

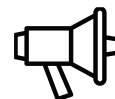
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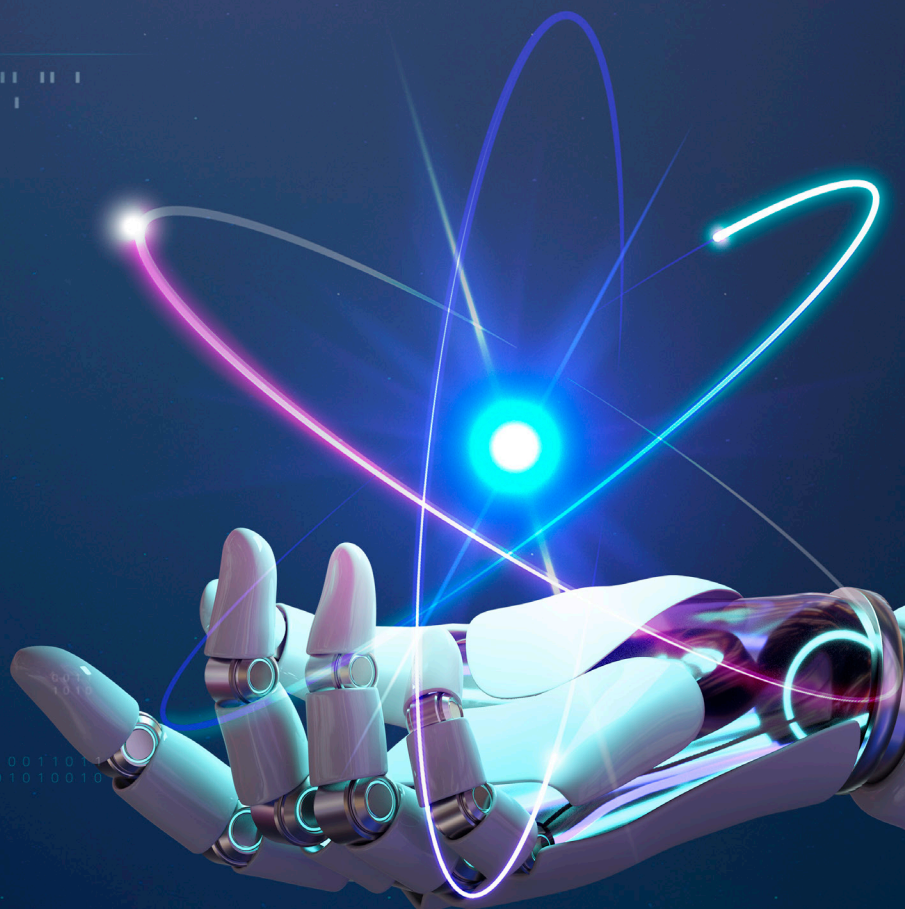
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REVIEW OF THERMAL STRENGTHENING METHODS FOR ROLLING ROLLS MADE OF ALLOY STEELS USED IN THE PRODUCTION OF SEAMLESS PIPES

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Abstract: A technological process aimed at improving the strengthening of rolling mill rolls made of alloyed steels used in the production of seamless pipes was developed. The study comprehensively analyzes the theoretical foundations of the rolling process, the technological sequence of strengthening, internal defects of rolling mill rolls, issues of energy efficiency, economic effectiveness, as well as environmental and occupational safety aspects.

Key words: rolling mill rolls, heat treatment of rolls, technological process, modernization, energy efficiency, safety.

INTRODUCTION

At present, both in Uzbekistan and in developed countries worldwide, increasing the service life of rolling rolls made of alloy steels used in the production of seamless pipes has become a significant scientific and practical issue. In particular, ensuring the durability of their main working components and improving operational efficiency are of great importance.

In this context, special attention is being paid to the development and practical implementation of advanced technologies aimed at enhancing the wear resistance and durability of rolling rolls operating under friction conditions. Such research is actively conducted in scientific institutions of technologically advanced countries, including the United Kingdom, the United States, Canada, Switzerland, and India [1].

LITERATURE REVIEW

Strengthening rolling rolls made of alloy steels used in the production of seamless pipes is considered one of the key tasks in modern metallurgical engineering. In scientific literature, considerable attention has been devoted to improving the durability and operational efficiency of rolling rolls used in metallurgical enterprises.

