,03	0,010	0,012	Cr=0,10 Ni=0,08 Cu=0,10
Requirements of GOST 32400	0,17–0,25	0,3–0,5	0,9–1,4	0,04–0,16	0,02–0,06	no more than		Cr≤0,03 Ni≤0,3 Cu≤0,06

The study of the structure was carried out at various scale levels: macro, micro. For the research, samples were made, cut from a wedge and a side frame (figure 1).

Figure 1-Side frame (a) and process sample (wedge-shaped) (b) of 20GL steel.

The analysis of fragments of the side frame after normalization and after thermal hardening by volume-surface quenching was carried out on samples that were cut from the side frame of 20GL steel.

Sample Preparation. For the preparation of all types of samples, cutting, pressing, grinding and polishing operations were carried out.

Cutting of samples with a size of no more than 10x10 mm and a thickness of 3 mm was carried out on a precision water-cooled Isomet 4000 cutting machine. Cutting was performed at a disk rotation speed of 2500 rpm and a milling cutter feed speed of no more than 2 mm / min, the samples in the machine are fixed with a special clip.

The dimensions of the samples after cutting were measured with an electronic Vernier caliper.

For the preparation of metallographic grinds, the samples were hot pressed into a special mixture of epoxy resin. Hot pressing was carried out in an automatic Buehler Simplimet 1000 press with a working chamber diameter of 25 mm at a temperature of 150 °C and a pressure of 2×10^7 Pa. The sample was placed on a special press table and filled with a powder mixture of Pheno Cure epoxy resin (a phenolic compound with a filler in the form of wood powder, which has an average hardness). After that, the table with the sample and the mixture was lowered into a special chamber by an electric drive, where the epoxy resin was pressed and solidified.

The pressed samples were removed from the working chamber of the press and processed manually on a Buehler Vector Head / Beta sanding and polishing machine (Figure 2) by successive sanding, starting with the less dispersed sanding paper (P 400) and ending with the most dispersed sanding paper (P 2500). The processing time at each stage was from 1 to 5 minutes. Before proceeding to each subsequent stage, the samples were washed with water. At the final stage, when polishing, a cloth (or velvet) was used with a Masterprep suspension with a SiO2 particle size of 0.05 microns and polished for 3 to 5 minutes, as a result of which a mirror surface of the cut was achieved.

Figure 2 - Automatic Grinding Machine Buehler Vector Head/Beta.

After polishing, the grinding surfaces were cleaned from the remnants of the polishing suspension with a cotton swab moistened with ethyl alcohol or water and dried with hot air.

Metallographic analysis. The sections were examined by optical microscopy using an Axio Lab A1 Carl Zeiss microscope (Figure 3) in the reflected light mode. The sample was placed on a slide table, so that the surface of the slot was on top.

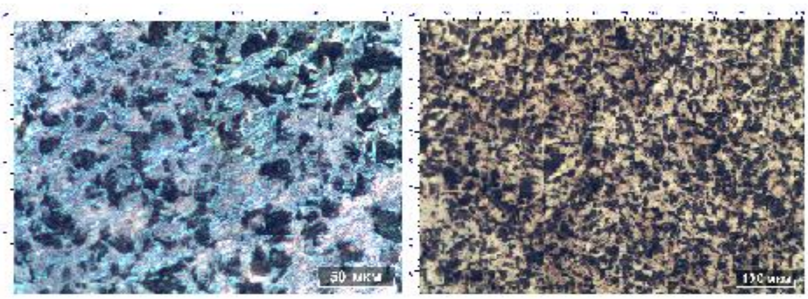
Figure 3 - Photo of the Axio Lab A1 Carl Zeiss microscope.

Two sections of each fragment were examined. The analysis of the sections was carried out at magnification ×200, ×500 and ×1000. Using a camera connected to a computer, images of the sections were photographed with an optical microscope. Obtaining austenitic grains in samples after normalization.

Preparation of the etchant: distilled water 100 ml, 3 drops of surfactant, 5 mg of picric acid. The etching holding time is 5 seconds. After applying the etchant on the surface of the sample, we wash it with water and dry it quickly so that the steel does not oxidize.

To measure the percentage of excess ferrite in the samples after the OPP, we use the Paint program, find the characteristic areas and paint the ferrite inside the grain in yellow, and along the grain boundaries-in red. After the selection using the Image Expert program, we calculate the percentage of ferrite and perlite.

Results of the research. *Results of metallographic analysis.* Figure 6 shows the structure of the side frame after normalization. The microstructure is ferrite-pearlite, fine-grained, with a uniform distribution of structural components



a) б)

Figure 6 - Microstructure of the side frame after normalization at x500 (a) and x200 (b)

Figure 7 shows the microstructures of the samples cut from the wedge after normalization. The results of the quantitative metallographic analysis are presented in table 2.

