

Behaviour of moulding sands with hydrophilic binders in dry air

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Abstract

The work presents results of research on changes of elasticity and durability properties of moulding sands with a hydrophilic binder. The research concerns the surface layer of a mould. The presented loss of durability in the layer can be caused by too fast dehydration of the binder. The course and degree of changes depend on air temperature and moisture, grain size of the moulding sand, and amount of the binder. An ultrasonic method developed by the author allows observation of kinetics of the changes. Results obtained from the method have practical meaning for the mould technology.

Keywords: Ultrasonic, Moulding sand, Surface layer

1. Introduction

The surface layer of the sand mould determines quality of produced castings, mainly in relation to their surface. However, a direct contact of the mould with an atmosphere results in instability of its parameters, consequently its mechanical and technological properties may vary in a broad range. The major changes are caused by evaporation of water or other compounds of chemical binders. The evaporation rate depends both on air temperature and its moisture. The investigations of changes in the moulding sand strength made so far are limited to assessment of the strength in normalised samples, usually by means of R_g .

The R_g measurements are performed in selected time intervals on samples kept in wet air [1]. The work presents results of testing of moulding sands using an ultrasonic method [2-7]. Excessive drying of moulding sand, involving the surface layer of the mould (Fig.1.) leads to cracking of binder layers both on the surface of matrix grains, and within binder bridges (Fig.2.b).

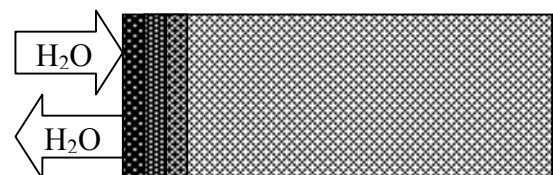


Fig.1. The sand mould as a multilayer porous body. Water vapour exchange with the mould surface.

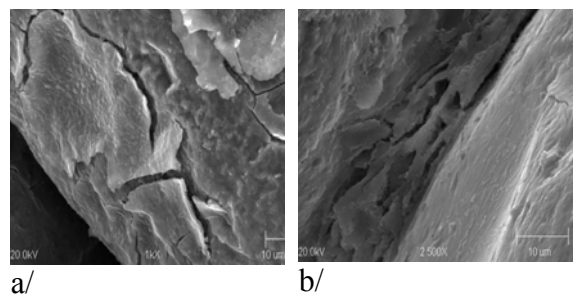


Fig.2. Cracks observed in the binder layers: a) on the grains surface, b) within binder bridges (water-glass 145).

2. Results

Results of the investigations refer to behaviour of moulding sands with hydrophilic binders in conditions of low air moisture, which is arbitrary set to the relative humidity (W) lower than 15%. Dry air conditions usually take place during summer season, but may also happen in winter. The behaviour of the moulding sands in such conditions is interesting for assessment of their value in technological processes. The investigations are mainly based on the moulding sand bound with water-glass. A tubular sample of the moulding sand of 3,5 mm height represents a layer of a mould with the same thickness, thus the investigations enable estimation of behaviour of the moulding sands in the surface layer of the mould.

2.1 Effect of the air temperature

Increase of the temperature causes reduction of water viscosity and surface tension, which makes easy its migration in grains in form of a thin layer, which thickness does not exceed few micrometers. High surface area of the binder facilitates its drying. During testing, the moulding sand samples [3-6] are placed in a climatic chamber. of investigations of E_d modulus of the samples with water-glass, and kept in air with the relative humidity 12-15% at temperatures: 10°, 20°, 30°C. During the first period of the drying process, the moulding sand elasticity (E_d modulus), and related to it mechanical properties increase [3-6]. The second stage of the drying process begins after 90 – 120 minutes, and it is characterised by decrease in the sand elasticity, which is caused by cracking of the binder bridges (Fig.3).

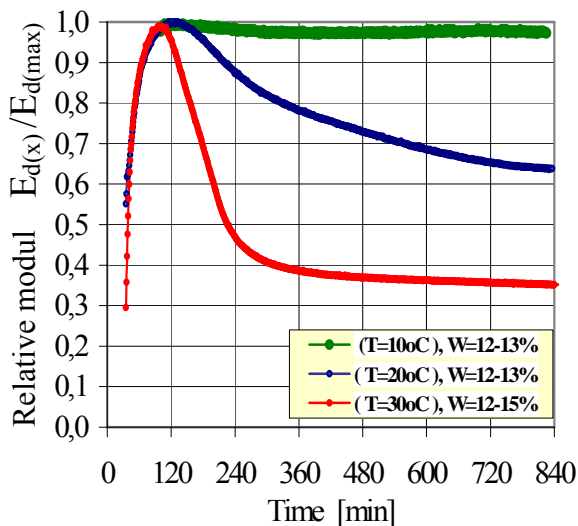


Fig.3. Influence of the temperature (with constant air humidity $W=12-15\%$) on the process of changes of the relative modulus E_d of the moulding sand with water-glass ($M=2.5$) in the surface mould layer. (binder= 3.5%).

