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# High-temperature expansion and knock-out properties of moulding sands with water glass

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## Summary
The article focuses on the topic of improving the knock-out properties of moulding sand with water glass and ester hardener. It is settled that the cause of worse knock-out properties of moulding sand can be brought by their thermal expansion in increased temperatures. There is a presentation of the influence of different additives, containing $Al_2O_3$, on moulding sands' expansion in increased temperatures. Within the frames of research, there was an elaboration of the influence of authors own additive- Glassex, on the expansion phenomenon of moulding sands with water glass and ester hardener. It is concluded, that the new additive stops the expansion of moulding sands and as well it improves their knock-out properties.

**Keywords:** Moulding sands; Water glass; Knock-out properties; New additive Glassex

## 1. Introduction

In times of the increasing requirements of ecological aspects, much more important become the technologies of producing the moulding and core sands based on inorganic binders. Within them, the most important are the moulding sands with water glass. However, the inorganic character of binder causes the worse knock-out properties of these moulding sands.

Basing on the literature [1-5], it is said that the cause of incorrect knock-out properties of moulding sands, is their expansion under the influence of high temperature, that makes the stresses appear. It is connected with the characteristic run of so-called retained strength, which is widely described in literature.

It is said, that bringing in the $Al_2O_3$ into moulding sand, causes the decrease of its' expansion in high temperature. In order to describe the influence of different crystallographic modifications of $Al_2O_3$ on the retained strength, P. Jelinek [5, 7] did the researches using materials containing $Al_2O_3$ in different forms. The chamotte powder was used, where $Al_2O_3$ is stable bounded ($3{\cdot}Al_2O_3{\cdot}2SiO_2$), and kaolinite clay, where the kaolinite is the basis ($Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O$). At the temperature of 600$^o$C, after dehydroxylation, the kaolinite becomes the metakaolinite and in temperature of 950 – 1000$^o$C $Al_2O_3$ appears in very reactive form $\gamma$. The aloxite, that has a very classical $\gamma$ form was also used. Author also used to the researches the calcinated $Al_2O_3$, which is a mix of two modifications $\alpha$ and $\gamma$-$Al_2O_3$. There is also unstable $\gamma$ form, that in the temperature of 900 – 1200$^o$C , becomes a $\alpha$ form, which leads to the decrease of volume. Also the bauxite was elaborated, as it can contain the hydralgillite ($Al_2O_3{\cdot}3H_2O$), böhmit ($\gamma$-$Al_2O_3{\cdot}H_2O$) and diaspore ($\alpha$-$Al_2O_3{\cdot}H_2O$). Author found that, during the heating, in the area after minimum (600$^o$C), strongly reactive $\gamma$-$Al_2O_3$ is being released. As it can be seen, these analysis are not obvious.

Fig.1 presents the influence of materials containing $Al_2O_3$ - used by an author, on the II maximum of retained strength and moulding sand's expansion [5].

a) b)

