The economical and ecological aspects of using the modified water-glass

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Summary. Moulding sands were prepared, using chemically modified water-glass, hardened with diacetate ethylene glycol and CO_2, and tested for their binding properties. In the case of using of modified chemically water-glass his participation in moulding sands can be diminished about 20% (to 2,0 w.%.). Residual strenght of the moulding sands with modified chemically water-glass in the temperature range to 300 ^{0}C is smaller from about 35% to about 60%, in temperatures 500 to 700^{0}C has a nearing value to the residual strength of the moulding sands with not modified water-glass and in temperatures from 700 to 900^{0}C stays practically invariable. The usage of modified chemically water-glass, as binder in the "*CO_2 process*", makes possible the increase of the compression strength of the sand mixes samples about 50%, comparatively to the compression strength of the moulding sands, containing 3,0 weight % not modified water-glass.

Key words: moulding sands, water-glass, structure, modification.

INTRODUCTION

Soluble sodium silicate (water-glass), along with other binders and technology of casts from ferrous and nonferrous metals, is one of the most popular self-hardening, inorganic binders [18,20-21,23-24,28-29]. Water glass used for over 50 years in foundry industry as binder for cold hardening moulding and core sands is cheap, easily available and nontoxic. However, in comparison to organic binders it has some drawbacks such as higher brittleness, limited knock-out properties of moulding mixtures, more difficult reclamation of the sand grains, as well as insufficient thermal resistance and formation of sinters due to a susceptibility of the Na_2O-SiO_2 system to react with quartz sand at elevated temperatures. These disadvantages can be limited by producing in the silica gel of organic nets *IPN* (*IntraPenetratingNets*) which make reducing amounts of binder in moulding sands and reducing residual strenght cores and moulds. Modified soluble sodium silicate make possible:

– optimum conditions for hardening of moulds and cores of required physical and mechanical properties,
– reduced strength of cores and moulds within temperatures between 300 and 1200^{o}C, and consequently diminishes labor costs involved with knocking out foundry moulds and cores from castings,
– easier reclamation of the sand grains.

These tasks should be developed together, i.e. better mixture properties should be accompanied by improved knock-out proprieties and reclamation capabilities.

Binding properties of sodium silicate solution can be improved by introducing morphoactivators into its structure, to control morphology of the final product. Water soluble high molecular compounds with active functional group such as –OH, $-NH_2$, =CONH, $-CONH_2$, –COOH and others can be used as modifiers. Modifiers accelerate the process of dissolving solid silicate glass, contribute to the formation of higher adhesive strengths, increase especially cohesive strengths and reduce the brittleness of the mass formed. Their presence in silicate solution can rise its working performance as a cohesive, and reduce its consumption [1-17, 19, 22, 25-27].

It was found that most favourable conditions for chemical modifying sodium silicate solution exist in the process of autoclave dissolving solid sodium silicate glass in water. Hydrated silicate anions pass then continuously into solution and undergo hydrolysis, to form of polysilicate anions and alkali metal cations, simultaneously. The modifiers introduced in this step have a favourable influence on shaping the structure and properties of the silicate binder. Structures with intrapenetrating polymer nets (*IPN*) are then formed, with a consequence that sodium silicate polymer matrix becomes reinforced with organic polymer bonds.

Commercial sodium silicate solution is known to possess various chemical composition designated by SiO_2 to Na_2O molar ratio (*M*), ranging from 2 to 3.3. In the foundry, to manufacture moulding mixtures where esters e.g., ethylene glycol diacetate, are used as hardeners, a product with *M* = 2,0-2,5 is used, especially that of *M* = 2,0.

PURPOSE AND METHODS

Moulding sands were prepared, using chemically modified water-glass *R-145S/MC1,0* and *R-150/MC1,0* [8], hardened with diacetate ethylene glycol and CO_2, and tested for their binding properties. As reference sample unmodified commercial water- glass of *R-150* type was used. The amount of binder in the moulding sands accounted to 2,5 weight parts while the hardener represented 15% in relation to the mass of the water-glass. The main fraction of the grains of the used quartz sand was 0.20/0.40/0.32 with homogeneity index 90. At ambient temperature, the specimens prepared were tested for bending strength (R_g^u), tensile strength (R_m^u), compressive strength (R_c^u), and - after baking at temperatures ranging from 100°C to 900°C – residual strength R_c^r. Permeability (P^u) of the samples of investigated moulding sands in relation to hardening time was determined.

RESULTS AND DISCUSION

Results of research represent on the fig. 1-3. Moulding sands with the participation of modified chemically water-glass *R-145"S"/MC1,0* in the quantity 2,5 w.%, possess nearing technological proprieties to the propriety of technological sandmixes with the participation not modified chemically water-glass R-150 in the quantity 2,5 w.%.