The cracking process intensifies with increase of the air temperature. The cracks are caused by too fast build up of the binder shrinkage stresses. Linear shrinkage of water-glass is 10 to 20 %. Stability of the sand with W lower than 12-15% at temperature 30°C does not exceed 6 hours. This conclusion concerns the moulding sand based on silica matrix (Szczakowa, $d_L=0.294$ mm) containing 3.5% of water glass.

2.2 Effect of the grain size (permeability)

Rate of water (vapour) exchange between the porous body and channels created by intergranular spaces. For the moulding changes of the moulding sand kept in dry air. Water-glass bound practice, the actual course of the drying process is less important than its effects measured by degree of changes of strength indicators related to E_d modulus. Water-glass bounded moulding sands based on sand grains with different sizes ($d_L = 0.20 - 0.63$ mm) were prepared. The diversified matrix was prepared by separating grains using sieves. The prepared moulding sands showed distinct differences in permeability. Figures 4 and 5 presents results of ultrasonic investigations of changes in E_d modulus. In case of the moulding sands with coarse-grained matrix, the second stage of the drying process (weakening of the sand) is distinctly faster. By lowering permeability of the moulding sand it is possible to reduce the unfavourable process of fast strength loss of the moulding sand.

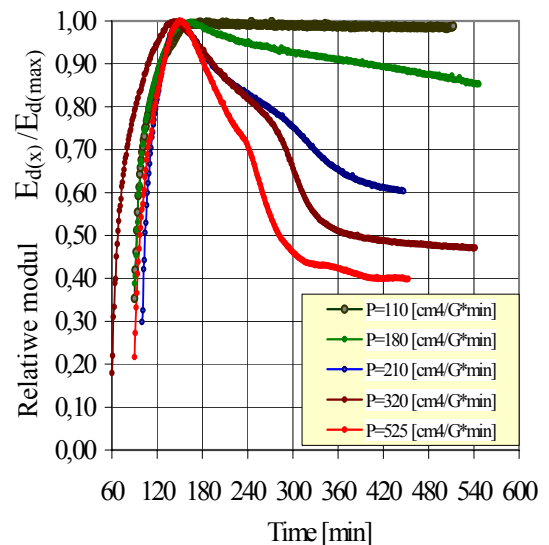


Fig.4. Effect of permeability on the course of E_d modulus surroundings depends on the mould porosity, and size of moulding sands; $T=32^\circ\text{C}$, $W=8-12\%$.

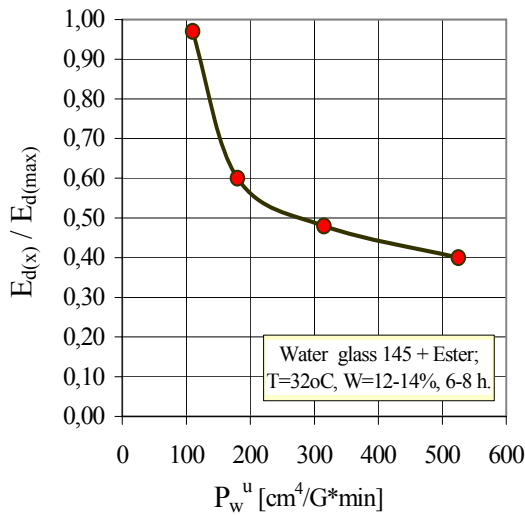


Fig. 5. Effect of permeability on the course of E_d modulus surroundings depends on the mould porosity, and size of moulding sands; $T=32^\circ\text{C}$, $W=8-12\%$. Time (past) 6-8h.

2.3 Effect of the binder amount

The binder amount, when the grain size of the matrix is constant, determines thickness of its layer on the grains surface. The effect of binder amount was investigated using the described method. Test were performed in the relatively high air temperature ($T=32^\circ\text{C}$). The matrix grain size $d_L = 0.40 - 0.63$ mm. Increase of the binder amount (water-glass, fosforan-binder) distinctly slows down the process of strength loss of the moulding sand in dry air (Fig. 6,7 and 8), but it cannot eliminate it completely. The final value of E_d modulus (the moulding sand strength) of the sand also increases.

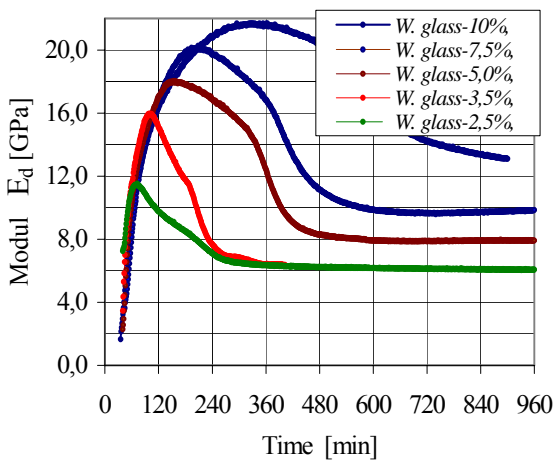


Fig. 6. Effect of the binder amount on the course of changes of the dynamic modulus of the moulding sand kept in dry air. $T=32^\circ\text{C}$, $W=12\%$. Esteric process.

