CO_2 Microwave Hardened Sodium Silicate Sand Study and Mechanism Analysis for the Moisture Resistance

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Abstract. Strong hygroscopic of sodium silicate sand is a key problem in the practical application. Hygroscopic mechanism research of sodium silicate sand is not enough. CO_2 hardened and microwave heating hardened to composite hardened process of sodium silicate sand has been proposed in this paper. Through optimization of air temperature, blowing time, microwave power and heating time, get the best resistance to moisture absorption process parameters of composite hardened sodium silicate sand. The process and the mechanism of moisture absorption were analyzed for composite hardened sodium silicate sand. The influence factor of moisture absorption was made clear. Laid a preliminary foundation to solve the problem of sodium silicate sand strong hygroscopic

1. Introduction

Sodium silicate bonded sand non toxic tasteless, environment friendly, is considered a possible green sand casting, but its moisture absorption is strong, breakup sex difference, old sand regeneration difficulty [1, 2]. Scientific researches personnel after long term effort. Instant sodium silicate sand hardened intensity is high, but at room temperature and high moisture in the air, easy to moisture absorption, intensity is significantly reduced, can deposit time is shorter[3, 5]. Sodium silicate sand molds after moisture absorption, surface loose, fall off easily pulverization. When pouring easy to produce the problem such as collapse box and sand washing, affect the success of casting or casting quality [6, 7]. At present, the domestic and foreign scholars on the moisture resistance of sodium silicate sand is not enough in-depth research, theoretical models of sodium silicate sand moisture absorption and moisture resistance measures study enthusiasm is not high, in the field of relevant publications and academic works of rare silicate sand wet resistance research[8]. In the process of microwave hardened sodium silicate sand of materials and equipment research and development has been more mature, the quantity of adding sodium silicate can be dropped to 1.5%, sand mold have good pieces. Microwave hardened sodium silicate sand advantages obviously, but strong hygroscopic [9].

In order to retain the advantages of microwave rapid hardening sodium silicate sand, this paper puts forward a new method of the CO_2 microwave heating composite hardening. Through the optimization of air temperature, blowing time, microwave power and heating time, gets the best moisture resistance composite hardening sodium silicate sand process parameters. Microwave hardening and CO_2 microwave compounded hardening to comparative study, from the sodium silicate binder membrane

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composition and microstructure of the difference of two aspects to elaborate the differences of moisture absorption. Of sodium silicate sand composite hardening process and the mechanism of moisture absorption were analyzed, and clear about the factors that influence the hygroscopic of targeted anti hygroscopic measures are put forward, to further solve the difficulties in strong hygroscopic of sodium silicate sand made a foreshadowing.

2. Preparation of experiment

2.1. Main materials

Forest scrubbing sand (particle size 70 / 140); sodium silicate (modulus M= 2.06, density 1.45 g / mL).

2.2. Main equipments

SWY hydraulic universal strength testing machine; JJ-5 sand mixer; The SAC hammer style prototype; Electronic analysis balance, accuracy of 0.01 mg; Intensity meter; The microwave oven.

2.3. Experimental methods and procedures

Mix the forest scrubbing sand and sodium silicate proportionally. Stir in the mixer for 2 minutes. After sanding, made from special die Φ 50 mm x 50 mm cylindrical specimens, fine wire with a diameter of 1 mm for each sample is empty. The air is heated by the heater, and the CO_2 hardening is carried out at a certain temperature and air blowing time. When the sample reaches the die strength, stop blowing CO_2 and remove the mold. The test samples were hardened by microwave heating, and the heating was stopped after the prescribed intensity was reached. The sample was taken out and the moisture absorption and strength test of CO_2 microwave hardening sodium silicate was carried out.

3. Experimental data

3.1. Moisture absorption and strength of microwave hardening

Microwave heating process water in the glass after absorbing microwave energy, silicate molecules and water molecules in a sand mold high speed oscillation at the same time, the temperature rising rapidly, colloidal particle thermal motion increases, cohesion, make the silicate condensation, rapidly forming small colloidal particles, uniform glassy sodium silicate mesh structure. The parameters of the microwave hardening process are set as: sodium silicate is 1.8%, microwave heating power is 1400 W, and microwave heating time is 60 s. The moisture absorption of sodium silicate was used to measure the moisture absorption and storage strength of the sodium silicate. The detailed results are shown in table 1.

