

Investigations of the Sorption Process' Kinetics of Sand Moulds' Surface Layers under Conditions of a High Air Humidity

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Abstract

The results of investigations of the sorption process of surface layers of sand moulds under conditions of a high air humidity are presented in the paper. Investigations comprised three kinds of moulding sands with inorganic and organic binders: moulding sand with hydrated sodium silicate with furfuryl resin and with alkyd resin. Tests were performed on the prototype research stand allowing to maintain a constant, high temperature of surroundings (28 – 33°C) and the relative air humidity (above 95%). The gravimetric method was applied in measurements. The proposed method allows to assess the amount of water which permeates by the area unit of surface layers of sand moulds into their insides. Knowledge of such parameter allows to select the proper storage conditions of casting moulds waiting for being poured with liquid metals. This can limit the occurrence of surface defects which are caused by too high humidity of casting moulds.

Keywords: Sand moulds, Surface layer, Moisture sorption, Furan moulding sands, Alkyd moulding sands, Water glass

1. Introduction

Casting defects - in dependence on a place of occurrence - are divided into five main groups: – shape, surface, ductility, internal and material defects. In the foundry sector an increased occurrence of surface defects such as: orange pill, pitted skin, pinholes or external skin-holes is periodically observed. They are mainly caused by excessive water amounts occurring at various stages of a casting production including also storage times of ready casting moulds waiting for the pouring process. The hereby paper concerns the investigation of the kinetics of the moisture sorption by surface layers of sand moulds under high air humidity conditions. This effect influences the moisture state

of the casting mould and - in consequence - the surface quality of the obtained castings.

A porous material definition as a solid body with a significant number of empty spaces of relatively small dimensions as compared with the dimension characteristic for the body [1] allows to classify the moulding sand to this type of materials. Due to a system of pores a sorption is in it possible, it means an intrinsic process of water vapour absorption from the surrounding air [2]. It allows to assume that a moulding sand absorbs moisture from the atmosphere and that the intensity of this process depends on the kind of the applied binder.

A behaviour of surface layers of casting moulds under variable atmospheric conditions, mainly moisture content and a surroundings' temperature, is assessed in references [3-7] on the

bases of ultrasound investigations. The rate of the longitudinal ultrasound wave passing through a special sample is measured and then changes of the dynamic module are determined. The dynamic module E_d is changing due to moisture increasing as well as due to its decreasing in a moulding sand. These changes are especially large when the absorbed water decreases strength of binder bridges e.g. in case of moulding sands with hydrated sodium silicate. However, this method does not allow to determine the water amount which permeated - from surroundings - inside the sample. This became the reason of starting studies on the method of measuring water amounts penetrating through surfaces of sand moulds, in order to be able to perform complex analyses of the behaviour of moulding sands - with different binders - under variable atmospheric conditions.

2. Investigation methodology

2.1. Idea of performing investigations

Moulding sands on account of their structures (pores) reveal the ability of absorbing moisture from the surroundings. This process is the fastest in surface layers (of a thickness of a few mm) of casting moulds. Perpendicular samples of a thickness of 5mm were tested, which at a double-sided moisture exchange with the surroundings corresponds with the conditions occurring in surface layers of moulds (down to 2.5 mm).

In order to analyse the observed effect the prototype research stand, allowing to monitor the water vapour sorption process by

surface layers of sand moulds under high air humidity, was constructed.

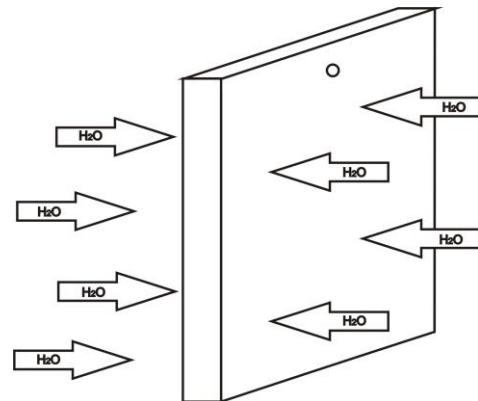


Fig. 1. Schematic presentation of a humidity exchange in the surface layer of the mould

Moulding sands with three binders of various water affinity: alkyd resin, furfuryl resin and hydrated sodium silicate, were subjected to investigations.