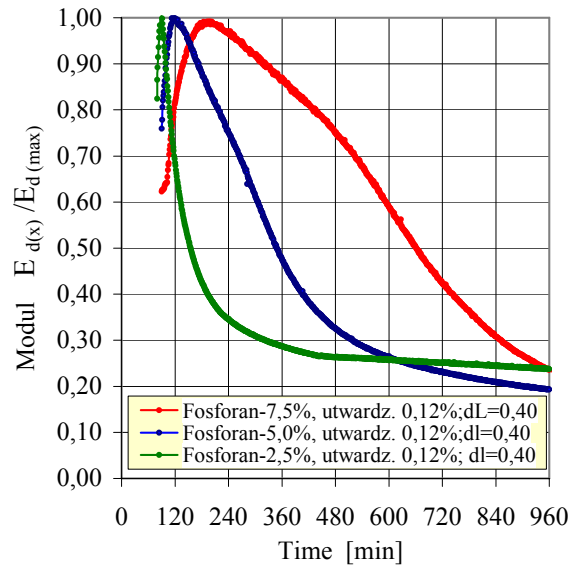


Fig. 7. Effect of the binder amount on the course of changes of the dynamic modulus of the moulding sand kept in dry air. $T=32^\circ\text{C}$, $W=12\%$. Fosforan binder (Glinfos S).

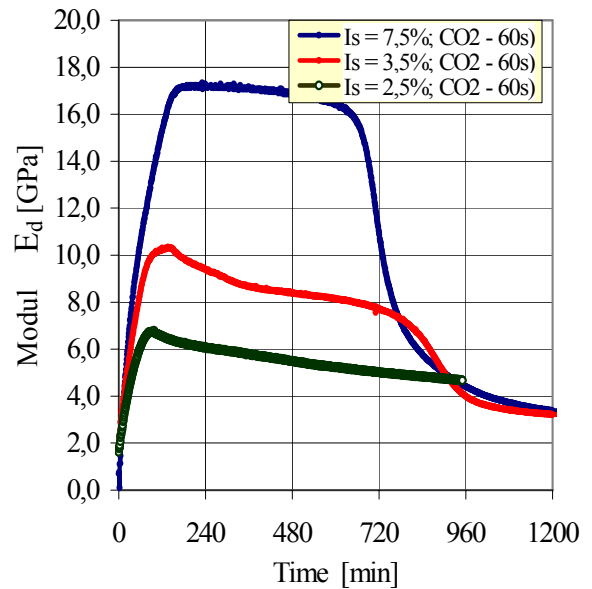


Fig. 8. Effect of the binder amount on the course of changes of the dynamic modulus of the moulding sand kept in dry air. $T=32^\circ\text{C}$, $W=12\%$. Water glass + CO_2 process.

2.4 Moulding sands with other binders

Due to the poor knock-out properties of the water-glass bound moulding sands, water-glass is often modified with various additions e.g. saccharine (S-10 binder, Besil binder).

However, the stability of such moulding sands in conditions of dry air is very limited, which can be confirmed by results of investigations presented in **Fig. 9**. In conditions of dry air and relatively high temperature, stability of the moulding sand bound with water-glass modified with saccharine does not exceed 3 – 5 hours.

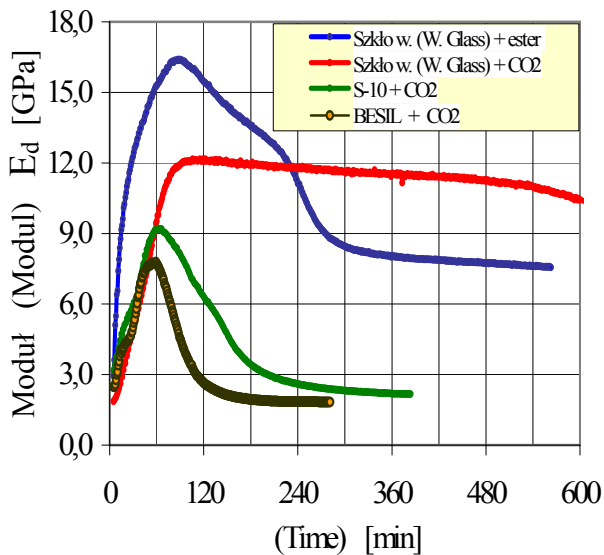


Fig.9. Behaviour of the water-glass bound moulding sands. The sand grain size $d_L = 0.40 - 0.63$ mm. Conditions: $T=32^\circ\text{C}$, $W= 8-12\%$.

3. Conclusions

The effect of different factors on the behaviour of the moulding sands with hydrophilic binders in air with humidity lower than 15% is as follow:

- The air temperature, at constant low-humidity level ($W < 15\%$) determines the rate of strength loss of the moulding sand,
- Increase of the moulding sand porosity favours the process of the strength loss,
- Increase of the binder amount slows down the process of strength loss of the moulding sand in dry air,
- Additives modifying composition of water-glass change the water-glass bound moulding sand resistance to extensive drying

References

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