Kailin Foundry
Material

Application of Kailin Ceramic Foundry Sand on Heavy Steel Castings

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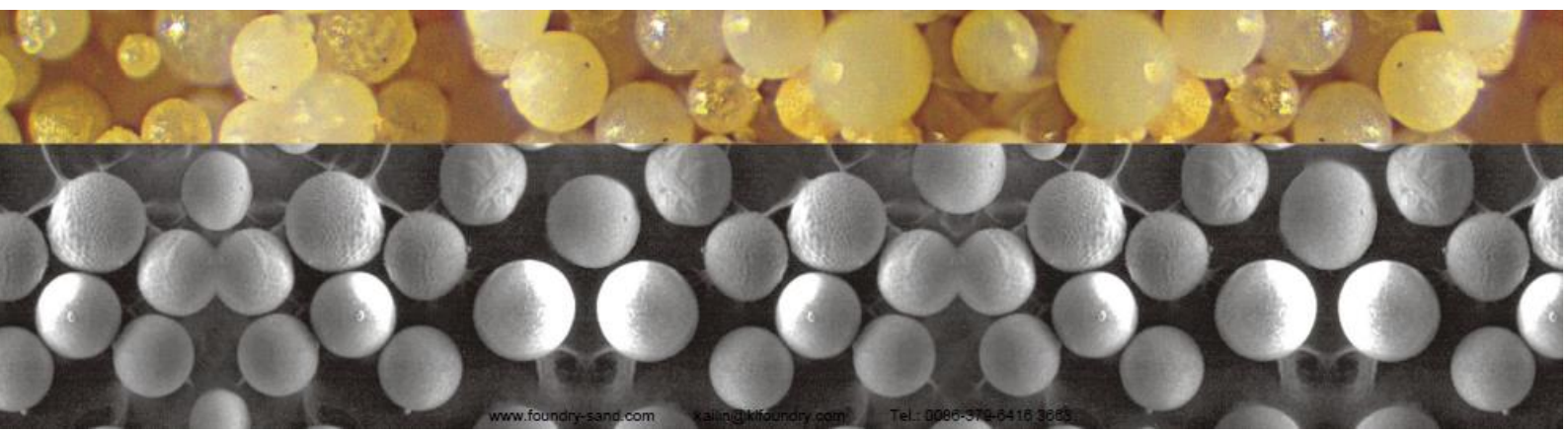

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Abstract:

To solve the problem of metal penetration and burn-on, veins and sometimes sand sintering at riser pad of heavy steel casting, foundry men take advantages of using alkaline phenolic resin boned sand or sodium silicate bonded sand with Kailin ceramic sand, finding that those problems and defects are successfully solved. And, the waste sand and dust emission are remarkably reduced.

1. Introduction

Heavy steel castings usually require tens or even hundreds of tons of molten steel to be poured, and some sand cores are soaked by a large amount of molten steel. And the thermal action time of molten steel on the molding material is very long, the hydrostatic pressure is also very high, and the working conditions are extremely harsh. Therefore, the chromite sand is used as facing sand in the production of heavy steel castings. At present, the better quality chromite ore is a high-quality for foundry use are mainly imported from South Africa. Using chromite sand as the core material, although the expansion rate is low,its grain shape is rather angular, so the sand flowability is poor, which will lead to poor performance of gas permeability and shake-out thereafter. In some cases (Such as some thin-skin or blind-hole sand cores), even chromite sand is difficult to be shaken out, correspondingly increased the finishing work of castings. The production of large-scale heavy steel castings has been using water-glass (sodium silicate) sand CO_2 technology since the 1970s. With the increasing demand for product quality, this casting process has been difficult to meet the requirements for casting quality. In most cases follow-up grinding and other means are needed to achieve the quality requirements of castings, which will not only increase the manufacturing cost of castings, but also extend the production cycle of castings. The use of Kailin ceramic foundry sand in heavy steel castings, such as the fillets, grooves and hot spots concentrated in slender holes, can eliminate local metal penetration and burn-on, reduce the cleaning cost of castings and improve the surface quality of castings

At present, many large-scale heavy steel foundries have undergone technological transformation, using alkali phenolic resin bonded sand, furan resin bonded sand or ester hardened water-glass (sodium silicate) bonded sand. Ester hardened alkali phenolic resin bonded sand has a history of more than 30 years since developed by the British Borden company in 1980. Due to its advantages in environmental protection and other aspects, more and more steel foundries have adopted this production process. For the superior physical and chemical properties of Kailin ceramic foundry sand, alkali phenolic resin bonded sand is currently widely used in the production of steel castings and has been well welcomed by customers.