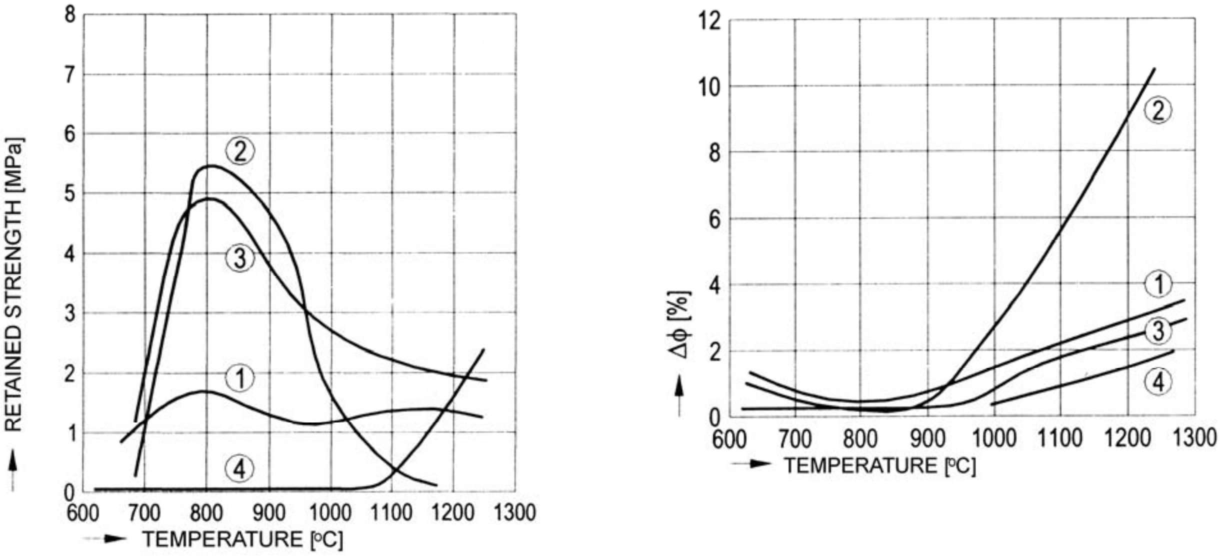


Fig.1. The influence of materials containing $Al_2O_3$ on II maximum of retained strength and the moulding sand's expansion; a) an influence of temperature on the retained strength of moulding sand with different additives by constant contents of $Al_2O_3$ – 1,5%; b) an influence of temperature on the changes of dimensions (Δϕ) of samples from moulding sand with different materials by constant contents of $Al_2O_3$ – 1,5%. 1) moulding sand with chamotte, 2) moulding sand with corundum 3) moulding sand with calcinated $Al_2O_3$, 4) moulding sand with kaolinite clay [5].

a) b)

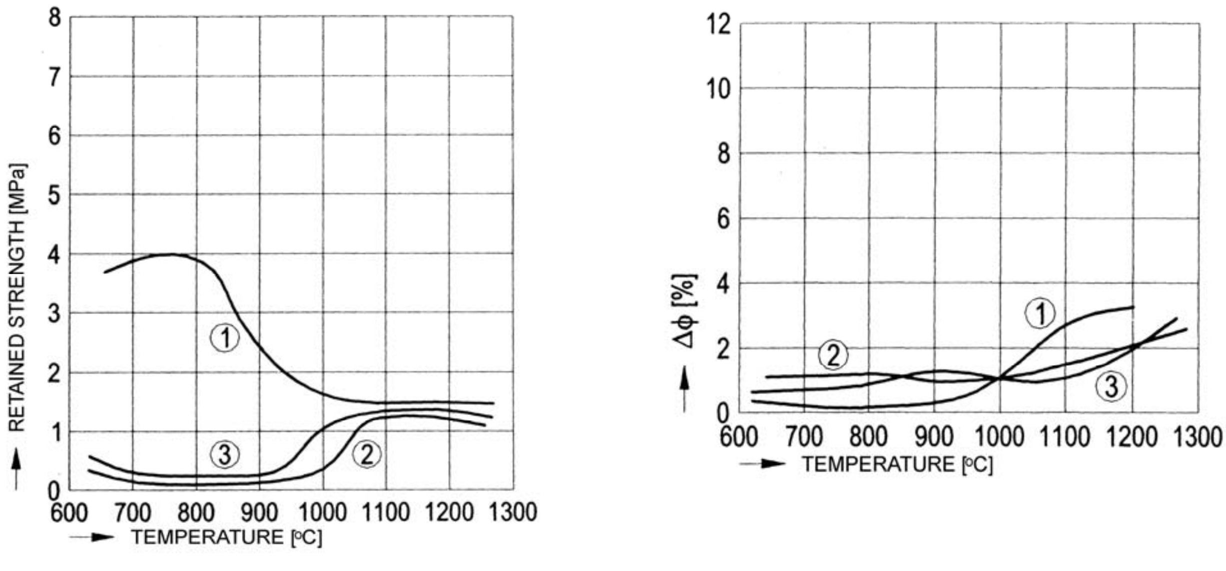


Fig. 2. The influence of kaolinite clay and bauxite on the retained strength in the area of II maximum and the moulding sand's expansion; a) dependence of retained strength from temperature of moulding sand with different additives by constant contents of $Al_2O_3$ – 1,5%; b) dependence of changes of dimensions (Δϕ) from the temperature of samples of moulding sand with different additives by constant contents of $Al_2O_3$ – 1,5%; 1) moulding sand with annealed clay ( the clay is annealed in the mullitization temperature of 1300°C/1h 2) moulding sand with bauxite and clay (bauxite/clay ratio : 3,5:1); 3) moulding sand with bauxite [5].

