Study on the Specificity of Artificial Spherical Ceramic Casting Sands

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Abstract: The common production processes for artificial spherical ceramic casting sands include fusion blowing, sintering after spray granulation, and sintering after rolling granulation. Spherical ceramic casting sand produced by the fusion blowing process is referred to as fused ceramic casting sand; those produced by spray granulation and rolling granulation are known as sintered ceramic casting sand. The surface of fused ceramic casting sand can be described as "smooth orange peel", the main crystalline phase being amorphous phase, corundum phase and with a small amount of mullite phase; the surface microstructure of sintered ceramic casting sands is "rough orange peel", the main crystalline phases being mullite phase, amorphous, and a small amount of corundum phase or quartz. Compared to sintered ceramic casting sands, fused ceramic casting sand has lower thermal stability, poorer impact abrasion resistance, and higher density; and for the same mold (core), results in higher sand usage and higher gas emission.

Keywords: spherical; ceramic; foundry sand; specificity

1 Introduction

Artificial spherical ceramic foundry sand has spherical shape, high refractoriness, low acid consumption, and low thermal expansion, making it suitable for various sand casting processes and for various alloy casting materials. In addition to the common properties of ceramic materials such as high strength, hardness, wear resistance, and high temperature resistance [1], ceramic foundry sand also possesses specific characteristics attributed to its preparation process, chemical composition, and microstructure. These specific characteristics lead to subtle differences in the casting performance of artificial spherical ceramic foundry sands. This article takes artificial spherical ceramic foundry sand prepared from Al-Si refractory raw materials as an example to introduce the specificity of artificial spherical ceramic foundry sands and their correlation with casting process performance.

1. Types of artificial spherical ceramic foundry sands

The common production processes for artificial spherical ceramic casting sand include fusion blowing, spray granulation, or rolling granulation, followed by sintering. Fusion blowing involves mixing sand-making materials and fusing them into a liquid in a furnace. When the liquefied material exits the furnace, it is blown with high-speed airflow to disperse it into small droplets. The droplets finally form spherical sand particles. These particles are then sieved and graded to obtain artificial spherical ceramic casting sand. The artificial spherical ceramic casting sand produced by the fusion blowing process is referred to as fused ceramic casting sand, with commercial names such as 'Baozhu Sand', etc.

Spray granulation includes two main processes: spraying and drying. The sand-making materials are mixed, crushed, and pulverized, then made into a uniform slurry with a proper solid content. This slurry is sprayed into mist-like micro-droplets in a hot airflow environment, where the moisture is evaporated by the hot air. The solid phase within the droplets aggregates into dry particles (sand blanks). The sand blanks are then dried, sintered, cooled, sieved, and graded to obtain sintered ceramic casting sand.

Rolling granulation involves first mixing and pulverizing the sand-making materials, then placing the powdered materials into a rotating granulation disk. The sand billet is made by rolling granulation process. The sand blanks are then dried, sintered, cooled, sieved, and grading to obtain sintered ceramic casting sand.

Sintered ceramic casting sands commercial names include Cerabeads, CPS, etc.

2. The specificity of artificial spherical ceramic foundry sands

The specificity of artificial spherical ceramic foundry sand mainly lies in three aspects: morphology, structure, and density of the sand. Taking the fused ceramic foundry sand produced by a certain company and the sintered ceramic foundry sand produced by Shandong Jinpu New Materials Co., Ltd. as research objects, their morphology and structure were observed under electron microscope and X-ray diffractometer, and their bulk density and true density were measured using the tapping method.

It can be seen that both the fused ceramic foundry sand and the sintered ceramic foundry sand exhibit uniformly spherical grain shapes. When observed under relatively low magnification, both show smooth porcelain-like surfaces. Upon further magnification, it is observed that the surface of the fused ceramic foundry sand appears to have a "smooth orange peel", while the surface of the sintered ceramic foundry sand appears "rough orange peel."

It can be observed that sintered ceramic foundry sand is composed of mullite phase, amorphous structure, and a small amount of quartz phase. The fused ceramic foundry sand, on the other hand, consists of an amorphous structure, corundum phase, and mullite phase. The content of the amorphous structure in fused ceramic foundry sand is much higher than that in sintered ceramic foundry sand. The true density and bulk density of fused ceramic foundry sand are higher than those of sintered ceramic foundry sand.

3. Correlation between the specificity of artificial spherical ceramic sands and performance of casting process

The sintered ceramic foundry sand and the fused ceramic foundry sand were separately placed into a ball mill for grinding. After 30 minutes of milling, the surface of the fused ceramic foundry sand surface was damaged, while it took 60 minutes of milling for the surface of the sintered ceramic foundry sand to exhibit similar damage. This indicates that the sintered ceramic foundry sand has a better resistance to impact, abrasion, and damage compared to the fused ceramic foundry sand.

The average bulk density of fused ceramic foundry sand is 1.31 times greater than that of sintered ceramic foundry sand. When manufacturing the same mold (core), the amount of fused ceramic foundry sand used will be 1.31 times that of sintered ceramic foundry sand.

The ceramic foundry sand samples were heated to 1400°C and then cooled to room temperature. The amorphous content before and after calcination was determined using X-ray diffraction. It was found that before calcination, the fused ceramic foundry sand had a significantly higher amorphous content than the sintered ceramic foundry sand. After calcination at 1400°C, the amorphous content in the sintered ceramic foundry sand remained essentially unchanged, while the amorphous content in the fused ceramic foundry sand decreased significantly.

2 Conclusion

(1) The surface of fused ceramic foundry sand exhibits a "smooth orange peel" appearance, with its matrix composed of amorphous structure, corundum phase, and a small amount of mullite phase. The surface of sintered ceramic foundry sand appears as "rough orange peel" and its matrix comprises mullite phase, amorphous structure, and a small amount of quartz phase.

(2) Compared to sintered ceramic foundry sand, fused ceramic foundry sands demonstrate reduced thermal stability and poorer resistance to impact and abrasion.

(3) The density of fused ceramic foundry sand is higher than that of sintered ceramic foundry sand and for the same mold (core), results in higher sand usage and higher gas emission.

References

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