Among local researchers, the scientific works of B.M. Saydumarov are of particular importance, as they provide a technological justification for improving the strengthening processes of rolling rolls made from alloy steels. In several scientific articles, as well as in the textbooks "Rolling Machines and Equipment" and

"Technologies of Rolling Production," the author comprehensively analyzes the durability of rolling rolls, the enhancement of operational efficiency through heat treatment, and the associated economic benefits.

Furthermore, in the work "Design of Rolling Equipment," the structural features of rolling mills and scientifically grounded methods for strengthening rolling rolls are thoroughly explained.

In addition, technological processes of heat treatment and strengthening methods aimed at increasing the operational efficiency of rolling rolls have been extensively studied by foreign researchers. Scholars such as D. Benasciutti, N. Boris, L.S. Kokhan, A.V. Aldunin, N.A. Farunda, and others have conducted both fundamental and applied research focused on increasing the impact toughness of alloy steels, developing the theory of fatigue damage, and extending the service life of rolling rolls.

Moreover, S.K. Kasimkulov has carried out scientific research on technological processes for manufacturing rolling rolls from difficult-to-deform materials.

RESEARCH METHODOLOGY

Rolling rolls made of alloy steels used in the production of seamless pipes were selected as the objects of the study. These rolls are widely applied in seamless pipe rolling processes, and their microstructure, as well as operational properties, were identified as the primary focus of the research [2].

The study involves the application of intermediate tempering heat treatment aimed at controlling the dislocation density in the crystal lattice of alloy steels, forming a favorable initial microstructure for subsequent quenching, and ensuring the operational durability of rolling mill rolls [3].

ANALYSIS AND RESULTS

The durability of rolling rolls used in rolling processes depends on numerous factors, which can be classified into metallurgical, structural, technological, and operational groups. One of the key factors is the chemical composition of the steel. Alloy steels such as 17X2, 14X17H2, X12MF, and 65XNM, widely used in the production of rolling rolls, contain alloying elements such as chromium, molybdenum, vanadium, and others. These elements play a crucial role in the formation of carbide phases, which significantly affect the strength, wear resistance, and overall performance of the material.

The operational properties of steels used for working rolls of rolling mills are directly related to their structural state, which is primarily formed during the heat treatment process. Heat treatment is considered one of the most effective technological methods for controlling the internal structure of steel and improving its mechanical and operational characteristics [4].

The microstructure of the prepared samples (Fig. 1.1; Fig. 1.2) was examined using metallographic microscopes "iScope IS.1053 PLM" and the inverted metallographic microscope "Oxion Inverso OX 2653-PLM" at magnifications ranging from 50× to 1500×. Surface images of the investigated samples were captured using a "Euromex" 5.1 MP (1/2.5" CMOS sensor) micro-photographic attachment. The obtained images were recorded and stored on a computer connected to the camera (Figure 1.1 and Figure 1.2).



Figure. 1.1. Model *iScope IS.1053 PLM* metallographic microscope

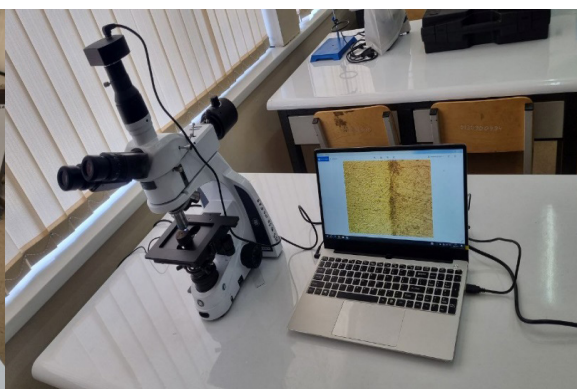


Figure. 1.2. Inverted metallographic microscope *Oxion Inverso OX 2653-PLM*

The sample was cut to dimensions of 15 × 20 mm using a metal-cutting machine and subsequently cleaned on an abrasive wheel.

During the study, the internal characteristics of the steels were investigated. For example, 14X17H2 steel is a martensitic–ferritic chromium–nickel alloy characterized by high mechanical strength and corrosion

resistance, which are optimized through heat treatment. As a material for rolling rolls, it performs effectively under high loads, thermal cycling, and chemical exposure, making it a reliable solution for demanding operating conditions.