According to P. Jelinek [5] durable bindings of active $\gamma$-$Al_2O_3$ in mullite keep their run of curve of resistance with II maximum in temperature 800$^{o}$C (4 MPa) (curve 1, fig. 2). In case of bauxite, released $\gamma$-$Al_2O_3$ moves the II maximum to the area of high temperature (above 1000$^{o}$C ).
Researches of P. Jelinek clearly say that the introducing of additives decreasing the moulding sand's expansion, so influencing on stabilization of $\alpha$-$SiO_2$, makes the knock-out properties better. The phenomenon of expansion has a crucial influence on knock-out properties of moulding sand, because the strong changes of volume causes significant stresses in moulding sand, which can not be relaxed by a moulding sand because of its low plasticity. As a result, these stresses can be a cause of worsening knock-out properties.
The Graph lets us conclude that the higher consistence of $\alpha$-$Al_2O_3$ there is in the material, the lower is its influence on II maximum. In case of material containing at the same time $\gamma$-$Al_2O_3$ phase (as calcinated $Al_2O_3$), the II maximum is lower and the decrease after maximum is lower, complying with the higher stabilization of $\alpha$-$SiO_2$ in direction of expansive stable growth [5]. The higher content of $\gamma$-$Al_2O_3$, freed in the area of II maximum temperatures there is, the further is the movement of II maximum away from the areas of high temperature and there's also a bigger stopping of expansive growth of sand grains [6].

# 2. Examination

Basing on the applied analysis of the influence of high temperature on the processes appearing in the moulding sands with water glass, the influence of a new additive Glassex, which as it is described in other publications – improves the knock-out properties of moulding sands [8-12], was defined. It was anticipated, that this additive can have an influence on the expansion of moulding sands with water glass, because of the contents of oxides (mainly $Al_2O_3$, and MgO). The researches were done on roll samples, measuring the height and diameter of samples in three places (top, middle and bottom of sample). The values of diameter of each sample were averaged. The samples were measured before and after heating. The heating was carried out in the range of temperature from 100 to 1200$^{o}$C. To obtain the most precise results, every time a set of six samples was investigated. The comparison of change of diameter and height of samples from moulding sands with and without the Glassex additive is presented on Fig. 3 and Fig. 4.

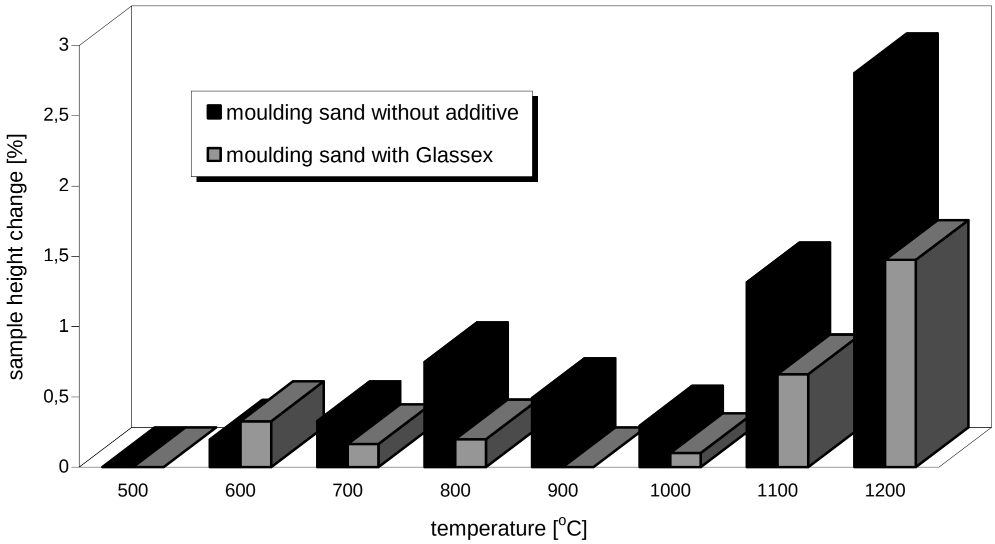


Fig. 3. Sample height change under the influence of heating temperature.

# 3. The analysis of achieved results and conclusions.

Graph 3 presents the results of measurements of moulding sand's expansion starting from samples heated in temperature of 500$^{o}$C, because the measurements of profiles' height In lower temperature didn't show any changes. The observations are in compliance with literature facts. The expansion appears after crossing the temperature of polymorphic transformation of $\beta$-quartz into $\alpha$-quartz. Then it comes to the rapid growth of expansion (graph 3 and 4). Introducing the Glassex additive leads to the significant decrease of this expansion, decrease of size of stresses, which leads to the improvement of knock-out properties.

Similar results were achieved during measurement of samples' diameter under the influence of heating (Fig. 4) Also here it can be observed, that the expansion is decreased by bringing in the Glassex additive.

