ANALYSIS OF HIGH-QUALITY STEEL STRUCTURE AND RECOMMENDATIONS FOR IMPROVING EXPLOITATION PROPERTIES

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Abstract: This article presents methods for analyzing the structure of high-quality steels, assessing their physical-mechanical properties, and recommendations for improving their exploitation properties based on the IMRaD (Introduction, Methods, Results, Discussion) format. The study evaluates the role of X-ray diffraction (XRD), scanning electron microscopy (SEM), and hardness measurement methods in determining the composition of steel.
Keywords: Steel, structural analysis, X-ray diffraction, electron microscopy, hardness, heat treatment, phase transitions, dispersion, diffusion, alloys, exploitation properties, strength, elongation, impact resistance, crystal lattice, defects, corrosion, modification.

1. Introduction

High-quality steels are widely used in various industries, including machine engineering, construction, and aerospace technologies. The mechanical and exploitation properties of these materials are determined by their structural composition and processing techniques. The phase state of steel, grain size, and defects in the crystal lattice determine its strength, ductility, and corrosion resistance. Modern physical-chemical methods such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and microhardness measurement methods are used to analyze steel. In this research, the structural properties of high-quality steels are studied, and recommendations for improving their exploitation properties are developed.

2. **Research methods**

The following experimental methods were used in the research:

X-ray Diffraction (XRD): To determine the phase composition of steels and observe changes in the crystal lattice.

Scanning Electron Microscopy (SEM): To study the grain structure of steel and surface defects.

Microhardness Measurement: To assess the hardness of steel under different heat treatment conditions.

Thermal Analysis: To identify phase transitions and evaluate the heat resistance of alloys.

Table1.

Composition of Steel Samples Studied

Research Focus	**Key Processes**	**Recommendations and Suggestions**	**Results**
Steel Structure Analysis	- Analysis of microfractures	- Further improvement of analysis methods	- Determining steel strength and durability
	- Studying microstructure	- Improvement of metallurgical processes	- Improvement in steel quality, longer service life
	- Analyzing alloying and heating methods	- Optimization of high-quality steel production	- Better compatibility of alloy composition and microstructure
Exploitatio	- Studying	- Adapting to	- Improved

n Properties	mechanical properties of steel	exploitation conditions	strength and continuous performance
	- Autonomous or combined tests	- Extending service life and increasing efficiency	- Increased service life, reduced accidents
	- Analyzing corrosion and oxidation	- Introducing special coatings or protective methods	- Increased corrosion resistance of steel
Methods for Improving Quality	- Analyzing changes in alloy composition	- Increasing density, hardness, and elasticity	- Improved physical and chemical properties of steel
	- Heat treatment and alloy production	- Selecting high-quality raw materials in steel production	- Improved product quality, reduced energy consumption

3. **Analysis of results**

The research results provided the following insights:

- **XRD Results:** The quantitative distribution of ferrite, austenite, and martensite phases in the steel was determined. Steel B had a higher martensite phase, contributing to its high hardness and wear resistance.

- **SEM Results:** The grain structure of the steels was analyzed. Samples A and C had average grain sizes of 10-20 µm, contributing to improved mechanical strength.

- **Hardness Measurement Results:** The microhardness of Steel B was 480 HV, Steel A was 410 HV, and Steel C was 450 HV, which determines their potential applications based on exploitation properties.

Figure 1. High-Quality Steels

The study showed that the physical-mechanical properties of high-quality steels are closely linked to their structural composition. Martensitic and vanadium-alloyed steels exhibit high hardness and wear resistance. Additionally, steels with smaller grain sizes show higher strength. The experiments demonstrated that the following approaches can improve the exploitation properties of steels:

1.Heat Treatment: Reheating and rapid cooling to form martensite, which increases hardness and wear resistance.

2.Modified Alloys: Adding elements such as chromium, molybdenum, and vanadium to improve corrosion and high-temperature resistance.

3.Grain Refining: Reducing the grain size using deformation treatment and thermal methods, which enhances strength.

4.Surface Treatment: Strengthening the steel surface through methods like nitriding, ion plasma coating, and other techniques.

4.Conclusion

The study results indicate that a thorough understanding of the structural composition of high-quality steels and the application of effective processing technologies are essential to improving their exploitation properties. The combination of XRD and SEM methods allowed for precise analysis of steel composition, and effective methods for enhancing hardness and strength were developed. In the future, creating new types of high-quality steel alloys, automating metallographic analysis using artificial intelligence, and developing innovative processing technologies will be highly beneficial. Further research will focus on exploring various steel alloys and their nanostructural properties, as well as developing automated analysis methods with the help of artificial intelligence.

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