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Distinctive Features of Phase and Structural Transformations in Unconventional Modes of Thermal Treatment of Structural Steel

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ABSTRACT: The article discusses the results of heat treatment of structural steel with heating to an extreme temperature (during quenching or normalization), an increase in the density of dislocations in the crystalline structure of the α - phase is comparable to heating to a standard temperature (Ac_3+30÷50°C), it's change in dependence is determined on the amount of carbon and alloying elements in the steel composition.

KEY WORDS: Heat treatment, high hardness, dislocation density, low carbon steels, unconventional heat treatment modes.

I.INTRODUCTION

The most important problem of modern engineering and repair enterprises should be considered a reduction in metal consumption and energy. However, the service life of metal products is determined mainly by their mechanical properties.
The main parts of the machines are made of carbon and low alloy steels, they are strengthened by heat treatment - these are tempering with tempering.
Conventional, standard modes of heat treatment of metal products, as a rule, provide a sufficiently high level of mechanical properties. However, in some cases this is not enough. In particular, this concerns the viscosity of the metal of the product [1], which ensures its high reliability.
In recent years, considerable attention has been paid to structural heredity, since it was not always possible to get rid of the presence of large grains in harvesting [2].
The aforementioned even concerned a uranium alloy [3], questions of the dependence of the mechanical properties of low-carbon martensitic steels on the degree of manifestation of structural heredity during heat treatment [4]. The review article [3-5] considers heredity in phase transformations.
Based on the studies, it was found that all unconventional modes of heat treatment of steel are based on the fundamental laws of phase transformations [6]. The essence of unconventional heat treatment modes is that by means of preliminary high-temperature heat treatment a high level of defectiveness of the crystal structure of steel is achieved. This allows for repeated heating, depending on the completeness of repeated structural transformations, to greatly grind steel grain [5].
However, there are unresolved issues in the direction of research relating to the phase transformations of steels, theoretical and practical plans:
- how does the heating time affect the temperature and the extremum of the dislocation density after the γ - α transformation during quenching cooling, in air, and after annealing of steel;
In this work, the mechanism of α - γ - α transformations is considered in detail, but it is also noted that at high heating temperatures there is an extreme temperature when atoms of refractory impurity phases transfer into a solid solution (austenite). In this case, upon cooling (γ - α transformations), a high density of dislocations in the α - phase is obtained. During repeated phase recrystallization, part of these dislocations is retained and very strongly influences to increase the performance of steel products.

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II. OBJECT AND METHODS OF RESEARCH

The objects of research were samples of steel for industrial smelting of grades 45 and 40X. Armco iron samples were used as reference material. Steel grades are regulated by GOST 3541-79.

Heat treatment of the samples was carried out by heating to various temperatures, the first of which was selected for each steel from the calculation of Ac_3 + 30 ÷ 50°C, and then 900°C, 1000°C, 1100°C, 1150°C and 1200°C. The exposure time at these temperatures was different: 5 minutes, 20 minutes, 2 hours and 5 hours. Depending on the exposure time, heating was carried out in a salt bath or in a furnace. The samples were cooled in air, in water or oil, and also with cooling of the furnace. Thus, the thermal background of steel was created. Repeated phase recrystallization was always carried out with heating to Ac_3 + 30 ÷ 50°C for each steel.

Metallographic analysis was performed using MIM-8M microscopes [7]. X-ray diffraction analysis was performed on a DRON-2.0 apparatus. The state of the fine structure of steel (dislocation density), the amount of residual austenite, the lattice period, and the amount of carbon in the phases of hardened steel were determined [8].

With an increase in the heating temperature, a known fact of the growth of austenitic grain is observed. However, in all cases there is an extreme heating temperature of 1100°C with an austenitization time of 20 minutes, when after cooling it is possible to fix the maximum level of dislocation density (table 1).

With the normalization of large parts, the exposure time in the austenitic region during heating can be calculated in hours. In this case, the effect of extreme temperature on the state of the fine structure of steel has not been determined.

Table 1. The density of steel dislocations after normalization at various heating temperatures (austenization 20 min)

Normalization temperature, °C	Steel grade					
	Fe - armco		Steel 45		Steel 40X	
	$\rho \cdot 10^9$ 1/cm^2	ρ/ρ_{900}	$\rho \cdot 10^9$ 1/ cm^2	ρ/ρ_{850}	$\rho \cdot 10^{10}$ 1/ cm^2	ρ/ρ_{870}
Ac_3 +30÷50	-	-	1,0	-	1,13	-
900	0,37	-	-	-	1,13	1,0
1000	0,88	2,38	1,73	1,73	2,31	2,0
1100	1,40	3,78	4,5	4,5	4,54	4,0
1200	0,73	1,97	2,99	2,99	1,26	1,08

Note: ρ/ρ_{st} is the ratio of the density of dislocations of the current temperature to the first temperature, as to the standard ρ/ρ_{st}). The relative increase in ρ is large, but the absolute difference is not large.

Studies have shown that with an increase in the holding time during steel heating after the γ - α transformation, the α-phase dislocation density is lower, and the peak shifts to lower heating temperatures (Fig. 1).