2.2. Research stand

The research stand consisting of the measuring chamber, electronic balance, computer and watertight thermo-hygrometer is presented in Figure 2.

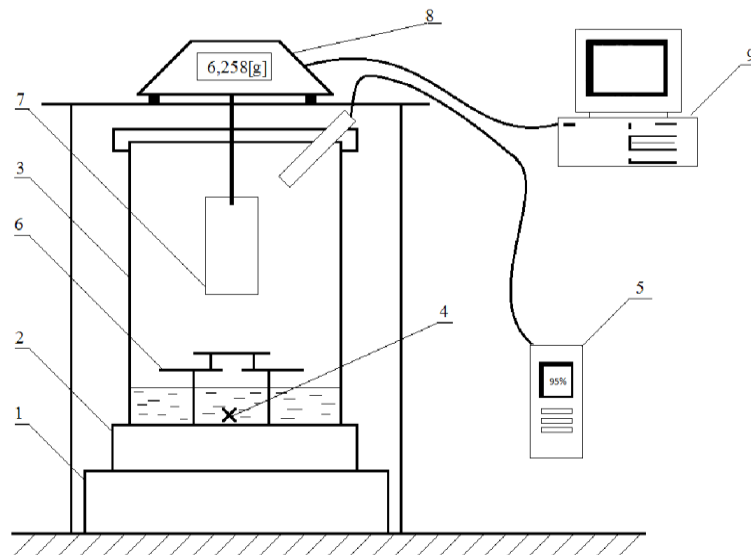


Fig. 2. Research stand for measuring the process of a moisture sorption by surface layers of a casting mould:
1 - controller, 2 - heating plate, 3 - measuring chamber, 4 - stirrer, 5 - hygrometer,
6 - casing, 7 - sample, 8 - electronic balance, 9 - computer

The tight measuring chamber (3) is filled with water to a level of 3.5 cm from the bottom and placed on the heating plate (2). A temperature set on the controller (1) assured maintaining constant temperature inside the chamber at a level: 28 – 33°C and a relative air humidity above 95%. In addition, the magnetic stirrer (4) on the chamber bottom allowed changing the intensity of mixing liquid, that is analysing the absorption of water vapour at various intensity of the air circulation. The thin-walled sample (7) was placed in the chamber and simultaneously suspended on the electronic balance (8), which warranted continuous measurements of an increased sample weight due to water absorption. Joining the balance with the computer (9) allowed cyclic recording of the results during the whole period of investigations. The thermo-hygrometer (5) was used for controlling thermal-moisture conditions inside the measuring chamber.

2.3. Investigation proceedings

In order to obtain identical initial conditions, before starting investigations, each sample was dried in the moisture balance at a temperature of 50°C for 15 minutes and then in 5-minutes cycles up to obtaining the constant mass. When the mass was stabilised the sample was placed in the measuring chamber of constant thermal-moisture conditions. The sample placed in the measuring chamber was simultaneously suspended on the electronic balance in a way allowing moisture sorption by its surface from surroundings. Mass changes, with the accuracy up to 10^{-3} g, were continuously measured during the whole investigation period, i.e. 12 hours and recorded by means of a computer every 30 seconds.

3. Analysis of the results

The performed tests concerned the sorption process of surface layers of sand moulds under conditions of a high relative air humidity – above 95% and a constant temperature within the range 28 – 33°C.

The results of investigating the moisture sorption from surroundings for three kinds of moulding sands with binders are presented in Figure 3.

It was found that characteristics of the process for moulding sand on the base of hydrated sodium silicate (water glass) and furfuryl resin (furans) have similar pathways but significantly differ in the intensity of increasing water mass permeated from surroundings. On the bases of both curves the sorption process can be divided into two periods. In the first one, the process is fast and in a relatively short time period large amounts of water vapour penetrate through the sample surface. In the second period the sorption process slows down, a water mass increase in the sample is smaller and its character can be described, in approximation, by the linear dependence. Another pathway of the process indicates the alkyd moulding sand. An increase of the sample mass is - from the very beginning - of a more linear character.

