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Basic investigation into water cooling behavior of the high temperature green molding sand

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The sand cooling process before the mulling of green sand is very important process in order to obtain the green molding sand with comfortable characteristics. In this study, the high temperature molding sand with more than 100 degree C (Celsius) is investigated, then the water cooling behavior of the molding sand is investigated by fundamental experiment. The components of the molding sand are the silica sand/the artificial mullite sand and Na-type bentonite. The compactability index which is one of the properties of molding sand is controlled by contents of water. Temperature and moisture content during sand cooling are studied to clarify the difference cooling method of by air and water. Further, theoretical analysis try to estimate the cooling the water cooling behavior by using a heat transfer and an evaporation equations. It is clear that the difference of cooling degree between more than 100 degree C of sand temperature and less than 100 degree C of ones.

Keywords: *green sand, moisture content, cooling behavior, heat transfer.*

1. Introduction

The temperature of return sand becomes higher because of the change of the component of green molding sand and the speedup of the molding line. The sand cooling process before the mulling of green sand is very important process in order to obtain the green molding sand with comfortable characteristics [1]. It is necessary to adjust the value of the sand temperature and moisture contents of the molding sand.

The high temperature molding sand with more than 100 degree C is investigated in the present study, then the water cooling behavior of the molding sand is investigated by fundamental experiment. Further, theoretical analysis try to estimate the cooling the water cooling behavior by using a heat transfer and an evaporation equations.

2. Experiments

2.1 Experimental setup

New silica sand and ceramic sand (synthetic mullite beads) with 10% sodium bentonite are used. The properties of molding sand are controlled by the compactability index. The experimental conditions are shown in Table 1.

Table 1 Experimental Conditions.

Molding sand	Sand 90% +Bentonite 10% +Water
Sand	Ceramic sand (Mullite beads), Silica sand
Bentonite	Na-Type
Compactability	30, 35, 40 %
Initial Temp.	120, 100, 80℃
Weight of sample	100g
Cooling type	Natural(air), Watering

2.2 Cooling Experiments

The molding sands are pre-heated to the initial temperature of 120, 100 and 80 degree C in the heater. In the first experiment, the molding sand is cooled naturally by being left in the atmosphere. Then, the temperature and moisture content of the molding sand are measured during cooling. The second experiment, the molding sand is receiving the proper amount of watering, then it has been left in the atmosphere.

2.3 Cooling behaviors

Figure 1 shows the cooling behavior of molding sand after watering in the case of ceramic sand and initial temp. of 120 degree C. The temperature of molding sand is rapidly decreased immediately after watering, then it is gradually cooled. Figure 2 shows the cooling behavior of molding sand in the case of

natural (air) cooling and watering, initial temp. of 120 degree C and ceramic sand.

In the later stage of cooling, the temperature drop for the water-cooling and the air-cooling are almost the same. In the case of the high temperature molding sand with more than 100 degree C, the evaporation cooling was mainly occurred just sprinkling the water, then the temperature was decreased in accordance with heat transfer behavior. It is the same tendency in molding sand with silica sand.

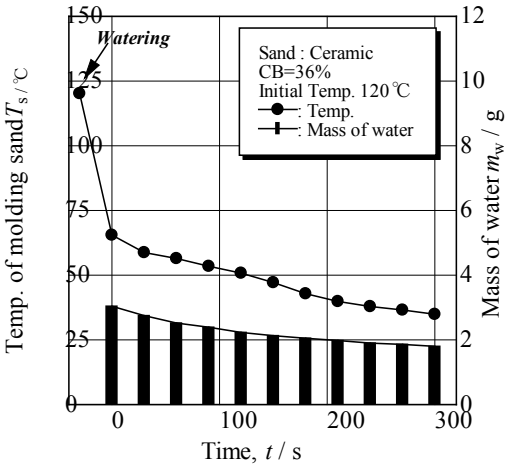

Fig.1 Cooling behavior of molding sand after watering in the case of ceramic sand and initial temp. of 120 degree C.

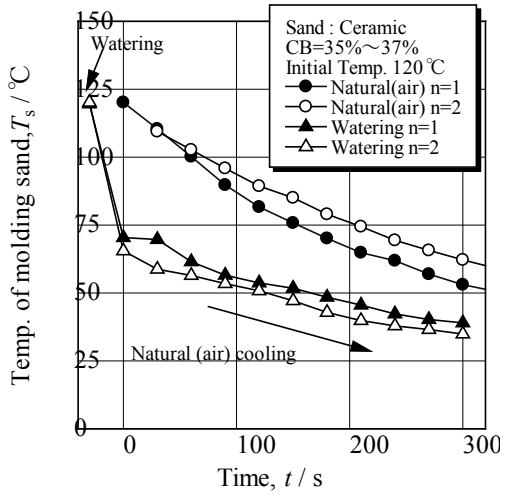

Fig.2 Cooling behavior of molding sand in the case of natural (air) cooling and watering, initial temp. of 120 degree C and ceramic sand.

3. Numerical Analysis

Theoretical analysis try to estimate the cooling the watering behavior by using a heat transfer and an evaporation equations. Referring the theoretical analysis of air-cooling for wet and dry sand by Ohnaka [2], the governing equations are following;

Heat transfer for wet sand:

$$\frac{dT_{sw}}{dt} = \frac{L_s}{C_s + w} \cdot \frac{dw}{dt} - \alpha \frac{\beta A_s}{\beta m_s (C_s + w)} \cdot (T_{sw} - T) \quad (1)$$

Heat transfer for dry sand:

$$\frac{dT_{sd}}{dt} = -\alpha \frac{\beta A_s}{\beta m_s (C_s + w)} \cdot (T_{sd} - T) \quad (2)$$

Where, T : Temperature [K], t : Time [s], L_s : Latent heat of vaporization [J/kg], C : Specific heat [J/kgK], w : moisture content [kg/dry.kg], α : heat transfer coefficient [W/m^{2}K], β : rate of wet sand, A : surface area [m2], m : Mass [kg], subscript: a : air, s : sand, sw : wet sand, sd : dray sand

Solving Eq.(1) and Eq.(2), it is possible to obtain the temperature of molding sand cooled by heat transfer. Figure 3 shows the comparison of cooling behavior between experiments and calculation in the case of natural (air) cooling, initial temp. of 120 degree Cand ceramic sand. The calculated values can be estimated well the experimental values.

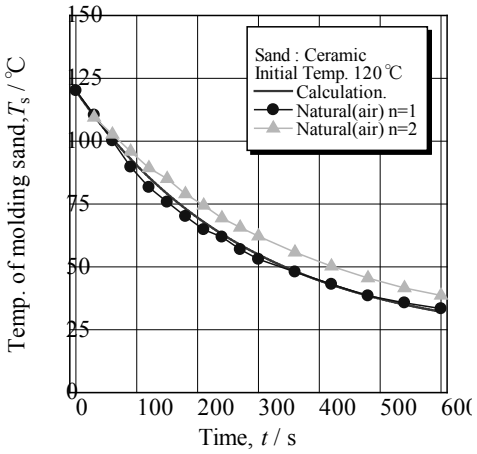

Fig.3 Comparison of cooling behavior between experiments and calculation in the case of natural (air) cooling, initial temp. of 120 degree C and ceramic sand.

4. Conclusions

It is clear that the difference of cooling phenomenon between more than 100 degree C of sand temperature and less than 100 degree C of ones. In the later stage of cooling, the temperature drop for the water-cooling and the air-cooling are almost the same. These results provide valuable information to produce casting stably.

References

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