Table 1. Amount of absorbed water and strength under microwave hardened.

Storage time (h)		0	2	4	8	24
Amount of absorbed water (g)	Humidity 83 %	0	0.296	0.412	0.463	0.611
	Humidity 98 %	0	0.417	0.713	0.920	1.346
Strength (MPa)	Humidity 83 %	2.535	1.612	1.175	1.036	0.561
	Humidity 98 %	2.535	0.971	0.693	0.562	0.135

3.2. Moisture absorption and strength of compound hardening

In order to determine the optimal process parameters, find out the influence law of various factors, the selection of has obvious effects for strength of gas temperature, blowing time, microwave power and heating time on 4 factors in L_9 (3^4) orthogonal experiment. The amount of sodium silicate in the test was 1.8%, the relative humidity was 98%, and the 8h storage strength of the sample was tested. The experimental results of storage strength are shown in table 2.

Table 2. Test results of different test method.

Number	Temperature (℃)	Time (s)	Power (W)	Time (s)	Strength(MPa)
1	1(30℃)	1(5s)	1(800W)	1(120s)	0.561
2	1	2(10s)	2(1200W)	2(140s)	0.604
3	1	3(15s)	3(1600W)	3(160s)	0.621
4	2(50℃)	1	2	3	0.582
5	2	2	3	1	0.616
6	2	3	1	2	0.625
7	3(70℃)	1	3	2	0.620
8	3	2	1	3	0.601
9	3	3	2	1	0.641
K1	1.786	1.763	1.787	1.818	
K2	1.823	1.821	1.827	1.849	
K3	1.862	1.887	1.857	1.804	
R	0.076	0.124	0.070	0.045	

Selection based on the above, the conclusion blowing gas temperature (70℃), time (s) 15, microwave power (1600W) and the heating time (140s), and other process parameters, the sodium silicate sand water absorbing capacity and strength test, the detailed results are shown in table 3.

Table 3. Amount of absorbed water and strength under composite hardened.

<table>
<tr><th colspan="2">Storage time (h)</th><th>0</th><th>2</th><th>4</th><th>8</th><th>24</th></tr>
<tr><td rowspan="2">Amount of absorbed water (g)</td><td>Humidity 83 %</td><td>0</td><td>0.134</td><td>0.245</td><td>0.333</td><td>0.515</td></tr>
<tr><td>Humidity 98 %</td><td>0</td><td>0.246</td><td>0.451</td><td>0.589</td><td>0.912</td></tr>
<tr><td rowspan="2">Strength (MPa)</td><td>Humidity 83 %</td><td>2.483</td><td>2.095</td><td>1.925</td><td>1.575</td><td>0.931</td></tr>
<tr><td>Humidity 98 %</td><td>2.483</td><td>2.015</td><td>1.525</td><td>1.042</td><td>0.725</td></tr>
</table>

4. Comparison of results

Through the experimental study on the anti-hygroscopic properties of microwave hardening and composite hardened glass sand, we have a clear understanding of the anti-hygroscopic rules of sodium silicate sand. The hygroscopic properties of sodium silicate sand in different hardening process were compared, as shown in figure 1. The greater the humidity, the more the water can penetrate and spread into the bonding interface of the caking film and the sodium silicate and the sand, and the sodium silicate sand absorbs more water. In the anti-hygroscopic aspect, CO_2 microwave composite hardening process is better than microwave hardening process. It is mainly because the cement bridge in the glass sand is not caused by the excessive water loss. Next due to CO_2 and binder can produce chemical reaction, sodium silicate sand hardened generated not easy bibulous silica gel, which to a certain extent, slows down the water into the sand mold, improve the moisture resistance of sodium silicate sand.