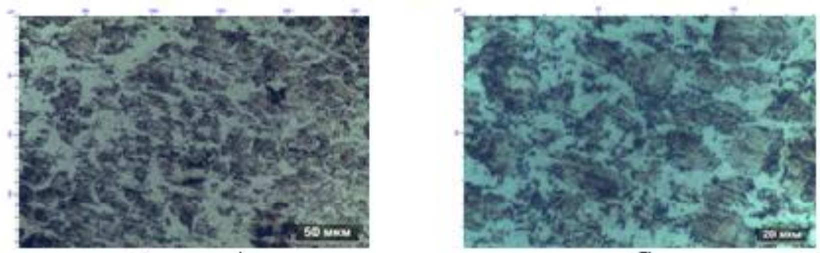


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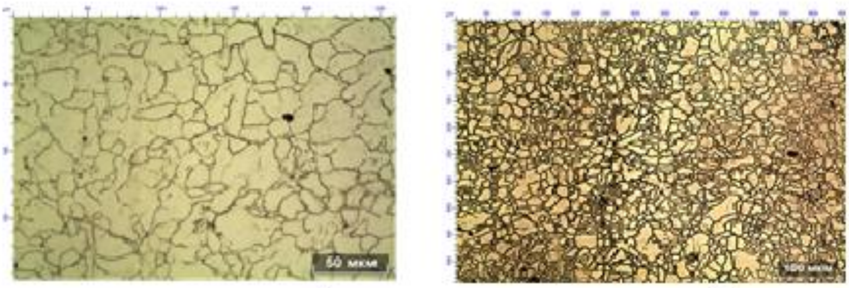
Figure 7-Microstructure of samples cut from a wedge-shaped after normalization at x500 (a) and x1000 (b)

Table 2-Microstructure parameters in samples

Sample	Ferrite grain size, mkm	Perlite grain size, mkm
Frame, normalization	25,62 ±6,4	14,70 ±8,1
Wedge-shaped, normalization	22,44 ±5,6	15,26±8,3

Table 2 shows that the average grain size of ferrite and perlite in the samples from the frame and wedge after normalization coincide within the error range.

Figure 8 shows the microstructure of a sample cut from a wedge after etching on austenite (after normalization).



a) б)

Figure 8-Microstructure of samples cut from a wedge-shaped sample after etching on austenite (after normalization, at x500 and x200)

The average size of large austenitic grains in the wedge samples was 35.39 microns, and the average size of small austenitic grains in the wedge samples was 9.1 microns.

Figures 9 and 10 show the microstructure of the samples cut from the side frame and the wedge-shaped after the VSQ.

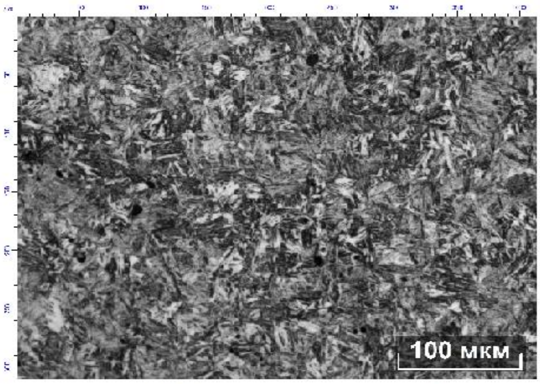


Figure 9-Microstructure of the sample cut from the side frame (after the VSQ).

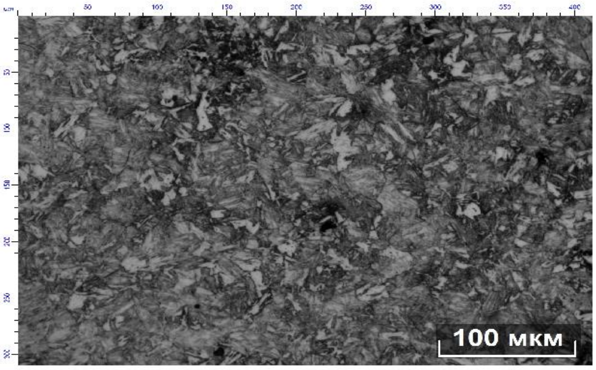


Figure 10-Microstructure of the sample cut from the wedge-shaped (after the VSQ).

The results of the excess ferrite fraction are presented in Table 3.

Table 3 -The proportion of excess ferrite in the samples

Sample	The proportion of ferrite inside the grain (%)	The proportion of ferrite at the grain boundaries (%)
Side frame (VSQ)	11,1±3,4	7,6 ±2,6
Wedge-shaped (VSQ)	13,7±2,5	8,5+2,1

Table 3 shows the results of measuring the proportion of excess ferrite in the samples from the wedge and frame after the VSQ. It can be seen that the percentage of excess ferrite inside the grains is greater than at the grain boundaries. The proportion of excess ferrite inside the grains in the samples from the side frame (11.1 %) and from the wedge (13.7 %) after the VSQ is the same.

Conclusions. 1. The microstructure of the side frame and the wedge-shaped after normalization is a ferrite-perlite mixture. The average ferrite grain sizes in the sample from the wedge-shaped and side frame after normalization coincide and are 22,44 ±5,6 and 25,62 ±6,4 microns, respectively. The average values of the grain size of perlite in the sample from the wedge and the side frame after normalization coincide and are (15.5±8.4) and 11,1±3,4 microns, respectively.

2. VSQ leads to a change in the structure of the cross-section: from the surface to the center from troostomartensite to sorbitol. In the case of samples from the frame, a decarburized layer is present on the surface. The proportion of excess ferrite inside the grains is greater than at the grain boundaries. The proportion of excess ferrite at the grain boundaries in the samples from the side frame is 7.6±2.6 % and from the wedge-shaped 8.5±2.1 %.

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