

Research, Application and Development of Inorganic Binder for Casting Process

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Abstract: Inorganic binder used in casting process has the advantages of low odor, labor-friendly conditions, and relatively low cost, which is one of the main development directions for casting molding materials in the future. However, compared to organic binders (such as resin binders), inorganic binders exhibit lower bonding strength and are more sensitive to environmental humidity. This sensitivity poses challenges, particularly in the reclamation of used sand, thus limiting their broader application. In this paper, the research and application status of inorganic binders (mainly silicate inorganic binders) and their curing methods are summarized. Meanwhile, the development direction of inorganic binders is clarified.

Keywords: inorganic binder; silicate system; used sand reclamation; development trend

1 Introduction

With the increasingly stringent environmental regulations. foundries are under pressure to enhance their development and adopt eco-friendly inorganic binder sand casting technology. There is a particular focus on improving and refining silicate inorganic binders with the aim of replacing organic binder sand casting processes with more environmentally friendly alternatives ^[1-3]. The development of silicate inorganic binder has generally undergone four stages: CO₂ cured sodium silicate sand process, powder cured sodium silicate sand process, ester cured sodium silicate sand process, and new silicate inorganic binder sand process. Currently, the CO₂ cured sodium silicate sand process and the ester cured sodium silicate sand process are mainly used in the production of steel castings, while the new silicate inorganic binder sand process is mainly applied in aluminum alloy castings^[4, 5].

At present, silicate inorganic binders remain the most successful environmentally friendly binders applied in sand casting process. This paper focuses on the research and application status of silicate inorganic binders and their curing methods. Finally, the future development direction of inorganic binders for casting process is discussed.

Silicate system inorganic binder

Currently, the inorganic binders used in the foundry industry mainly refer to sodium silicate binders ^[6]. According to different curing methods and a wide range of applications, silicate inorganic binders have undergone four development stages, as shown in Fig. 1. Among them, CO₂

cured sodium silicate sand process and ester cured sodium silicate sand process are mainly used in the manufacturing of steel castings in industries such as railway, shipbuilding, and engineering machinery. However, the new silicate inorganic binder sand process cannot withstand high temperatures and is mainly used for aluminum alloy casting.



Fig. 1. Development of silicate inorganic binder

CO2 cured sodium silicate sand process

The CO₂ cured sodium silicate sand process involves blowing CO₂ gas into the sodium silicate sand to harden the sodium silicate binder, thereby achieving the bonding strength. Currently, the ordinary CO₂ cured sodium silicate sand process still has a large application market in the production of steel castings because of its simple process operation, low cost, rapid hardening speed, and strong adaptability. However, with increasingly strict environmental requirements, the adoption of new CO₂ cured sodium silicate sand processes, such as modified sodium silicate binder combined with gas-blowing processes like pulse method and heating method, further reduces the dosage of sodium silicate (<3%), and improves the bonding strength and heat collapsibility. This is expected to be the development trend of the CO₂ cured sodium silicate sand process.

Ester cured sodium silicate sand process

Ester cured sodium silicate sand has the comprehensive advantages of sodium silicate sand and resin self-hardening sand, such as high bonding strength, adjustable curing speed, convenient operation, good working environment. Furthermore, the dosage of sodium silicate binder can be decreased to 3.5%-4.5%. In addition, the ester-cured modified sodium silicate sand process can further decrease the content of sodium silicate binder to less than 3%. At present, the new ester cured sodium silicate sand process is gradually replacing ordinary sodium silicate sand and part of resin self-hardening sand process in the actual



production of steel castings for industries such as metallurgy and mining machinery, rail transit, engineering machinery, coal mining machinery, and pump valves, etc. With the continuous improvement of this process, as well as the technical and equipment levels of modified sodium silicate materials, the new ester cured sodium silicate sand process has become the preferred technology for the production of steel castings.

New silicate inorganic binder sand for aluminum alloy

At the beginning of the 21st century, German company HA developed the Cordis system inorganic binder, and the ASK company invented the INOTEC system inorganic binders, which are suitable for aluminum alloy castings ^[7]. This process uses a modified alkaline silicate binder (1.8%-2.5%, based on sand weight) and a metal oxide powder (approximately 50%, based on binder weight), and is cured under hot air (150 °C-200 °C) conditions. Fig. 2 shows the comparative results of tar content and harmful gas emissions in the core making process ^[8].



In the past decade, Chinese foundry material manufacturers and research institutions have successively developed various new silicate inorganic binder materials based on modified sodium silicate and conducted production trials. They have achieved good results in several areas, including the inorganic binder warm box process, composite blow air cold box process, and inorganic coated sand process.

2 Conclusion

CO₂ cured sodium silicate sand and ester cured sodium silicate sand remain the most widely used inorganic binder sand in the production of steel castings, while new silicate inorganic binder sand has seen rapid development and application in the production of aluminum alloy castings. For silicate inorganic binders, whether applied to steel castings or aluminum alloy castings, improving the ambient temperature strength of molding (core) sand, enhancing the collapsibility of used sand, and promoting the reusability of reclaimed sand are the goals pursued in the development of this type of inorganic binder. Furthermore, deeper research is needed into the bonding mechanism and hardening characteristics of silicate inorganic binders, improving the quality of binder and hardener materials, refining traditional curing methods, processes, and equipment, and focusing on solving the recycling and reclamation problem of used sand.

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