2. Experiment Materials and Methods

Ceramic foundry sand is also known as fused ceramic sand for foundry. It is made by spraying the melted the high-quality calcined bauxite raw materials in the molten state to obtain spherical or nearly spherical sand particles with smooth surfaces. Figure 1 is a photomicrograph of ceramic foundry sand.

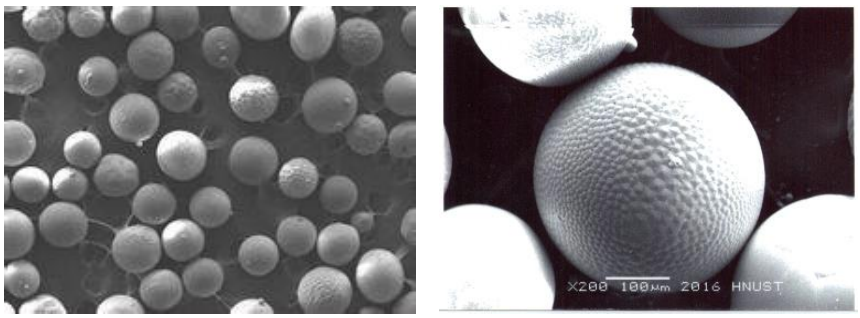


Figure 1 Photomicrograph of ceramic foundry sand

Ceramic foundry sand has the advantages of high thermal resistance, good permeability, easy to breakdown, acid and alkali corrosion resistance, and low crushing rate. Its physical and chemical properties are shown in Table 1.

Table 1 Physical and Chemical Properties of Kailin Ceramic Foundry Sand

Grain shape	spheroidal	Color	Dark Brown	Angularity Coefficient	＜1.1
Thermal Conductivity	(1200 ℃)5.27W/M·K	Al_2O_3	65-85%	SiO_2	12~25%
Expansion Coefficient	(20~1000℃)6×10^{-6}/℃	Fe_2O_3	≤5%	TiO_2	3~4.5%
Bulk Specific Weight	1.95-2.05g/cm^3	True Density	3.4g/cm^3	Refractory Temperature	＞1800℃
Particle Size	6~320 Mesh(φ0.053~3.36mm)	PH	7~8		

It can be seen from the comparison of Ceramic foundry sand, chromite sand and silica sand in Table 2 that the bulk density of ceramic foundry sand is only 0.67~0.71 times that of chromite sand, and the shape of ceramic foundry sand is spherical with the minimal consumption of resin and curing agent or catalyst. Ceramic foundry sand is inert, it's suitable for various steel castings (carbon steel, alloyed, manganese steel, etc.). In addition to the above advantages, Ceramic foundry sand also has advantages over chromite sand in terms of lower price and easily recycling.

Table2 Properties comparison between ceramic foundry sand, silicon sand and chromite sand[1]

Items	PH Value	Refractory /℃	Bulk Density /t·m^{-3}	Thermal Conductivity /W（m·K）	Thermal Expansion /%	Specific heat capacity /J·（kg·K）$^{-1}$
Silica sand	7~8	1710	1.4~1.5	0.7~0.8	1.5	1130
Ceramic Sand	7.6	1800	1.9~2.0	0.5~0.6	0.13	2210
Chromite Sand	7.8	1830	2.8	0.65	0.3~0.4	1214

Note: The method for measuring the thermal expansion rate is to make a φ35×55mm cylindrical specimen of mixed sand with a binder, and after it is fully hardened, heat it to 1000°C for 5 minutes, measure the dimensional change, and calculate the expansion rate.

