

Research Progress of Modeling and Casting Technology of Zirconium Alloy

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Abstract: Zirconium and zirconium alloy are very important strategic metallic materials in the 21st century. With the advantages of low neutron absorption rate, corrosion resistance and high temperature resistance, they are widely used in chemical equipment manufacturing and nuclear industry. In recent years, zirconium and zirconium alloy have attracted more and more attention from researchers at home and abroad, and the research on modeling and casting technology has been developed rapidly. This paper introduces the main application scenarios and development of zirconium and zirconium alloys, presents the research status and progress of the casting processes by comparison, then points out the problems and difficulties and finally the development prospect of zirconium and zirconium alloy casting technologies.

Keywords: Zirconium; Zirconium alloy; Casting process; Overview;

1 Introduction

This paper is a review paper, which mainly discusses the research progress of zirconium and zirconium alloy casting technology. This paper successively introduces the characteristics and applications, the R&D history and the research progress on modeling technology of zirconium and zirconium alloys. In addition, the smelting technology of zirconium and zirconium alloys such as vacuum self-consumable electrode arc condensation shell technology and vacuum induction condensation shell technology, as well as the modeling technology of zirconium and zirconium alloys such as hard mold casting, sand casting and investment casting are systematically described. Finally, the problems existing in the casting process and forming technology of zirconium and zirconium alloys are summarized, and the future development trend is proposed.

2 Experimental procedure

The smelting technology and formative technology of zirconium and zirconium alloy are mainly introduced. Smelting technology includes vacuum consumable arc melting and vacuum induction melting. Both smelting techniques have their own advantages and disadvantages, and are widely used in the field of zirconium and zirconium alloy casting.

The molding process includes hard die casting, sand type casting and investment casting. Hard die casting is the use of metal shells and graphite shells for casting. In contrast, the metal type is high cost and short life, is not often used. But graphitic shells are often used to produce large castings. Sand casting has a low frequency of use in industrial production. The investment casting has low modeling cost, and the casting quality is high, which is widely used in industrial production, and more related experimental research. Oxides are often used as a surface refractory material.

3 Result and discussion

Vacuum consumable electric arc furnace melts the electrode generated by the arc discharge between the self-consuming electrode and the crystallization holder. Vacuum induction smelting is a method of heating metal using the magnetic field generated by the induction coil in a sheet water-cooled copper container.

In metal casting, cast steel, cast iron and other materials are mainly used as the type shell. Graphite casting uses high purity, fully graphitized artificial graphite electrode blocks. Sand casting uses bauxite as type sand, type sand surface is coated with a layer of oxide coating, used as zirconium and zirconium alloy casting sand type. The materials used as the mold casting layer are graphite powder, refractory metals, refractory compounds and oxides. The most commonly used materials are oxides, such as yttria, zirconia, etc.

4 Conclusion

1) Compared with other common metals, the research of zirconium and zirconium alloy started late and developed slowly, with only more than 70 years of development history, but zirconium and zirconium alloy are an indispensable material today, especially in the field of nuclear industry, and there is still a long way to go for the research on zirconium and zirconium alloy casting process.

2) At present, there are three main methods for zirconium and zirconium alloy casting: hard mold casting, sand casting and investment casting, among which sand casting is almost not used in industrial production; Hard mold casting is mainly used in large castings with simple structure and low requirements for surface quality, and machined graphite type is generally used; Investment casting is suitable for small and medium-sized castings

with complex structure and high dimensional accuracy requirements, and oxide is generally selected as the shell surface layer material. At present, the commonly used refractories still cannot meet the quality requirements of zirconium alloy castings, and further research is needed to find new refractories with excellent performance, high matching degree with zirconium alloy castings and reasonable cost. BaZrO₃ is a new type of refractory material under development, which has lower cost and unique properties than Y₂O₃ and ZrO₂, and has a good application prospect in zirconium and zirconium alloy casting.

3) Vacuum self-consumable electrode condensation shell technology is the main smelting method of zirconium and zirconium alloys, but its energy consumption is high and the process is complex. Vacuum induction shell technology is less costly than it, and the temperature of the molten metal can be controlled more uniformly, the filling capacity is improved, and the quality of zirconium and zirconium alloy castings can be effectively improved.

Acknowledgments

This work was financially sponsored by Liaoning Provincial Science and Technology Plan Joint Plan Project in 2023(2023020930-JH2/1017).

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