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Study on Water Glass Modified Using Methyl Sodium Silicate

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Abstract

A simple and easy hardening technique of sodium silicate sands was studied, which was ester-microwave composite hardening. Microwave-hardened sodium silicate sand has the advantages of high strength, rapid hardening and low residual strength, but sodium ions in the sand can absorb atmospheric moisture, resulting in reduced storage strength, so it is vital to protect the bond bridges between the sodium silicate sands. Microscopic analysis of the sodium silicate sand before and after modification was carried out using scanning electron microscopy (SEM) and energy spectrum analysis (EDS). The results showed that the strength of the modified sodium silicate sand was significantly higher than that of the unmodified sodium silicate sand and that the optimum amount of sodium methyl silicate to be added to the sodium silicate was 15%. It was also found that the bonding bridge density of the modified sodium silicate sand was dense. The bond bridge of the water-glass sand sample modified with sodium methyl silicate is, on the other hand, more stable, smooth and crack-free, resulting in a higher compressive strength, even under extreme humidity conditions.

Keywords

Sodium Silicate Sands; Ester-microwave Composite Hardening; Humidity Resistance; Non-mold; Sodium Methyl Silicate.

1. Introduction

Microwaves are broadly applied in such fields as telecommunications, meteorology or chemistry[1]. Microwave energy might also be used in foundry engineering and hardening process of molding sands, including sodium silicate molding sands. The microwave hardening of sodium silicate sands is low cost and energy saving because the energy is delivered directly to the objects to be heated [2-3].

Sodium methyl silicate is a new type of building waterproofing material with a molecular structure of CH3-Si (OH)2-ONa with excellent permeable crystallization effect[4]. It is widely used in industrial production because of lower price[5]. Methyl alcohol silicate can be generated under the action of water and CO2, and it can be further combined. The capillary effect can be realized via dehydration crosslinking in the silanol reaction between methyl alcohol silicate and silicate materials and the hydrophobic layer has the effect of micro-expansion and also increasing compactness[6-7].The reaction equation is as follows.

$$\begin{gathered} CH3(OH)2ONa+CO2+H2O \rightarrow 2[CH3Si(OH)3] \\ +Na2CO3n[CH3Si(OH)3] \rightarrow [CH3SiO3/2]n+3/2H2O \end{gathered} \quad (1)$$

In this paper, a new type waterproof material methyl sodium silicate was firstly introduced to the most important is that the rigid sodium silicate-bonded sand-casting industry. Test conditions were as follows: microwave heating power of 1400W and heating time of 120s (twice heating time, 20s, 100s, respectively). The addition of sodium silicate amounted for 1.5%

of the raw sands mass, while an addition of methyl sodium silicate made up 5%, 10%, 15%, 20%, 15% of water glass mass, separately. The order of sand mixing was that methyl sodium silicate sand and raw sands were firstly stirred for 1 min, then the binder was added and mixed for 1min. The last process was modelling. The storage strength of sand mold and an addition amount of sodium silicate were shown in Fig.1.

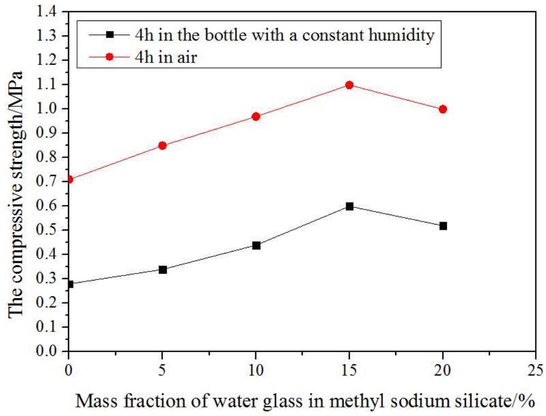

Fig. 1 Influence of methyl sodium silicate addition on the strength

2. Preparation of Molding Sands

The experimental materials include the quartz sands with the grain size of 50/100 meshes, the sodium silicate with the modulus of 2.06, the density of 1.45g/cm3 and modifier made up methyl silicone oil. The customized box microwave oven was used to harden the sands with a power of 1400W. The TESTO 610 temperature and humidity instrument were used to test the temperature and humidity. The ambient temperature was 23℃.SHY vane sands mixer was selected to mix binder, sands and others. Sands samples were prepared using a homemade columnar split wooden mold with a diameter and height of 30 mm(Φ30×30mm). The desiccator without desiccant was used as a constant humidity bottle by adding water (humidity of 98%~99%). The compressive strength was tested using an SWQ-A material high-temperature strength tester and the moisture absorbability (ψ) was tested by the electronic balance with the accuracy of 0.001g.