Alkaline phenolic resin bonded ceramic foundry sand does not contain harmful elements such as N, P, S, etc. It has good hot deformability, good hardness and permeability, so it is very suitable for the production of heavy steel castings. Since the ceramic foundry sand is spherical and has the smallest surface area, the amount of water-glass or resin addition will also be greatly reduced. Consider of the actual situation of the steel casting manufacturer, the particle size distribution of the selected ceramic foundry sand is shown in Table 3.

Table3 the size distribution of ceramic foundry sand

Size	Sieve number and remaining amount on the sieve (mass fraction, %)								
	20 Mesh	30 Mesh	40 Mesh	50 Mesh	100 Mesh	140 Mesh	200 Mesh	270 Mesh	Floor Offer
KL01	＜5	80~95	5~10	＜5	/	/	/	/	/
KL02		/	/	/	/	＜5	45~60	25~40	＜25

3. Experiment items and results

3.1 Experiment object

It is the slag pot used in the small batch of carbon steel castings. Because the slag pot needs to be in frequent contact with high-temperature smelting slag, it is prone to thermal fatigue. Therefore, cracks, shrinkage holes, porosity, pores, slag inclusion and other casting defects that affect the quality of the casting are not allowed. This slag pot weights 17000kg, has a wall thickness of 70 mm. Figure 2 is a schematic diagram of the slag pot casting structure.

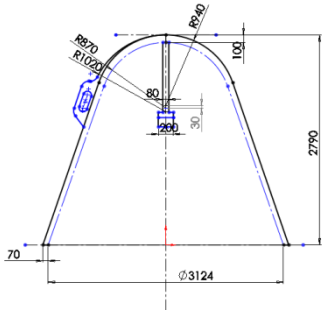


Figure 2 Schematic diagram of the slag pot casting structure

Due to the violent and long-term heat action between the thick and large surface of the slag pot and the molten metal, when chromite sand was selected for the facing sand, it was found that the upper and lower surfaces of the casting were severely penetrated with steel after shakeout, which increased the difficulty of cleaning and fettling by the workers. Now alkali phenolic resin bonded ceramic foundry sand is chosen as the surface sand of the sand mold instead of chromite sand, and the back sand can use water-glass (sodium silicate) bonded silica sand.

3.2 Molding sand preparation

1) Use a continuous sand mixer or a bowl-type sand mixer to mix 50% KL01 ceramic foundry sand and 50% KL02 ceramic foundry sand. The resin addition (accounting for the amount of sand) is 0.8%, and the curing agent addition (accounting for the amount of resin) is 20%, first mix the ceramic foundry sand and the catalyst evenly, and then add the resin mixture. The sand mixing time is generally 1~3 mins, and the sand is used immediately after mixing.
1) Use a continuous sand mixer or a bowl-type sand mixer to mix 70% KL01 ceramic foundry sand and 30% KL02 ceramic foundry sand, and the amount of water-glass addition is 4.5%. The sand mixing time is generally 8~15 mins, and the sand is used immediately after mixing.

3.3 Experiment results

Compared with the original chromite facing sand, using water-glass (sodium silicate) bonded ceramic foundry sand/alkali phenolic resin bonded ceramic foundry sand for the slag pot casting as facing sand, the quality of castings is significantly improved. The surface of the casting is smooth and clean, the contour is clear, the tendency of casting cracks and pores is reduced; the efficiency of molding and core making is significantly improved; due to the significant improvement of shake-out, the casting cleaning and fettling time is cut down to half; the workload of casting finishing is greatly reduced. Figure 3 shows the comparison of the surface of the slag pot after shakeout and cleaning. It illustrates that the shakeout and break-down of sand is easy and the surface of the casting is smooth and clean when using ceramic foundry sand. When using chromite sand, the core sand has poor collapsibility and serious metal penetration and burn-on on the casting surface.