The microstructure of the 17X2 steel roll was found to consist of a surface layer composed of fine needle-like martensite and carbides. The middle layer consists of martensite, troostite, carbides, and fragmented cementite networks. The chemical composition of the roll corresponds to that of 17X2 steel, and its hardness, measured at a depth of 2 mm, was determined to be 48 HRC.

Overall, the roll exhibits a fine needle-like martensitic–carbide microstructure, which is well suited for subsequent quenching and tempering treatments (Figure 1.3 and Figure 1.4).

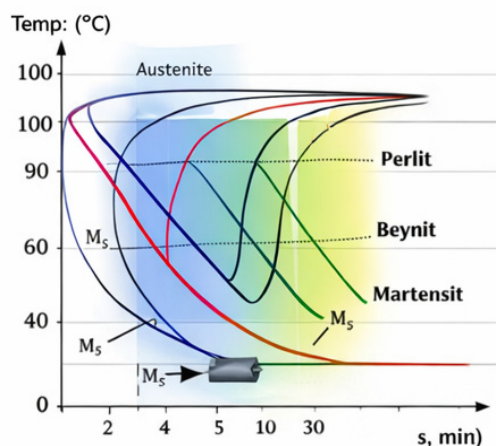


Figure 1.3. TTT diagram of 17X2 steel

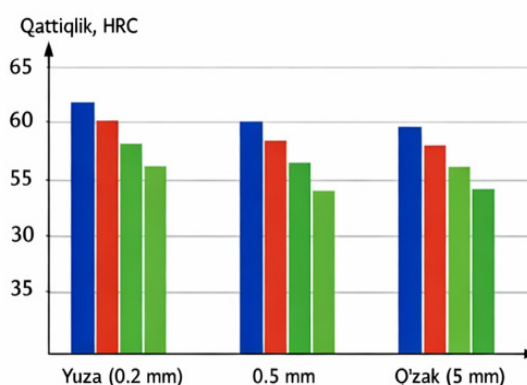


Figure 1.4. Comparison of hardness results

The TTT diagram of 17X2 steel reflects the isothermal decomposition behavior of austenite and enables the determination of the transformation boundaries of pearlite, bainite, and martensite phases. Based on this diagram, the quenching rate and intermediate holding temperatures are selected, thereby enhancing the operational properties of the steel (Figure 1.5).

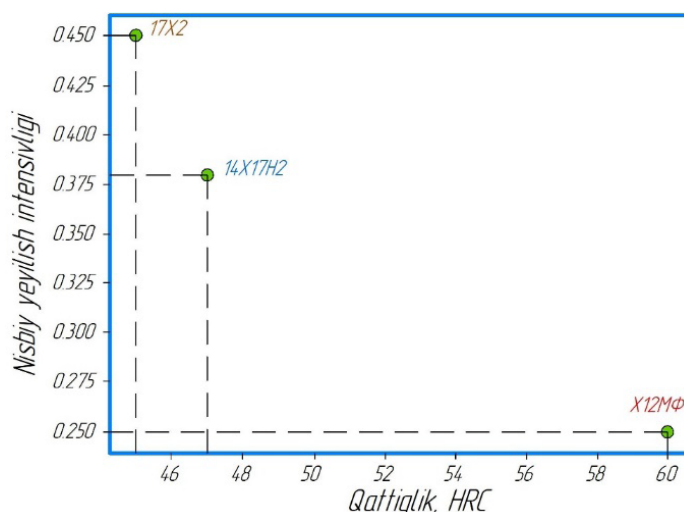
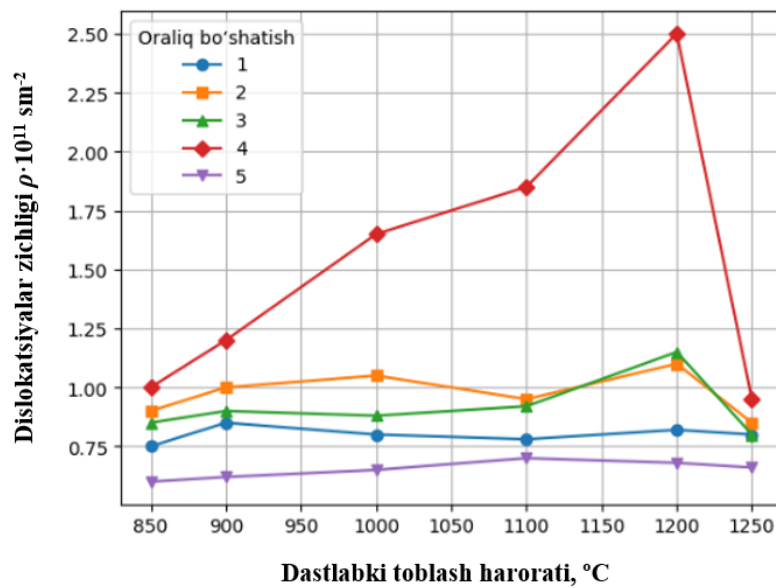


