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HEAT TREATMENT IMPACT ON MICROSTRUCTURE EVOLUTION OF CONVENTIONAL AND INNOVATIVE STEELS FOR TRANSPORT APPLICATIONS

The modern development of transport engineering places increased demands on the strength, reliability, and durability of load-bearing structures. The microstructure of steels, which is formed during thermal exposure (welding, heat treatment, straightening), plays a decisive role in ensuring these characteristics. The experimental selection of optimal modes is resource-intensive; therefore, the development of methods for predicting structural changes is a relevant scientific and applied task.

The aim of this work is to study the patterns of microstructure evolution of transport-purpose steels during thermal heating and to develop models for predicting the phase composition and grain size [1, 2].

As a result of the simulation, thermokinetic (CCT) and isothermal (TTT) diagrams of austenite decomposition were constructed. It was established that the optimization of the chemical composition (narrowing the tolerances for alloying elements, reducing the content of sulfur and phosphorus) significantly affects the kinetics of phase transformations.

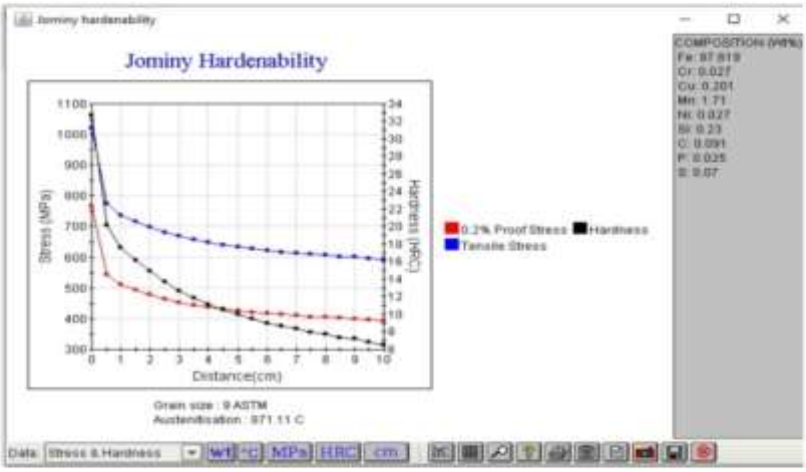

Fig. 1.. Computer modeling of the evolution of the strength properties of steel in the JMatPro software environment [4].

The data obtained from Fig. 1. The graph demonstrates a decrease in strength with an increasing distance from the sample surface. This is associated with a decrease in the cooling rate in the deeper layers of the metal, leading to the formation of less hard structures (for example, ferritic-pearlitic instead of martensitic). Such analysis allows for the assessment of the hardenability of the steel of a given composition [5].

In particular, for the optimized steel, a shift in the temperature intervals of transformations and an acceleration of static recrystallization processes are observed. The kinetics of recrystallization are described by the Avrami equation, for which the constants were experimentally determined. It was established that the time to reach 50% recrystallization ($t_{0.5}$) for the optimized steel is reduced by 50-60% (from 25-40 s to 12-18 s at 800°C), which indicates an intensification of structure formation [3].

Conclusions. The work solves a relevant scientific and applied problem of predicting the evolution of the steel microstructure during thermal heating. Based on the analysis of the dependence of strength characteristics on the distance from the sample surface (Jominy curve), it was established that the investigated steel with the chemical composition (Fe – 97.619%; Mn – 1.71%; Si – 0.23%; C – 0.091%, etc.) after austenitization at 871.11°C (grain size 9 ASTM) demonstrates a regular decrease in strength with increasing distance from the cooled end. This confirms the correctness of the chosen methodology for predicting hardenability.

The effectiveness of combining computer modeling and experimental methods for optimizing the chemical composition and processing regimes has been proven. The obtained data allow for predicting the steel microstructure at different depths from the surface without conducting labor-intensive metallurgical experiments.

The practical value of the work lies in the ability to predict the final microstructure (from martensitic structures on the surface to ferritic-pearlitic in the core) based on the analysis of the hardenability curve.

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