（a） （b） （c） （d）

Figure 3 Comparison of chromite sand and ceramic foundry sand as facing sand
(a) & (b) By using Chromite sand；(c) & (d) By using Ceramic foundry sand

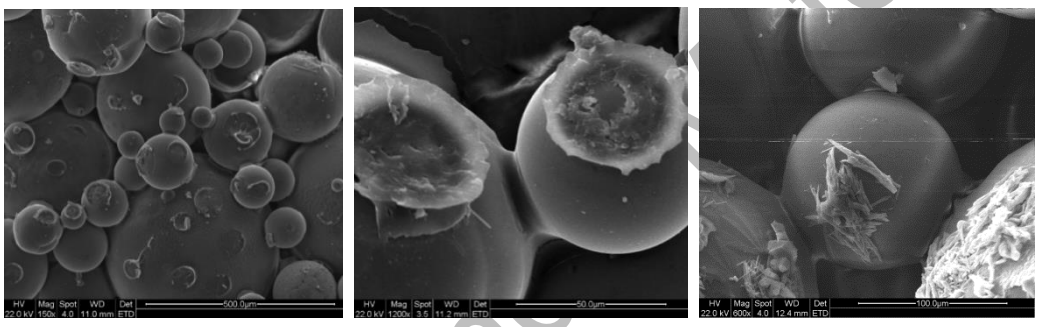
4. Analysis of experiment results

4.1 Analysis of ceramic foundry sand to prevent metal penetration and burn-on

Chromite sand is used to prevent the penetration of molten metal, generally because the molten chromite ore closes the pores at the interface between the melted metal and mold sand. Many large steel foundries, after using chromite sand as facing sand, find severe metal penetration and sand burn-on, which seriously affect the surface quality of steel castings. Studies have shown that this is

due to the REDOX reaction between chromite sand at the interface and high chromium steel or between chromite sand and resin carbonation film, the iron in chromite sand is reduced out, and this reduced iron and sand particles form a dense mixture and closely adhered to the surface of the casting and the formation of "glaze" clay sand [2]. In addition, the use of chromite sand with high clay content and many impurities will often cause sand burn-on defects in castings.

Due to its high refractoriness, the thermal expansion rate of Kailin ceramic foundry sand is almost zero. Its anti-penetration principles lie on its fine grained particle size, which closes the gaps between sand particles. In addition, because ceramic foundry sand grains are close to the spherical shape, they have good flowability, can be uniformly covered by the binder, and can obtain a smooth mold and core surface, dense structure and good permeability. Using ceramic foundry sand as facing sand can not only improve the dimensional accuracy of castings, prevent sand sintering, sand inclusion, molten metal penetration, etc., but also greatly reduce the workload of cleaning and finishing castings and improve workers' working conditions.



（a） （b） （c）

Figure 4 Scanning electron Microscope after adding the binder to ceramic foundry sand
(a) & (b) Alkali phenolic resin ceramic foundry sand (c) Water-glass (Sodium silicate) ceramic sand

4.2 Economic benefit analysis

By comparing the cost of alkaline phenolic resin ceramic foundry sand and chromite sand resin and curing agent, the amount of ceramic foundry sand resin and curing agent is less, and the overall cost per m3 of sand can be reduced by **$719 (Price from business partner)**, which greatly saves enterprises Casting production costs.

From the cost comparison of water-glass (sodium silicate) sand and chromite sand, it can be seen that the amount of water-glass addition is less, and the overall cost of each m3 of sand can be reduced by **$691 (Price from business partner)**, which can also greatly save the production cost of the enterprise's castings.

5. Conclusion

1) Ceramic foundry sand is used as the facing sand of heavy steel castings to replace chromite sand, which can prevent metal penetration / sand burn-on, and leads easier shake-out and cleaning.
2) For alkali phenolic resin bonded ceramic foundry sand, it uses lower resin and catalyst consumption improves the surface quality of castings, can save the production cost of castings for enterprises, and greatly improve the casting production environment.
3) The amount of ceramic foundry sand water-glass addition is less, casting falling sand is easy to clean, which can improve the environment of the foundry workshop and save the cleaning time of castings.

References:

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[2] Huang Jin, et al. Discussion on the mechanism of chromite sand adhesion[J]. Foundry Technology, 1998 (1): 37-40