Application of Rapid Manufacturing Process & Equipment System for Large Complex Light Alloy Structural Components

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Abstract: This paper introduces the key technologies of light alloy fire-retardant sand printing and forming processes, including material system optimization, feedstock ratios, mixing methods, and in-house developed additive manufacturing equipment. Through the shape-controllable composite mold technology, the challenges of matching and precise regulation between mold and casting properties have been addressed, enabling rapid manufacturing through mold-less composite forming. The impact of multi-material composite molds on the performance of castings has been investigated, leading to the invention of corresponding control principles and assembly methods. Furthermore, addressing the influence of sand parameters on forming quality and tool wear, formulas comprising materials such as quartz sand, zircon sand, and chromite sand have been devised, achieving synergistic optimization of mold properties. Finally, for future needs, ceramic core additive manufacturing equipment has been developed to further advance material forming technology.

Keywords: Rapid manufacturing, Multi-material, Light alloy

1 Introduction

The advancement of manufacturing technologies has been pivotal in the evolution of industrial production, particularly in the realm of casting processes. This paper delves into the innovative domain of light alloy fire-retardant sand printing and forming, a field that has witnessed significant strides in recent years. The research presented here encapsulates the core technologies that have been instrumental in enhancing the efficiency, precision, and adaptability of casting processes, thereby facilitating the rapid manufacturing of complex components with high dimensional accuracy and material integrity.

Light alloy fire-retardant sand printing and forming

The core of this research lies in the optimization of the sand material system for the printing process. The study delves into the effects of various parameters such as the content of curing agents, the shape function of the wedge-shaped sand spreading mouth, and the particle size distribution of the original sand [1]. These factors are critical in determining the mechanical properties of the sand molds, including their resistance to deformation and flow characteristics.

Material system and additive manufacturing equipment

The paper presents a detailed analysis of the composite flame retardant raw materials, highlighting the importance of pre-dispersion and high-precision addition. The study also emphasizes the need for thorough mixing with the original sand to achieve a homogenous mixture [2]. The optimization of the flame retardant additive quantity is crucial, as it directly impacts the mechanical strength and gas emission properties of the sand molds. The data presented in the paper demonstrates the relationship between the flame retardant content and the resulting tensile and flexural strengths, as well as the gas emission volume and permeability of the sand molds [3]. And a fire-retardant additive manufacturing equipment has been developed, as shown in Figure 1.

Fig.1 Fire-retardant additive manufacturing equipment

Shape-controllable composite mold technology

One of the key contributions of this research is the invention of shape-controllable composite mold technology, as shown in Figure 2. This technology addresses the longstanding challenges of matching and precise regulation between mold and casting properties [4]. By establishing an active control mechanism for different types of sand materials, the technology ensures that the mold's shape and properties are precisely tailored to the requirements of the casting process.

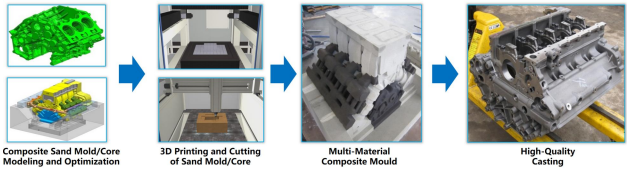

Fig.2 Mold-less composite forming

Impact of multi-material composite molds

As shown in Figure 3, the research has also investigated the impact of multi-material composite molds on the performance of castings. Through a series of experiments, the influence of different types of sand, such as quartz sand, zircon sand, and chromite sand, on the temperature field, microstructure, and mechanical properties of the castings has been studied [5, 6]. This has led to the invention of control principles and assembly methods that are specifically tailored to the needs of high-quality casting production.

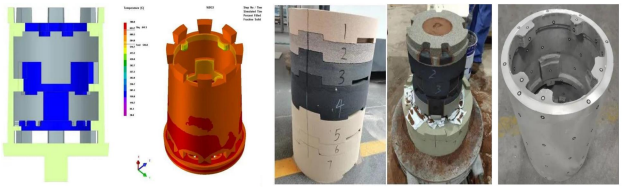

Fig.3 Manufacturing technique of multi-material composite molds

Synergistic optimization of mold properties

Addressing the influence of sand parameters on forming quality and tool wear, this study has formulated materials that are capable of synergistic optimization of mold properties [7]. The formulations have been designed to control the mold's permeability, curing strength, and cutting performance, ensuring that the molds are not only suitable for the casting of complex components but also exhibit high dimensional stability and resistance to wear.

2 Product cases

Casing Category

Casing Sand Mold: Dimensions 542mm x 446mm x 244mm. Using moldless composite precision forming technology, a sand mold with dimensional accuracy of ±0.5mm was obtained within two days, allowing the casting of 3mm thick-wall products that meet usage requirements.

Compartment category

Transition Section Sand Mold: Dimensions 2400 mm × 2400 mm × 1000 mm, weight 5000 kg. Using moldless forming technology, one set was completed within three days, controlling wall thickness error to within 0.5mm, completing high-precision assembly of separate sand molds and preliminary development of the compartment.

Shell category

Shell Part Sand Mold: Dimensions 700 mm × 700 mm× 500 mm, weight 250 kg. Using moldless forming technology, two sets were completed within two days, controlling wall thickness error to within ±0.5 mm, meeting the rapid production requirements of thin-walled parts.

3 Conclusion

This paper presents a comprehensive study on the key technologies that underpin the rapid and efficient manufacturing of light alloy components through fire-retardant sand printing and forming processes. The innovations discussed herein have the potential to revolutionize the casting industry by offering solutions that are not only cost-effective but also environmentally friendly and adaptable to a wide range of applications.

References

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