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Improving the Moisture Resistance of Mold with Inorganic Binder

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Abstract
The purpose of this study was to improve the moisture resistance of a mold with an inorganic binder. Some types of metallic salt were added to an inorganic binder to replace sodium ion in sodium silicate to metal ion, and produce an insoluble saline. In an experiment, a mold after shaping at 130 °C was stored at 30 °C and 90% relative humidity, and the mold strength was measured to compare the hygroscopic deterioration rate, which is defined as the strength ratio for fresh to regular hours of holding time, in order to find the deterioration by the absorption of moisture. Some types of alkali metal salt as an additive in the inorganic binder were found to reduce the hygroscopic deterioration rate to lower than 20% after 1 h of storing, where the storing time assumes a cycle time from molding to casting in the casting line. It is possible to use an inorganic binder in a mold in hot and humid conditions, such as those that prevail in Japan, by applying the additive of the alkali metal salt used in this study.

Keywords: *inorganic binder, moisture resistance. alkali metal salt, insoluble saline*

1. Introduction

An organic binder is used in the production of a mold, resulting in good productivity and mold quality. However, a mold with an organic binder might result in casting defects due to gases such as CO, CO_2, H_2, and N_2 owing to the heating during the casting process [1]. Inorganic binders have been actively investigated [2] for reducing casting defects and environmental concerns such as odor issues, and have become popular for use in the mold process in aluminum alloy casting. For the practical applications of inorganic binders with alkaline silicate in the molding process, the filling of sands with inorganic binder [3], moisture absorption of inorganic binders, and the collapse characteristics of the sand mold have been considered. An inorganic binder consists primarily of alkaline silicate and experiences a dehydration condensation reaction during the curing of the mold, which gives rise to the problem of hygroscopic deterioration of a mold prepared in hot and humid conditions. Hence, the effectiveness of spherical amorphous silica fillers and alkali metal salts, which are the agents added to inorganic binders to prevent moisture absorption for reducing the deterioration of the mold, was evaluated in this study.

2. Experimental method

2.1 Test pieces

Fig. 1 shows the optical and electron photomicrographs of natural silica sands and acid spherical amorphous silica fillers. The natural silica sands were coated by mixing them with 0.9mass% of spherical amorphous silica of acid (pH 3) fillers and 0.03 – 0.1mol of alkali metal salts for 60 s. Then, they were mixed for 60 s with 2% sodium silicate solution including surfactant agent. Next, test pieces were molded by curing with temperature of 130 °C and blow pressure of 0.1MPa.

Fig. 1 Optical and electron photomicrographs of natural silica sands and acid spherical amorphous silica fillers.

2.2 Measurement

The test molds were stored at 30 °C and 90% relative humidity, and the deflective strength was measured by supporting a 50-mm-long test piece at

two points and applying a load to the test piece center. The hygroscopic deterioration rate, which is defined as the strength ratio for fresh to regular hours of holding time in order to determine the deterioration due to the absorption of moisture, was calculated using Eq. (1):

$$S = \{100-(A/B)\}\times 100 , \quad (1)$$

Where,

S: Hygroscopic deterioration rate

A: Deflective strength after molding

B: Deflective strength after regular holding time at 30 ℃ and 90% relative humidity

3. Experimental Results

The moisture resistance was improved by adding acid spherical amorphous silica fillers in order to increase the gelation reaction and the filling rate during molding. Fig. 2 shows the hygroscopic deterioration rate for different cases, confirming the effectiveness of the use of spherical amorphous silica fillers. Lower hygroscopic deterioration rates indicate improved moisture resistance. The addition, the spherical amorphous silica fillers reduced the hygroscopic deterioration rate after 1 h of storage.

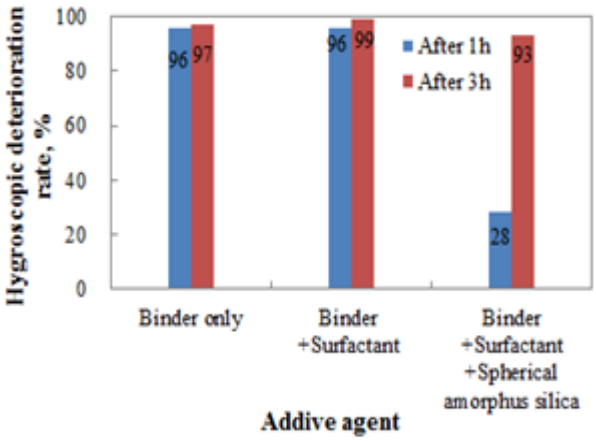

Fig. 2 Hygroscopic deterioration rate confirming the effectiveness of spherical amorphous silica fillers.

To further improve the moisture resistance, metallic salt was added because it is considered that the sodium ions in sodium silicate, which is an inorganic binder, are replaced by metal ions from the metallic salts, which results an insoluble saline compound , preventing hygroscopic deterioration. Fig. 4 shows a graph of the hygroscopic deterioration rate, which confirms the effectiveness of metal sulfate-s , obtained from metallic salts. A total of 0.003mol of each metal sulfates was added. Here, the blank consists of an inorganic binder, a surfactant agent, and spherical amorphous silica fillers, as shown in Fig. 3. The remaining additives were prepared by adding different metal sulfates to the blank. The alkali metal salt additive decreased the hygroscopic deterioration rate after 1 h of storage, which is sufficient for the mass production of sand molds with inorganic binders in hot and humid conditions. It is expected that this is a result of the insoluble saline compound partially generated by absorption or ion exchange between the inorganic binder and cations of the alkali metal salt.

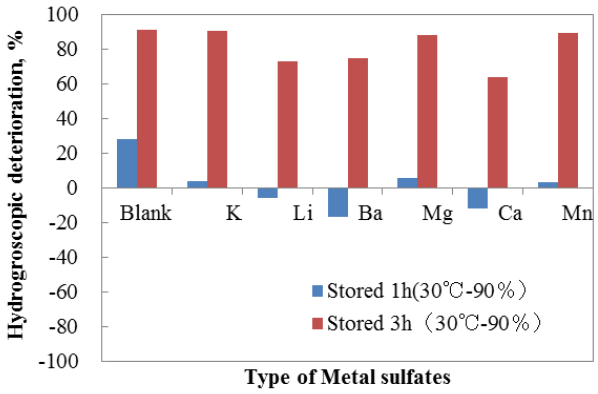

Fig. 3 Hygroscopic deterioration rate confirming the effectiveness of metal sulfates.

4. Conclusion

The moisture resistance of a mold with an inorganic binder was improved by using spherical amorphous silica fillers. The addition of alkali metal salts also proved to be effective for the same purpose. Hence, it is possible to use an inorganic binder in a mold in hot and humid conditions, such as those that prevail in Japan, by applying the alkali metal salts used in this study.

References

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