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Research paper

Performance of resin bonded sand for magnesium alloy casting

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ABSTRACT

The factors which affect performance of no-bake resin bonded sand (NBRBS) were investigated, including furan resin, curing agent and boric acid content and kinds of collapsibility agents and base sand. The results show that when the furan resin addition is 1.6 wt% of base sand content and the curing agent addition is 50 wt% of furan resin content, the comprehensive performance of NBRBS achieves optimization. The use of boric acid increases the curing speed, retained strength and gas evolution. The use of KI reduces the retained strength with a good tensile strength. When ceramacore being used as base sand, furan resin addition decreases greatly, and the tensile strength increases, gas evolution and retained strength both decrease, which can improve collapsibility of NBRBS. The SEM analysis demonstrates that the ceramacore particle is round, appears standard sphere, and the ceramacore can form complete bonding film and bridge.

1. Introduction

No-bake furan resin bonded sand (NBRBS) is widely used in magnesium alloy casting for its high dimensional precision, high strength, convenient operation and so on [1–4]. Due to the low pouring temperature ranges from 700 °C to 750 °C of magnesium alloy castings and low thermal melting amount, there is not enough heat for burning bonding bridges of the resin bonded sand samples, and so it leads to poor collapsibility for mold sand or core of magnesium alloy castings, especially the large complex casting molds or cores for less heat of liquid metal and its difficulty of deeping into the internal core, which could bring great difficulties for cleaning after casting and reclamation treatment of used sand [5–8]. Therefore, it has the important practical significance for studying optimized formula of no-bake furan resin bonded sand that satisfies production requirement of magnesium alloy castings and collapsibility. The recent research indicates that there are many factors which affect the performance of resin bonded sand, including resin content, curing agent content, types of base sand and other additives [9–12].

The effects of furan resin and curing agent addition on tensile strength, retained strength and gas evolution of NBRBS have been studied in this paper, the optimized basic formula which satisfies production requirement of magnesium alloy castings and collapsibility has been defined. The effects of boric acid content, kinds of collapsibility agents and base sand on the performances of NBRBS have been studied based on the above optimized formula. Scanning electron microscope (SEM) has been used to analyse surface morphology of NBRBS which were prepared by different kinds of base sand.

2. Materials and methods

2.1. Materials and equipment

There were three kinds of base sand used in the experiment, including silica sand from Dalin sand and Duchang sand, ceramacore with 40/70 meshes, the chemical composition of different base sand is listed in Table 1. Furan resin (Shangdong Jinan Shengquan Group Co.,Ltd., SQG700) was used as a binder, and curing agent (Shangdong Jinan Shengquan Group Co., Ltd., GC-09) was selected as its hardener. The characteristics of SQG700 furan resin and GC09 curing agent are listed in Tables 2, respectively. The other additives were as follow: boric acid powder, potassium nitrate powder, sodium hydrogen carbonate powder, potassium iodide powder and potassium permanganate powder.

Sand mixing was used by the type SHY sand mixer. NBRBS were fabricated manually using a standard "8" font mold with the dimension of 22.36 mm × 22.36 mm × 66 mm. The strength tests were measured by the type SWG lever-type universal strength testing

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Table 1
The chemical composition of different molding sand.

Base sand	Chemical composition(wt%)				
	SiO_2	Al_2O_3	Fe_2O_3	Na_2O+K_2O	TiO_2
Duchang sand	≥92.13	<4.50	<0.60	<2.50	<0.60
Dalin sand	≥91	<4.50	<0.30	<3.00	–
Ceramacore	5–20	75–85	≤5	–	≤1.5

Table 2
The characteristics of SQG700 furan resin and GC09 curing agent.

Viscosity (25 °C, mPa s)	Density (25 °C g/cm^3)	Nitrogen content (%)	Free formaldehyde (F.F.%)	Total acid (%)	Free acid (%)
SQG700 ≤ 75	1.15–1.2	≤7	≤0.05	–	–
GC09 60–80	1.2–1.4	–	–	24.5–27.5	2.5–4.5