In the case of using of modified chemically water-glass R-150/MC1,0 his participation in moulding sands can be diminished about 20% (to 2,0 w.%.). The moulding sands with such participation of water-glass possess sufficient technological proprieties. Permeability of moulding sands with the participation not modified and modified chemically water-glass, have nearing values (from about 420 to about 500 m · 10^{-8}/Pa · s). Residual strength of the moulding sands with chemically modified water-glass *R-145"S"/MC1,0* (2,5 w. %) in the temperature range to 300°C is smaller from about 35% to about 60%, comparatively to the residual strength of the moulding sands with modified water-glass *R-150* (2,5 w. %). In temperatures 500 to 700°C residual strength of the moulding sands with modified chemically water-glass *R-145"S"/MC1,0* has a nearing value to the residual strength of the moulding sands with not modified water-glass *R-150*

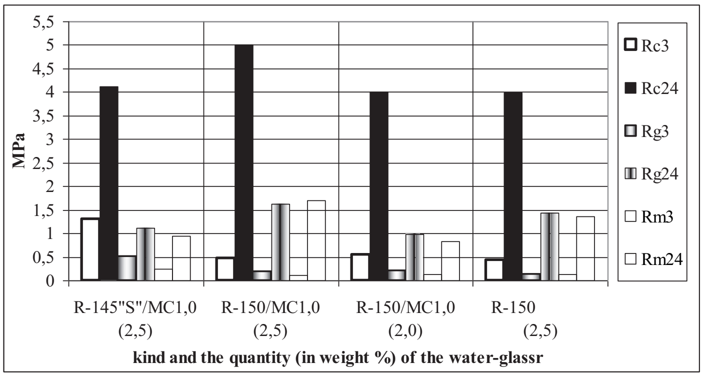

Fig. 1. Strenght proprieties of the samples of the moulding sands with the participation of the different content of chemically modified water-glass *R-145"S"/MC1,0; R-150/MC1,0* and not modified water-glass *R-150*, with diacetate ethylene glykol as a hardener. Marks on the drawing refer compression strengths after 3 and 24 hours of setting (Rc3, Rc24), bending strengths after 3 and 24 hours of setting (Rg3, Rg24) and tensile strenght after 3 and 24 hours of setting (Rm3, Rm24).

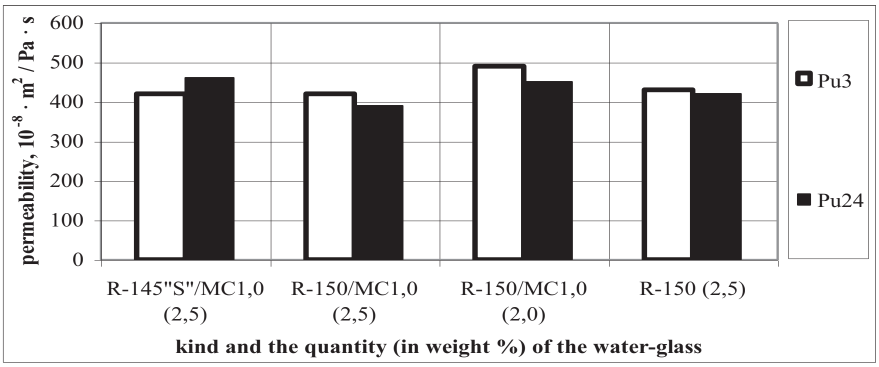

Fig. 2. Permeability of the samples of the moulding sands with the participation of the different content of chemically modified water-glass *R-145"S"/MC1,0; R-150/MC1,0* and not modified water-glass *R-150*, with diacetate ethylene glykol as a hardener. Marks on the drawing refer permeability after 3 and 24 hours of hardening (Pu3, Pu24)

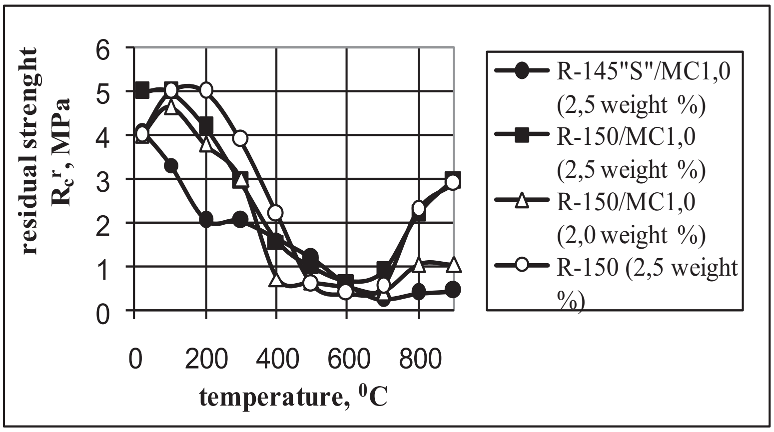

Fig. 3. Residual strenght of the samples of the moulding sands with the participation of the different content of chemically modified water-glass *R-145"S"/MC1,0; R-150/MC1,0* and not modified water-glass *R-150*, with diacetate ethylene glykol as a hardener

(2,5 w. %). In temperatures from 700 to 900^{0}C residual strength of the moulding sands with chemically modified water-glass *R-145"S"/MC1,0* stays practically invariable (about 0,5 MPa), and in the case of the moulding sands with not modified water-glass *R-150* (2,5 w. %) her value surrenders to the enlargement to about 3 MPa. The usage of modified chemically water-glass *R-145"S"/MC1,0* in the quantity 3,0 w. %, as binder in the "CO_2 *process*", makes possible the increase of the compression strength of the moulding sands samples about 50%, comparatively to the compression strength of moulding sands samples, containing 3, 0 w.% not modified water-glass *R-145*. At the participation in moulding sands of modified chemically water-glass *R-145"S"/MC1,0* in the quantity 4,0 w.%., the compression strength of moulding sands samples, is nearing to the compression strength of the moulding sands samples containing 6,0 w.% not modified water-glass *R-145* (fig. 4-5).