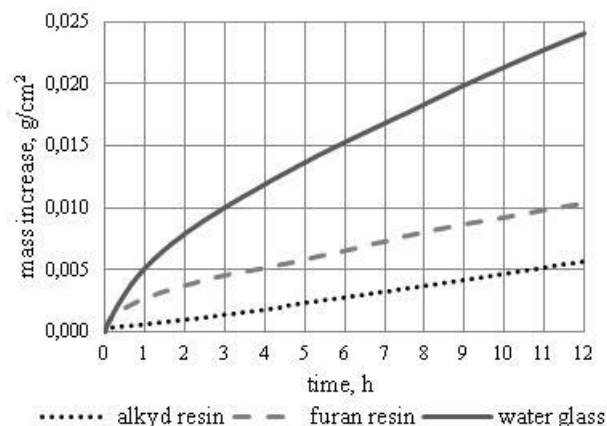


Fig. 3. Increased sample mass due to water sorption from surrounding, as a time function

It also results from Figure 3 that during the measurement, it means during 12 hours, none of the tested moulding sands achieved the maximum water saturation. Nevertheless, the moulding sand with the binder based on hydrated sodium silicate (water glass) indicates the highest sorption ability, out of all tested sands. During the test, through front surfaces of samples made of the moulding sand with water glass penetrates twice as much water as in case of the moulding sand on the bases of furan resin and nearly four times more than in case of the sand based on alkyd resin. This indicates the decidedly hydrophilic character of water glass. However it should be noticed that both moulding sands with resins also absorb water vapour from surroundings, despite a general opinion of their hydrophobic character.

The kinetics of the sorption process of casting moulds' surface layer is presented in Figure 4.

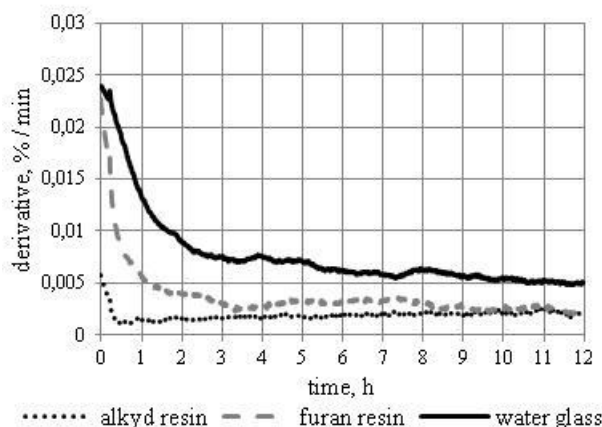


Fig. 4. Kinetics of the sorption process of moulding sands

The graph allows to determine the change of the moisture sorption rate from surroundings and to indicate its value at the very moment. Each presented characteristics has analogous pathway, the moisture sorption rate decreases systematically along with the increasing measurement time. However, values of these rates

differ for individual moulding sands. The observed effect is the slowest in the moulding sand with alkyd resin and the fastest when hydrated sodium silicate was used as a binder. This confirms the observation that the more hydrophilic character of a binder the more moisture and at a higher rate is absorbed by the moulding sand from surroundings.

4. Conclusions

The method of investigation of the sorption process of sand moulds surface layers, under conditions of a high relative air humidity, is presented in the hereby paper. The basic feature of the presented method is the possibility of estimating the amount of water which will penetrate through sand mould surface layers inside the mould.

Knowledge of the sorption process of moulding sands and their sorption ability allows to find the proper storage conditions for ready casting moulds waiting for being poured with liquid metals. Due to this, an influence of variable atmospheric conditions on casting moulds, which can negatively influence the surface quality of obtained castings, is limited.

In the light of the preliminary investigations the decidedly hydrophilic character of the binder, based on hydrated sodium silicate, can be confirmed. What's more, the effect of the water vapour sorption from surroundings is also observed in moulding sands generally considered as stable and resistant to a water influence, it means in moulding sands with furfuryl and alkyd resins.

It should be emphasised that the performed investigations are the preliminary ones and indicate the need of their continuation, including tests under different conditions, lower air humidity typical for the climate of the European climatic zone.

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