IMPROVING THE TECHNOLOGY OF PRODUCING COMPLEX-SHAPED STEEL CASTINGS USING VACUUM MOLDS

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Abstract: This article analyzes the technology of producing complex-shaped steel castings using vacuum molds. Key challenges faced in this process are examined, such as mold material wear, vacuum system efficiency, cooling process issues, and the limited service life of the molds. Suggestions are provided to improve the technology, including the use of high-quality materials, automated control systems, and artificial intelligence capabilities. The proposed solutions demonstrate that it is possible to improve both casting quality and production efficiency.

Keywords: Steel castings, vacuum mold, cooling process, automation, artificial intelligence, mold materials, casting technology.

Objective: The objective is to improve the vacuum mold casting technology for producing complex-shaped steel castings with high quality, identify existing issues, and develop scientifically grounded proposals to eliminate them.

Methods: This study involved analyzing scientific sources related to casting technologies, conducting practical observations, and evaluating current challenges associated with vacuum molds based on advanced foreign experience. The proposed improvements include the use of new materials, automation, and AI-based control technologies.

Results:

The research showed the following:

- Using modern materials reduces mold wear and extends service life.
- Automatic control of the vacuum system improves surface smoothness and internal structure of castings.
- Automating the cooling process helps prevent microcracks.
- Real-time monitoring through artificial intelligence improves the quality of castings.

Conclusion: Improving the vacuum mold casting technology for complex-shaped steel castings contributes to higher production quality and enhanced industrial competitiveness. Integrating advanced technologies can make the production process more stable and efficient.

Introduction

In today's industrial development, the production of complex-shaped steel castings with high accuracy and quality requires new approaches to metal casting technologies. Especially in industries such as aerospace, automotive, energy, and mechanical engineering, there is a growing demand for castings with complex geometry and high mechanical properties. The vacuum mold casting method plays a crucial role in meeting these demands, as it enables the production of castings with smooth surfaces and dense structures while minimizing oxidation.

However, practical implementation of this technology faces several challenges: rapid wear of mold materials, reliability and stability issues in the vacuum system, inconsistencies in the cooling process, and short mold service life negatively impact production quality. Therefore, it is vital to deeply analyze existing technological processes, propose modern solutions, and elevate the technology to a new level.

This article presents an in-depth analysis of vacuum mold technology for producing complex-shaped steel castings, identifies existing challenges, and offers scientifically grounded solutions. Specifically, the study explores the use of high-quality mold materials, automated control systems, and artificial intelligence technologies. These approaches not only improve casting quality but also enhance the overall efficiency of the production process.

Research Methods

A comprehensive scientific approach was employed to analyze the technology of producing complex-shaped steel castings using vacuum molds. Initially, scientific and technical literature, patents, and leading local and international research were reviewed and analyzed. Existing vacuum mold casting technologies used in the foundry industry were evaluated for their advantages and disadvantages.

The following methods were used in the research:

- **Analytical analysis** – to assess the effectiveness and structural/mechanical properties of existing technological processes.
- **Practical observations** – real-world production processes involving vacuum molds were studied, and related issues and malfunctions were documented.
- **Comparative analysis** – different materials, control systems, and cooling methods were compared for their relative effectiveness.

Steel Casting Process Using Vacuum Molds

The production of steel castings is primarily based on casting technologies, one of which is vacuum mold casting. This process typically involves the following stages:

1. **Mold Preparation:** Vacuum molds must be precisely prepared to ensure accurate shaping of the steel. These molds must be heat-resistant and adaptable to produce high-quality, defect-free castings.
2. **Vacuum System:** The vacuum system is used to remove air and gases from the mold. The efficiency of this system directly affects the quality of the castings.

Ways to Improve Technology for Producing Complex-Shaped Steel Castings:

High-Quality Mold Materials: It is essential to develop advanced ceramic and new metal materials for vacuum molds. These materials should have high thermal resistance and wear resistance. For example, the use of carbon-based materials can increase mold service life.

Modernization of the Vacuum System: To enhance the efficiency of the vacuum system, automatic control systems and high-performance vacuum pumps can be implemented. Ensuring fast and efficient operation of the vacuum system improves casting quality and increases overall production efficiency.

Conclusion

Improving the technology of producing complex-shaped steel castings using vacuum molds is crucial for enhancing casting quality and production efficiency. To optimize the vacuum molding process, it is necessary to employ new materials, modern vacuum systems, automated control, and artificial intelligence technologies. These proposals contribute to increased production efficiency, improved casting quality, and strengthened industrial competitiveness.

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