ACADEMIC JOURNAL
ISSN 2697-2212

Academic Journal of Digital Economy and Stability
Volume 38, Issue 1 | January-2025

Available Online: *https://economics.academicjournal.io/*

Article

Development of Technology for Chrome-Molybdenum Steels with The Subsequent Use of A Modifier to Improve Mechanical Properties

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Abstract: In modern conditions, improving the technical level of production, product quality, and reducing harmful effects on the environment is an imperative task for all industries, including metallurgy. In this article highlights of development of technology for chrome-molybdenum steels with the subsequent use of a modifier to improve mechanical properties.

Keywords: development, technology, modifier, chrome-molybdenum steels, mechanism, high-quality equipment

Citation: Khalikulov, U. M., Khasanov, A. S., Khamroev, V. B., & Dzheparova, M. N. (2025). Development of technology for chrome-molybdenum steels with the subsequent use of a modifier to improve mechanical properties. Academic Journal of Digital Economy and Stability, 38(1), 187–191.

Received: 30th November 2024
Revised: 11th December 2024
Accepted: 28th December 2024
Published: 11th January 2025

1. Introduction

Modern mining technologies require the use of high-quality equipment capable of operating under conditions of intense abrasive and dynamic impact. The working components of machines that operate in close contact with solid soils and rock formations are subject to significant impact-abrasive wear. This wear leads to a loss of working characteristics of the parts, a decrease in equipment performance, and an increase in operating costs for maintenance and repairs. One of the ways to address this issue is the use of chromium-molybdenum steels, which possess good mechanical properties and wear resistance, making them ideal for application in the mining industry, where components are subjected to heavy mechanical loads and exposure to abrasive materials.

2. Materials and Methods

The main issues that need to be addressed in the production of such steels are ensuring their durability and resistance to intense wear. To achieve this, it is necessary to optimize the chemical composition of the steel, as well as to apply modern modification methods that enhance its performance characteristics. In this context, special attention should be paid to the use of modifiers to improve the crystalline structure and enhance wear resistance, as well as the development of effective melting, pouring, and heat treatment technologies.

The goal of the development. The goal of this development is to create chromium-molybdenum steels with improved mechanical properties that will enhance the wear resistance and durability of working components in mining machinery and equipment. To achieve this goal, it is necessary to conduct a comprehensive optimization of the alloy's chemical composition and implement modifiers into the technological process that contribute to the improvement of the steel's performance characteristics. As a result, this will enhance the efficiency of mining equipment, reduce maintenance costs, and increase the overall productivity of mining processes.

The first stage in the production process of chromium-molybdenum steels is the preparation of the charge. The charge is a mixture of components from which the metal will be produced. It is important to carefully select the steel scrap, as its chemical composition plays a key role in determining the quality of the final product. To achieve this, the scrap undergoes chemical analysis to determine the content of elements such as carbon, silicon, manganese, chromium, and molybdenum. Based on the obtained data, auxiliary materials such as ferrochrome, ferromolybdenum, and ferrosilicon are selected to compensate for the deficiency of the necessary elements.

3. Results

The dosing of components in the charge must be carried out with high precision, as any deviation from the required composition can negatively affect the mechanical properties of the steel. Discrepancies in the concentrations of chemical elements can lead to defects in the material's structure, reduced strength, or increased susceptibility to corrosion. Thus, controlling the composition of the charge is the first and crucial step towards obtaining high-quality material.

In the next stage—melting—steel scrap is heated in electric furnaces or induction furnaces. During the melting process, the metal is enriched with necessary elements such as silicon (Si), manganese (Mn), molybdenum (Mo), and chromium (Cr), which are added to the melt to achieve the optimal chemical composition. Melting plays a crucial role in ensuring the uniform distribution of all elements in the alloy, which subsequently allows for the production of steel with specified mechanical properties.

Main Elements and Their Content in the Chemical Composition of Steel:

- Carbon (C): The carbon content in steel should be within the range of 0.30–0.35% to avoid deterioration of impact toughness, but it should not be too low to prevent a reduction in the material's strength characteristics.
- Silicon (Si): A silicon content of 0.15 to 0.3% is used to stabilize austenite and improve deoxidation.
- Manganese (Mn): Manganese in the amount of 0.7 to 1.0% helps stabilize austenite, enhances strength, and improves hardenability of the steel.
- Chromium (Cr): Chromium content from 0.8 to 1.2% significantly improves the wear resistance of steel.
- Molybdenum (Mo): Molybdenum in the amount of 0.15 to 0.25% increases strength, corrosion resistance, and wear resistance.

The elements contained in the alloy significantly affect the mechanical properties of steel, such as strength, impact toughness, and corrosion resistance. Special attention is given to the addition of chromium and molybdenum, as they play a crucial role in enhancing the wear resistance of the material.

The process of alloy modification involves adding special chemical substances to molten metal in order to improve its structure. Modification is carried out using a tribo-apparatus, which allows for precise dosing of additives and effective control of the crystallization process. Modifiers contribute to the formation of a fine-grained structure, which enhances the mechanical properties of steel and increases its wear resistance.

Moreover, modification contributes to a reduction in grain size, which improves the workability and machinability of steel. The formation of carbides, which are hard particles that enhance wear resistance, plays a key role in improving the operational characteristics of the material. Modification allows for a more uniform structure of the alloy, which enhances its mechanical and operational properties, making it more resistant to impact and abrasive forces.

4. Discussion

After modification, the molten metal is poured into a mold. The pouring temperature is of great importance, as it directly affects the structure and mechanical properties of the casting. An incorrectly selected pouring temperature can lead to defects in the material's structure, such as porosity, cracks, or cold shuts. For chromium-molybdenum steels, the pouring temperature should be within the range of 1500–1510 °C, while the melt temperature during the modification stage should be in the range of 1550–1590 °C.

This temperature regime promotes good mold filling, uniform cooling, and the formation of an appropriate crystalline structure, which in turn ensures a high level of strength and wear resistance of the final components. It is important to note that exceeding the specified temperature range can affect the alloy's structure, negatively impacting its operational characteristics.

After casting, the metal undergoes heat treatment. The heat treatment process includes several stages: quenching and tempering. Quenching is necessary to increase the strength and hardness of the material, while tempering after quenching helps to reduce internal stresses, improving the ductility and impact toughness of the steel.

The quenching process involves the rapid cooling of hot metal, which leads to the formation of hard structures that enhance strength characteristics. However, this can also result in the development of internal stresses that reduce the impact toughness of the material. To eliminate these stresses, the tempering process is used, during which the metal is heated to a specific temperature and held at that temperature for a certain period, allowing for the release of internal stresses and improvement of the material's mechanical properties.

5. Conclusion

The development of technology for chromium-molybdenum steels with improved mechanical properties is a multifaceted process that involves optimizing the chemical composition, using modifiers to enhance the alloy's structure, controlling the pouring temperature, and performing heat treatment. All these stages must be carefully designed and adapted to achieve high operational characteristics such as wear resistance, strength, and impact toughness.

The application of such technology for the production of working components of mining equipment and machines allows for a significant increase in their durability and a reduction in operating costs, which in turn contributes to the overall efficiency of mining processes. The improvement in wear resistance of materials and the enhancement of their reliability help to reduce repair and replacement costs, which is an important factor in increasing the competitiveness of mining companies.

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