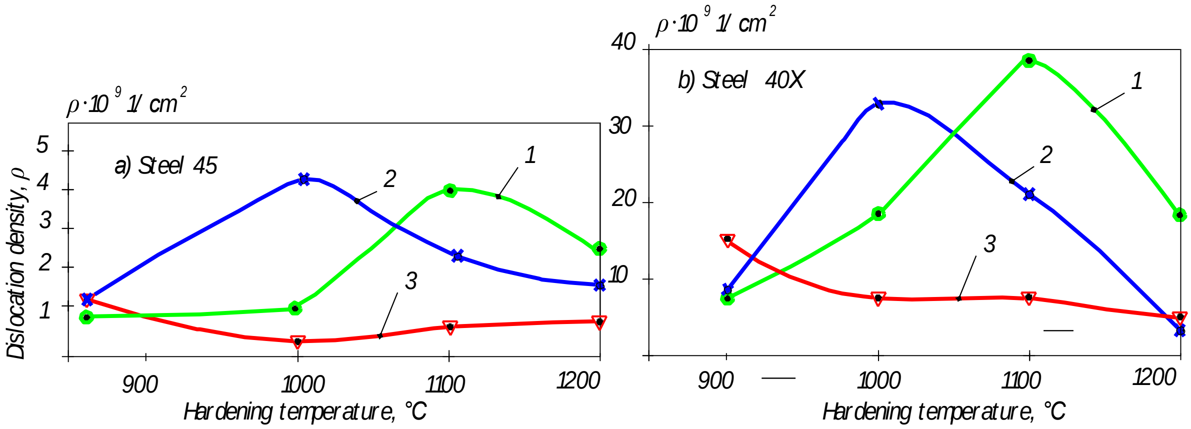

Fig. 1. The effect of heating temperature and holding time on the dislocation density of normalized steel. Steel holding time: 1 - 20 minutes; 2 - 2 hours; 3 - 5 hours

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Hardened steel samples are the most convenient objects for studying the parameters of their structure, since their main structure is martensite and some residual austenite. Of particular importance is the level of dislocation density in steels quenched with an extreme heating temperature compared to quenching in a medium from commonly accepted temperatures (above the heating temperature Ac_3 + 30 ÷ 50°C). This difference is large with a low carbon content, for example, armco-iron of 288%. On samples of steels 45 and 40X, it is 37 and 69, respectively. In this case, during quenching cooling and with low tempering at extreme positions, redistribution of carbon atoms between phases is observed. Carbon atoms pass to dislocations and to residual austenite.
The effect of the exposure time on the dislocation density level at various heating temperatures after quenching cooling can be judged by the results of experiments presented in Fig. 3.

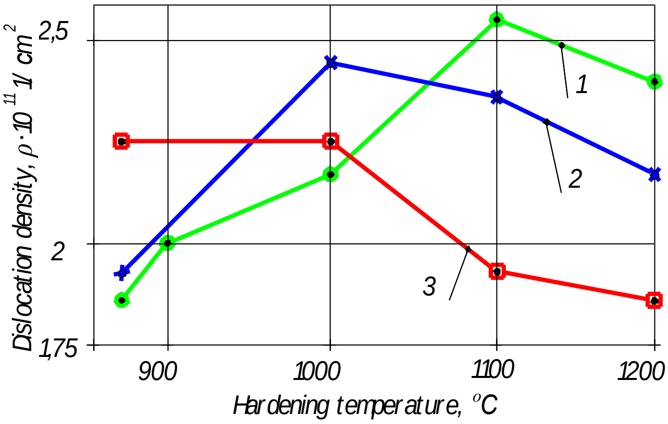

Fig. 3. The effect of temperature and heating time on the density of dislocations in hardened steel 45. Tempering during heating 200 ° C. Holding time during heating:
1 - 20 minutes; 2 - 2 hours; 3 - 5 hours

The nature of the change in the density of dislocations with increasing exposure time is similar to what occurred during normalization. Similar results were obtained in the study of steel 40X.

III. CONCLUSION

When steel is heated to high temperatures, extreme temperatures are observed when, after cooling, structures are formed with an increased level (after normalization) of the dislocation density or with its high level (after quenching). Extremes of the dislocation density occur at heating temperatures of 1100, 1000, 900°C with a holding time of 20-30 minutes, 2 hours and 5 hours, respectively, when heated. The magnitude of the increase in the density of dislocations depends on the content of carbon and alloying elements in it.

REFERENCES

[1]. Podrezov N.N., Podrezova I.S. The influence of structural heredity on the strength of reactor Cr-Ni-Mo-V steel // Global Nuclear Safety. - Volgodonsk, 2017. No. 4. S. 91-96.
[2]. Yugay S.S., Kleiner L.M., Shotsev A.A., Mitrokhovich I.N. Structural heredity in low-carbon martensitic steels // Metallurgy and heat treatment of metals. - Moscow, 2004. No. 12. S. 24-29.
[3]. Sagaradze V.V., ZuevYu.N., Bondarchuk S.V., Svyatov J.L., Shestakov A.E., Pecherkina N.L., Kabanova J.G., and Klyukinova M.F. Structural heredity in the U – 6 Nb Alloy and Conditions for its Elimination // The Phusics of Materials and Metallography, 2013. Vol. 114. №4. P. 299-307.
[4]. Yugai S.S., Kleiner L.M., Shatsov A.A. and Mitrokhovich N.N. Structural heredity in low-carbon martensitic steels // MetallSciens and teat treatment. 2004. Vol. 46. № 11-12. P. 539-542.
[5]. Dyuchenko S.S. Heredity in phase transformation: mechanism of the phenomenon and effect on the properties // Metall Science and heat treatment. 2000. Vol. 42. № 3-4. P. 122-126.
[6]. Sadovski V.D. Correction of the Course – Grained Structure During Thermal Treatment of Steel // Heat Treatment and technology of surface coatings. Proceedings of the 7th International Congress on Heat treatment of Materials, Vol. 1, December 11-14. 1990. Moscow. P. 10-14.
[7]. Bataev V.A., Bataev A.A., Alkhimov A.P. Methods of structural analysis of materials and quality control of parts - M.: Nauka, 2007. - 224 p.
[8]. Gorelik S.S., SkakovYu.A., Rastorguev L.N. X-ray and electron-optical analysis - M.: MISIS, 1994. - 328 p.