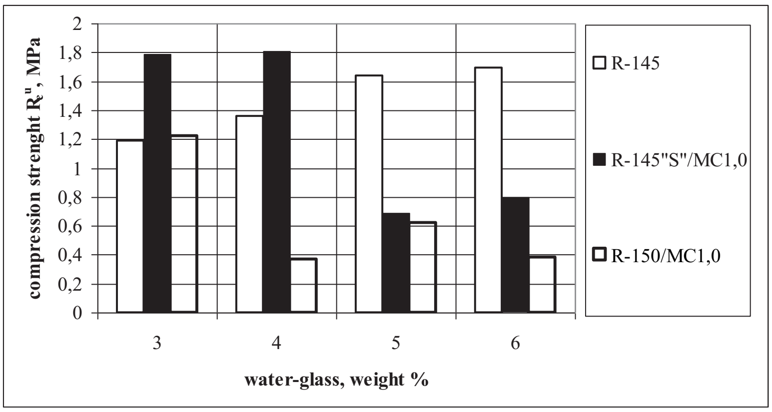

Fig. 4. Strength properties of the samples of the moulding sands (*process* CO_2) with the participation of the different content of chemically modified water-glass *R-145"S"/MC1,0; R-150/MC1,0* and not modified water-glass *R-145*

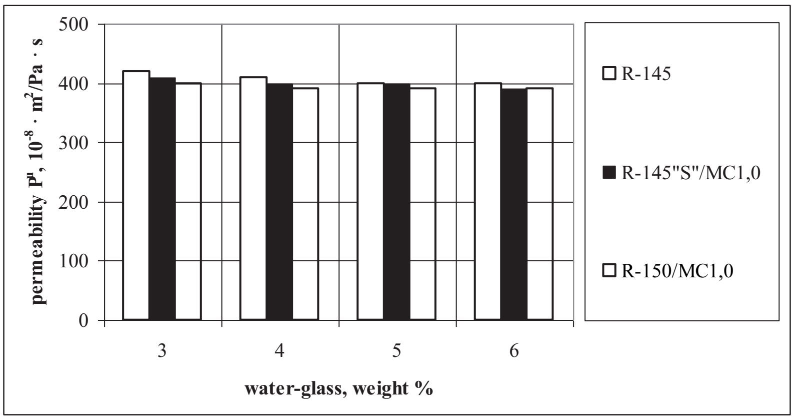

Fig. 5. Permeability of the samples of the moulding sands (*process* CO_2) with the participation of the different content of chemically modified water-glass *R-145"S"/MC1,0; R-150/MC1,0* and not modified water-glass *R-145*

CONCLUSIONS

1. The chemical modification of the water-glass makes possible the diminution of its contents in the moulding sands and the improvement of their knock-out properties. This improves economical efficiency of the production in consequence of the material costs decrease, diminishes costs of knocking out and cleaning of castings and improves the efficiency of the regeneration process of the used sands.
2. In many cases chemically modified water-glass replace expensive and toxic bindings.

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EKONOMICZNY I EKOLOGICZNY ASPEKT STOSOWANIA MODYFIKOWANEGO SZKŁA WODNEGO

S t r e s z c z e n i e. Określono właściwości technologiczne mas formierskich wykonanych z zastosowaniem modyfikowanego chemicznie szkła wodnego utwardzanego dwuoctanem glikolu etylenowego i CO_2. Stosując modyfikowane szkła wodne można zmniejszyć jego zawartość w masie formierskiej o około 20% (do 2 % masowych). Wytrzymałość końcowa mas formierskich z modyfikowanym chemicznie szkłem wodnym ma mniejszą wartość od około 35% do około 60% w temperaturze do 300^{0}C, w temperaturze 500 do 700^{0}C ma zbliżoną wartość do wytrzymałości końcowej mas wykonanych z nie modyfikowanym szkłem wodnym, natomiast w temperaturze 700 do 900^{0}C praktycznie nie ulega zmianie. Stosując modyfikowane chemicznie szkło wodne w „*procesie* CO_2" możliwe jest uzyskanie wartości wytrzymałości na ściskanie masy formierskiej większej o około 50%, w porównaniu do wytrzymałości na ściskanie masy formierskiej zawierającej 3% masowych nie modyfikowanego szkła wodnego.

S ł o w a k l u c z o w e: masa formierska, szkło wodne, struktura, modyfikacja.