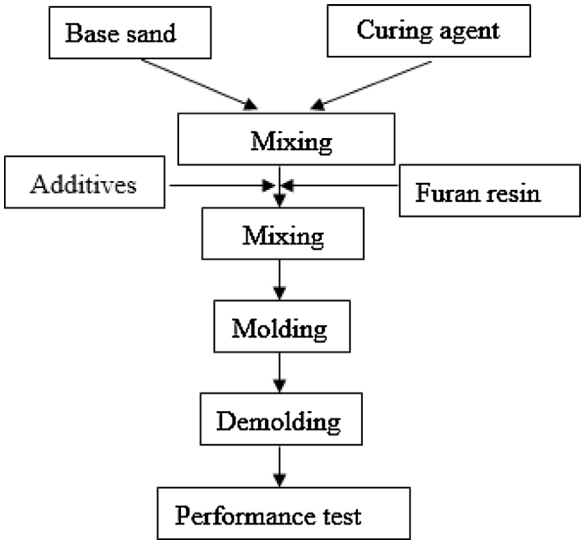

Fig. 1. Simplified flowchart of process.

machine, and the weight was tested by the type JA5003N electronic balance with the accurancy of 0.001 g. The gas evolution tests were measured by the type GET-III intelligent gas evolution tester. The muffle furnace was used to heat NBRBS. SEM analysis was used by Quanta 200 environmental scanning electron microscope (ESEM).

2.2. Methods

Fig. 1 shows the simplified flowchart of process. Firstly, base sand and curing agent were mixed uniformly with a certain ratio, and then additives and furan resin were added to the mixed sand successively using mechanical mixing to form uniform moulding sand. Afterwards, the mixed sand poured into the mold and allowed to cure at room temperature. After a certain time, NBRBS was demolded and stored in the air for several hours. Finally, the performance of NBRBS were measured in this paper.

The tensile strength of NBRBS being cured in the air after several hours was tested. Retained strength was the tensile strength of NBRBS after being put into a muffle furnace for a half hour at different temperature. Gas evolution (G) was tested by the type GET-III intelligent gas evolution tester. All the testing results were the average value of five measurements.

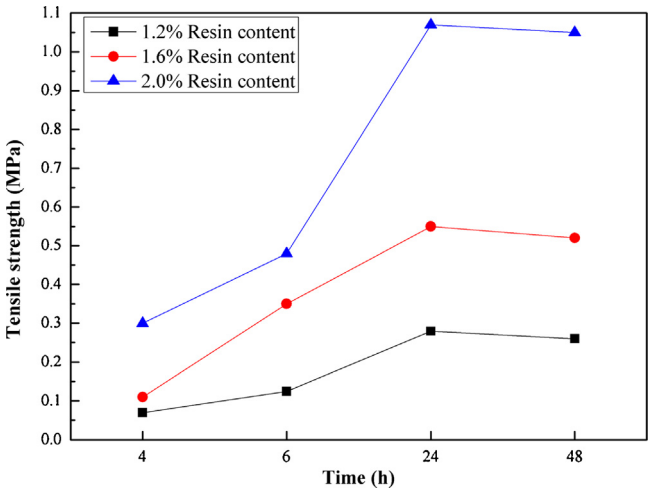

Fig. 2. The effect of furan resin content and curing time on tensile strength of NFBRS.

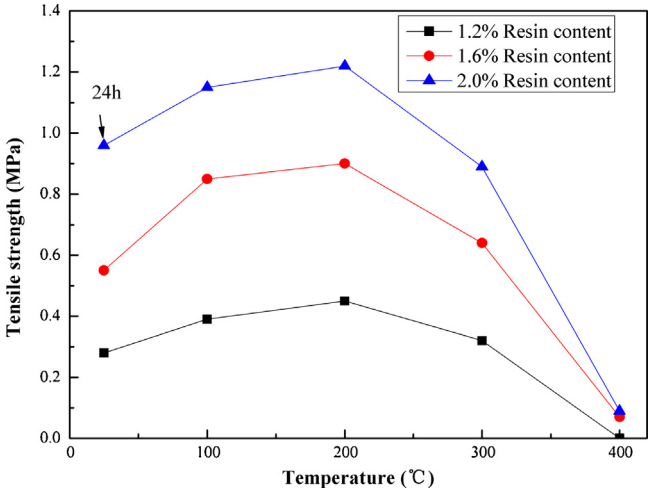

Fig. 3. The effect of furan resin content and temperature on retained strength of NFBRS.

3. Results

3.1. The effects of furan resin content

When the curing agent addition was 50 wt% of furan resin content, the effects of furan resin content on tensile strength, retained strength and gas evolution of NBRBS have been studied, and listed in Figs. 2 and 3, Table 3, respectively. Duchang sand was used as base sand.