3. Experimental Methods

Raw sands, sodium silicate and sodium methyl silicate weighed were put in the sands mixer according to certain proportion and sequence. The mixture was pulled out to prepare mould sands after mixing for 2 minutes.Do an experiment of samples strength and moisture absorbability of sands mould.Secondary microwave hardening new methods used in the experiment were as followed: Sodium silicate sands together with the wooden mould were heated 20s in the microwave oven, then taken out and demoulded, the sodium silicate sands were heated 100s by microwave. The moisture absorption of sands samples was tested by 4h storage strength in a constant humidity bottle (humidity of 98%~99%), 4h storage strength in the air (humidity of 80%) and instant strength after pulling out from microwave oven for three minutes to cool, respectively.

The compressive strengths of 24h indoor and 4h humidistat storage strength of the samples was tested. The former was the strength of samples stored in air for 24h, and the latter was in humidistat with the related humidity of 98~100% for 4h.

The bonding bridge and fracture morphology of mould sands treated by fixing in the little box and spraying-gold were observed using environmental SEM and its EDS[8-9].

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The ester-microwave composite hardening included two steps: Firstly, the sodium silicate was solution, and it reacted with ester of ethylene glycol diacetate, so the silicon dioxide, sodium acetate and glycerol were produced in the bonding bridges between the sand grains, where there were relatively more reactants of ester and sodium silicate[10]. At the same time, the most silica gel was dissolved to the nearby residual sodium silicate to produce higher modulus sodium silicate, thus the bonding bridges were built when the water was transformed into crystal water of sodium acetate and solvent water of ethylene glycol, so the stripping strength of 15Kpa was established. And locally, only the modulus of sodium silicate in the bonding bridge was improved.

4. Results and Discussion

As displayed in Fig.1, 4h humidistat storage strength both in air and in the bottle with a constant humidity was good when the addition amount of methyl sodium silicate was 15%, accounting for 0.225% raw sands in mass, the humidity of which were 80% and 98%, respectively. Comparing with unmodified sands, the strength of samples in air and the bottle increased by 100.1% and 70.7%, respectively.

It can be found in further study that in Table 1, water absorption ratio in the sand mold modified using methyl sodium silicate was 0.19% in the bottle with a constant humidity for 4h while that of unmodified sand mold was 0.22% under the same conditions. Comparing with unmodified samples, water absorption ratio was reduced by 13.6% in the bottle for 4h for the raw sand samples modified by methyl sodium silicate, demonstrating that the modified effect is better using methyl sodium silicate.

Table 1. Comparison of moisture absorption of sand mould modified by methyl sodium silicate

The types of sand mould	Water absorption ratio (%)
modified mold	0.19
ordinary mold	0.22

During microwave heating sclerosis and storage process, it can be found that micro-cracks (Fig.2) occurred in the unmodified bonding bridge from above micrograms, while the bonding bridge modified by sodium silicate in the sand mould was more stable and smooth (Fig.3). The compressive strength was larger due to the occurrence of no cracks. It was also very big under conditions with an extreme humidity.

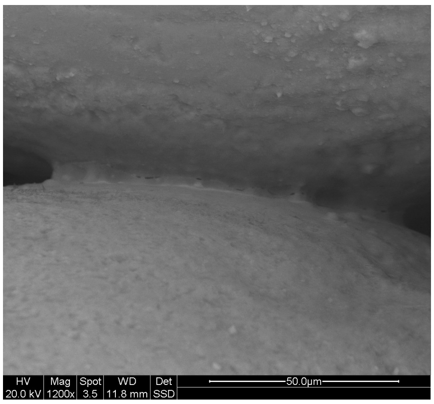

Fig. 2 Unmodified bonding bridge

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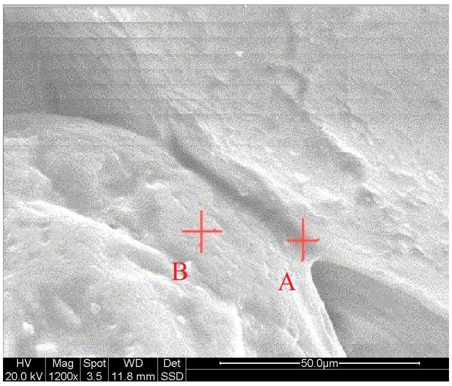