Concluding, it can be said, that Glassex additive stops the moulding sand's expansion in increased temperatures, so it also decreases the internal stresses in moulding sand, which leads to the improvement of its' knock-out properties.

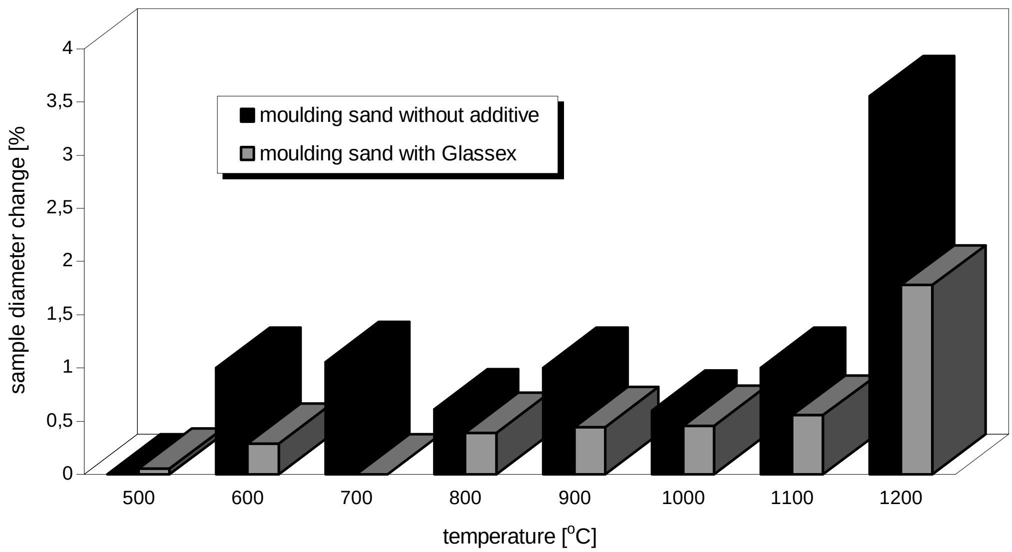


Fig. 4. Sample diameter change under the influence of heating temperature.

# Aknoweledgments

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# Literature


[1] Liu W-H, Guan J., Zhu C-X, Lu C, Dai Y: The development of water-glass sand, Foundry, 2001, nr 3, s. 125-128.

[2] Levin E.M., Robbins C.R., McMurdie H.F.: Phase Diagram for Ceramists, Columbus, Ohio, USA, 1964.

[3] Gitzen W.H.: Alumina as a Ceramic Material. The American Ceramic Society. Ohio.

[4] Fan Zitian, Huang Naiyu, Wang Huafang, Dong Xuanpu: Dry reusing and wet reclaiming of used sodium silicate sand, China Foundry, 2005, nr 1, s. 38-43.

[5] Jelinek P.: Binding systems of core and moulding sands.. Ostrava 2004. (in Czech)

[6] Syčev I.S.: Elaboration of moulding sands with good knock-out properties, Litejnoje Proizvodstvo, 1965, nr 6 s. 31-37. (in Russian)

[7] Jelinek P.: The influence of $Al_2O_3$ on knock-out properties of moulding sand wit water glass. Sbornik vedeckych praci Vysoke skoly banske v Ostrave. Rocnik XIV, cislo 6. Ostrava 1968. (in Czech)

[8] Dobosz St.M. Water in core and moulding sands. Wydawnictwo Naukowe „AKAPIT", Kraków 2006 (in Polish).

[9] Dobosz St. M., Major-Gabryś K.: Glassex- a new additive improving the knock-out properties of moulding sands with water glass. Archives of Foundry, Katowice 2004, Vol. 4, No. 13. s. 63 – 68 .(in Polish).

[10] Dobosz St. M., Major-Gabryś K.: Surface phenomenons versus knock-out properties of moulding sands with water glass. Archives of Mechanical Technology and Automation, Poznań 2004, Vol. 24, No 1, s. 49 – 56. .(in Polish).

[11] Dobosz St. M.: Moulding sands with water glass with increased knock-out properties. Archives of Foundry, Katowice 2004, Vol. 4, No 11, s. 108- 113 .(in Polish).

[12] Major-Gabryś K., Dobosz St. M., Zych J.: Criteria of estimatic the knock-out properties of molding sands with water glass. Archives of Foundry, Katowice 2005, Vol. 5, No 17, s.163 – 168.(in Polish).