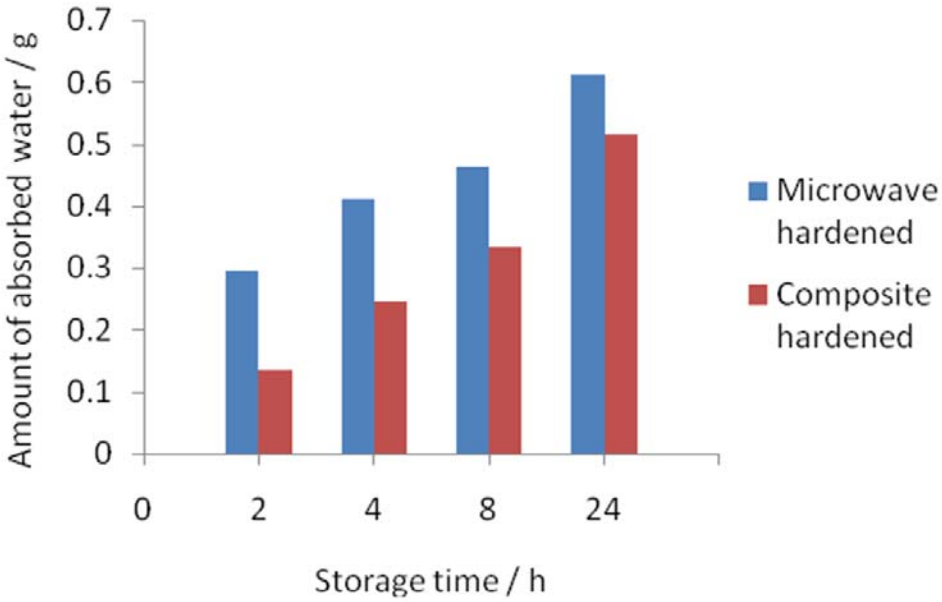

Figure 1. Compare moisture absorption resistance under humidity of 83%.

Compared with ordinary microwave heating and hardening sodium silicate sand technology, the CO_2 microwave composite hardening sodium silicate sand technology realized the microwave heating without mould, which improved the utilization rate of microwave. The strength loss rate of different hardened glass sand was compared. See figures 2 for details. Under the action of microwave heating, water and water can be changed into sodium silicone gel. In silicon gels, there are both surface and bridge connections between particles and particles. That is, the cat ions between the two surface layers are shared within the extended layer and are linked together by the bridge. The relative proportion of CO_2 hardening in compound hardening is increased, and the rate of water immersion is slowed down, so that the strength of composite hardened sand is higher than that of ordinary microwave hardened glass sand.

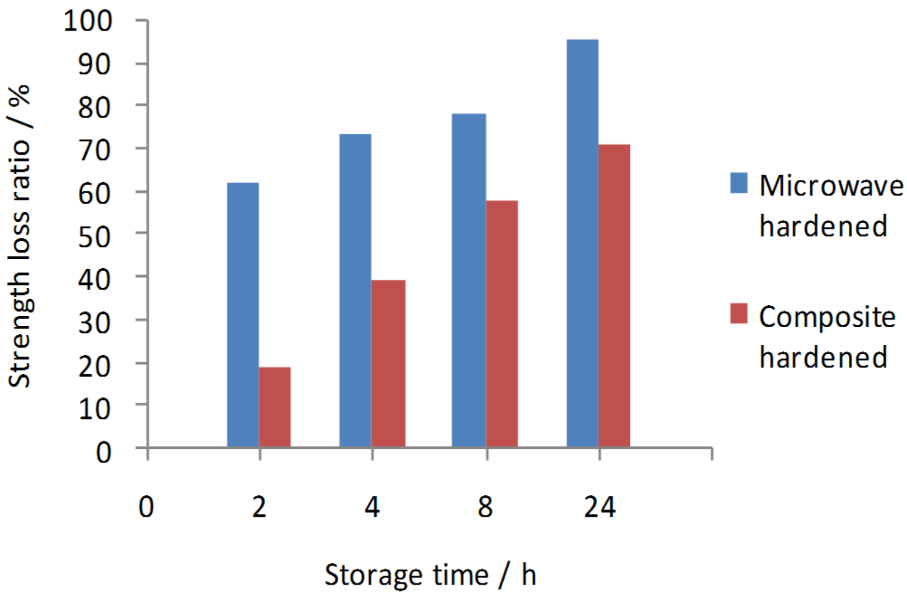

Figure 2. Compare strength loss ratios under humidity of 83%.