Fig. 3 Modified bonding bridge

Fracture of bonding bridge in unmodified and modified sand mould was shown in Fig.4, Fig.5 and Table 2. It can be observed that a lot of holes appeared in the fracture of unmodified bonding bridge in Fig.4, while it was very dense in modified adhesive bridge fracture in Fig.5. Large amounts of carbon gathered on the surface of bonding bridge after modification. In Fig.3 and Fig.4, it can be seen that the carbon content on the surface of bonding bridge (Point A) was higher than that inside bonding bridge (Point B) while that on the surface of bonding bridge (Point C) exceeded that inside bonding bridge (Point D), the data of which were shown in Table 2. These high carbon content substances were introduced in form of methyl sodium silicate as waterproof materials to protect the bonding bridge so as to improve the resistance to moisture absorption.

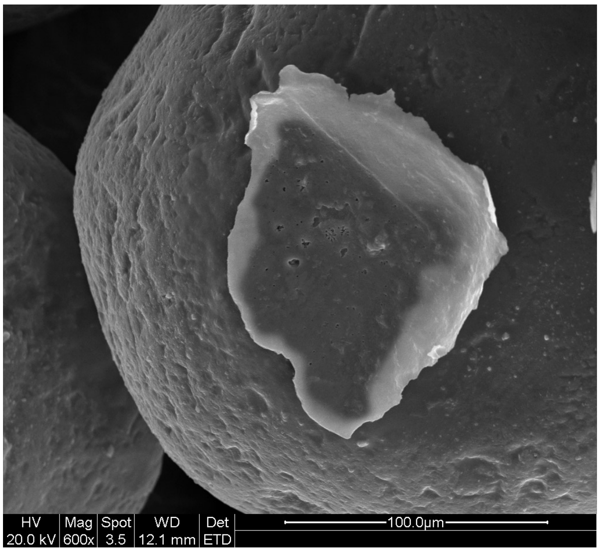

Fig.4 Fracture of unmodified bonding bridge

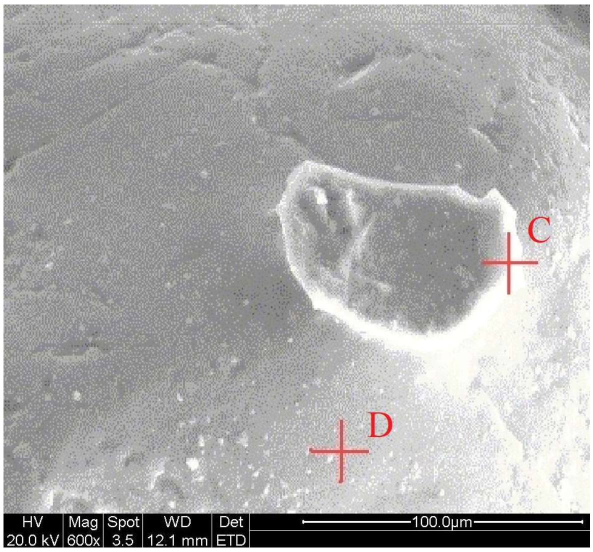

Fig.5 Fracture of modified bonding bridge

Table 2. EDS of methyl sodium silicate in the bonding bridge and its fracture

	C(wt%)	O(wt%)	Na(wt%)	Al(wt%)	Si(wt%)
A	9.39	27.85	9.10	1.29	52.28
B	6.06	17.59	1.31	1.24	73.83
C	13.85	26.38	11.38	0.87	47.52
D	9.19	25.17	8.17	0.60	56.46

5. Conclusion

The results showed that the strength of modified sodium silicate sands was significantly higher than that of unmodified sodium silicate sands, and the moisture absorption of modified sodium silicate sands was worse than that of unmodified sodium silicate sands, and the effect was best when the addition of methyl sodium in the quantity of sodium silicate was 15%. It was also found that the bonding bridge of modified sodium silicate sands was the density and the adhesive film was smooth, and the methyl silicone silicate was completely covered on the surface of the sodium silicate bonding bridge to protect it.

Acknowledgments

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