Figure 1.5. Relationship between hardness and wear resistance in steels

The wear resistance of working rolls is an important indicator for evaluating their operational performance. Several standard methods are used to determine wear resistance, primarily aimed at assessing the plasticity, hardness, and deformation resistance of various materials, including steels such as 17X2, 14X17H2, and X12MF.

Thus, the optimal heat treatment regime for 17X2 steel can be defined as follows: austenitizing at 850–880 °C, quenching in an oil medium, followed by tempering at 180–250 °C or 500–600 °C. This regime ensures controlled grain formation, the development of a tempered martensitic structure, and an optimal balance of

mechanical properties. As a result, a stable microstructure is obtained, providing high strength, sufficient plasticity, and enhanced wear resistance (Figure 1.6).



Intermediate tempering regimes:

- 1 – without tempering;
- 2 – 200 °C;
- 3 – 350 °C;
- 4 – 450 °C;
- 5 – 600 °C.

Figure. 1.6. Change in dislocation density ($\rho \cdot 10^{11} \text{ cm}^{-2}$) in 17X2 steel during heat treatment as a function of the initial quenching temperature. Final heat treatment: quenching followed by tempering at 200 °C (Figure 1.7).

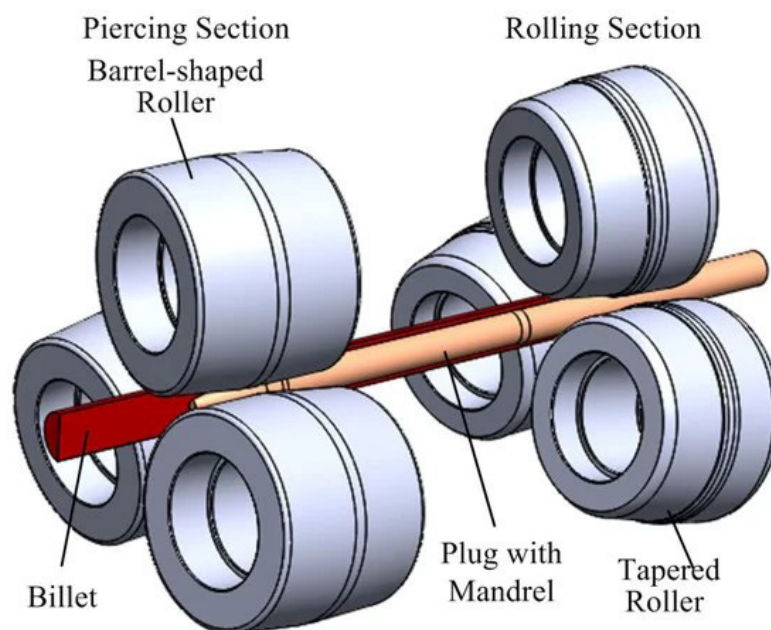


Figure. 1.7. Rolling rolls for seamless pipe production

CONCLUSION AND RECOMMENDATIONS

The proposed heat treatment technology for rolling rolls used in seamless pipe production demonstrates high technical and economic efficiency. Based on the conducted studies on the heat treatment of alloy steels,

the following conclusions can be drawn. It has been established that increasing the resistance of the working surfaces of rolling rolls to stress significantly enhances their operational properties and ensures the achievement of the required performance indicators. The conducted studies confirm the possibility of a comprehensive and reliable evaluation of the properties of selected steels, including 17X2, 14X17H2, and X12MF, used in the working surfaces of rolling rolls. Metallographic and X-ray structural analyses have proven to be effective tools for studying microstructural changes resulting from heat treatment, enabling precise control over the quality and properties of working rolls in accordance with established standards.

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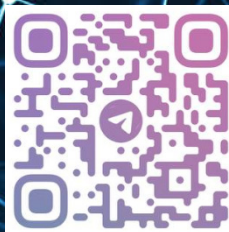
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