

Applications of 3D Printing Technology in Sand Casting

Qingwen Chen*, Garrison Zong

3D Printing Technology, Inc., Beijing, China

*Corresponding address: e-mail: qingwen.chen@3dptek.com

Abstract: Compared with the traditional casting process, 3D printing technology aided sand casting has advantages in terms of efficiency, cost and quality in high-end complex structural parts casting. This paper details the use of a 3D printing composite process that combines an SLS resin coated sand core with 3DP resin sand shell to create a combined sand mold for casting key components of the aero-engine, and produced casting products of complex structural parts with large thin-walled, complex small pipelines and other complex structures. And the use of 3DP sand mold combined with low-pressure casting technology and advanced solidification control process, produced the casting of key components of an underwater vehicle power unit with large-size thin-walled structure and complex runners. It further discusses the impact of 3D printing on the cost, quality, environmental protection, and other aspects in the application of sand casting. It was found that printing process parameters affect the cost of sand molds, for example, increasing the thickness of the printing layer can significantly reduce the printing cost.

Keywords: 3D Printing, Sand Casting, Precision Casting, High-end Complex Structure Casting, SLS, 3DP, EP, Intelligent

1 Introduction

3D printing technology is a multidisciplinary technique based on digital models, integrating laser technology, inkjet technology, and more. It uses filament or powder materials to construct objects directly through the layer-by-layer stacking of materials without the need for molds. In the field of high-end complex structural parts casting, the integration of 3D printing technology with sand casting technology has led to the development of rapid sand mold casting technology, which has shortened the production cycle of products, with saving development time and costs, and enhancing the performance and quality of products, and thus promoting the transformation and upgrading of the high-end complex product manufacturing industry.

1. The Current State of 3D Printing Technology

High-end complex structural parts have a wide range of application demands across various fields. In the field of high-end complex structural part casting, traditional

casting processes often face many challenges, such as long mold production cycles, high costs, and difficulty in adapting to the production of increasingly complex structural parts. 3D printing sand mold casting technology provides effective solutions to these problems and shows significant advantages. Therefore, this technology has been widely applied in the fields of new energy vehicles, energy power, aerospace, and so on. In recent years, the key technologies of 3D printed sand molds, Selective Laser Sintering (SLS) and Three Dimension Printing (3DP) have begun to be applied on a large scale in sand mold casting production services.

2. Introduction to 3DP Technology and Application Cases

This paper elaborates on the principles of 3DP technology and the sand mold casting process workflow, comparing to the conventional sand mold casting process, to demonstrate the efficiency and cost benefits of 3D printed sand mold technology in the casting of high-end complex structural parts. It showcases an application example of 3DP casting technology in the propulsion devices of modern underwater vehicles, with large dimensions, thin walls, ribs and protrusions, and intricate curved flow channels, which present challenges to traditional casting techniques. This paper delves into the use of 3DP sand printer to construct casting sand molds, allowing the flow channels to conform to more complex curved surface designs. Utilizing low-pressure precision casting technology, a gap-style casting system was thoughtfully designed, and state-of-the-art solidification control techniques were employed, enabling the casting of large-sized thin-walled structures and complex flow channels with an overall dimension exceeding 2 meters and a wall thickness of 5-7mm.

3. Introduction to SLS Technology and the Application of SLS-3DP Composite Process

This paper outlines the working principle of SLS technology and the process flow of sand mold casting, followed by an introduction to the composite sand mold casting process that integrates both SLS and 3DP technologies. It then elaborates on the application of this composite technique in the casting of casing components for aero-engines. Traditional casting methods encounter considerable challenges when manufacturing large, thin-walled, and intricate structures with fine channels. The adoption of a composite process involving SLS and 3DP

printing has become an innovative and efficient solution. Utilizing SLS technology, the laser sintering of specialized coated sand forms sand cores with dimensional precision of $\pm 0.1\text{mm}$, and the tensile strength in specific areas exceeds 4MPa, capable of creating complex structures with fine channels. For sand shells that are less complex but large scale, the 3DP technology uses inkjet bonding of silica sand, facilitating lightweight design, and ensuring high molding efficiency and reduced costs while maintaining quality.

5. Analysis and Summary

In the traditional sand mold casting process, especially in the fields of high-end complex structural parts and large structural parts, the mold-making cycle is long and the costs are high. 3D printing sand mold technology provides a completely new solution for the manufacturing of casting sand molds and demonstrates significant advantages. The advantages of 3D printing technology in the application of sand mold casting in terms of cost, efficiency, quality, intelligence, and environmental protection were also discussed.

6. Conclusion and Prospects

The application of 3D printing sand mold technology in the casting industry has propelled the development and innovation of traditional casting techniques, bringing more innovation and breakthroughs to the sand mold casting field. It has facilitated the transformation and upgrading of the traditional casting industry and plays a significant role in the intelligent, green, and high-end development of the casting industry. With the continuous research and development of new 3D printing technologies, materials, and processes, as well as the integration of advanced manufacturing technologies such as digitalization and intelligentization, rapid sand mold casting technology will continue to reduce costs, improve quality, and increase efficiency. The application prospects of 3D printing technology in the sand mold casting field will be even broader.