5. Composite hardening sodium silicate sand moisture resistance analyses

The main reason of strong hygroscopic is the strong hygroscopic property of sodium and hydroxide in sand. The sodium ions in sand mold first chemical adsorption of water molecules, absorbed water molecules by hydrogen ions, the catalysis of destabilizing silica keys, dismember silicate, make its mesh structure disconnect. The reaction process is as follows:

(1) The hydration of sodium ions. Because Na^+ ion coordination number is 8 or 6, hydration capacity is very big, in the sand after hardening, the coordination number of Na^+ are there still any vacancies, can absorb water molecules in coordination, the coordination number of saturated. In addition, water molecules have a large polarity and small size, and the substitution ability and hydrolysis are extremely strong, which can make the electrostatic binding bond of silicon hydroxyl and Na^+ to fracture, and make full hydration with Na^+, as shown in figure 3.

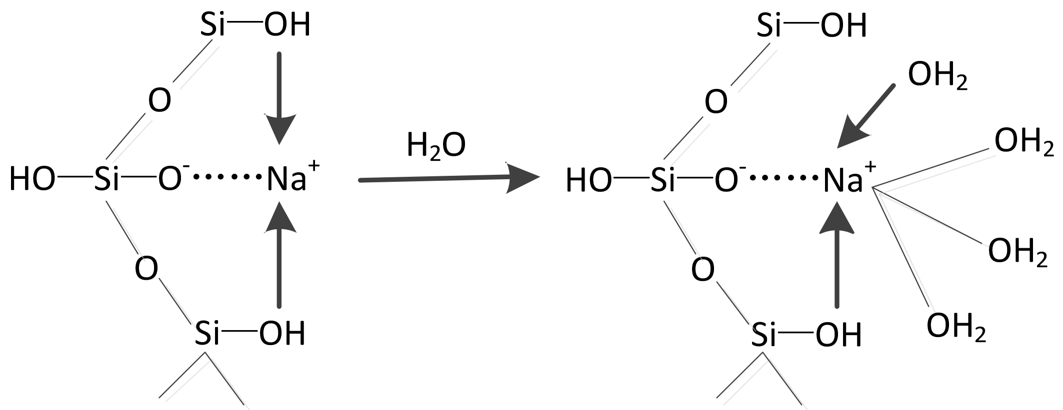

Figure 3. Hydration of sodium ions.

(2) The disconnection of the silicate network structure. Because water molecules are easy to penetrate, easy to spread and have strong offensive ability, after entering the adhesive film, the water and the Na^+ are combined to destroy the silicon oxygen bond, which makes the silicate stable reticular structure disconnect, as shown in figure 4.

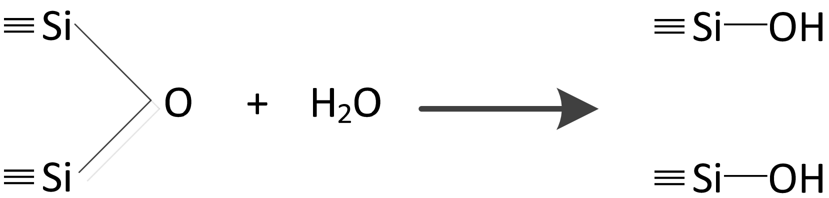

Figure 4. Disconnection of silicate mesh structure.

6. Summary

This chapter mainly studies the CO_2 sodium silicate sand microwave heating composite hardening process, in order to solve the traditional microwave mold demanding problems of the hardening process, in solving the problem of the mould at the same time, studied the following a series of microwave hardening sodium silicate sample performance characteristics. Preventing the hydration of Na^+ and stopping water molecules is the key to improve the moisture resistance of glass sand. Air humidity is an external factor affecting the moisture absorption of sodium silicate. The number of sodium atoms and the hydrophilic strength and quantity of the material contained in the water-glass sand bonded film are the internal factors that influence the moisture absorption. Measures to improve the moisture resistance of glass sand: the modified sodium silicate prevents Na^+ from hydrating, reducing the amount of sodium atoms in the bonded membrane, preventing the infiltration and diffusion of water molecules. The process of CO_2 microwave composite hardening has solved the difficult problem of microwave hardening.

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