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Reclaiming Ability of Spent Sands with Modified, Hydrated Sodium Silicate

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Abstract

The presented in the paper investigations were aimed at the determination of the reclaimed material (obtained in the dry mechanical reclamation process) addition influence on properties of moulding sands with hydrated sodium silicate modified by colloidal suspension of zinc oxide nanoparticles in propanol. Nanoparticles originated from the thermal decomposition of alkaline zinc carbonate, were used.
The results of the reclamation of the spent moulding sand with hydrated sodium silicate performed in the AT-2 testing reclaimer are presented in the paper. Both, spent sands from the Floster S technology and from the technology with the modified water-glass were subjected to the reclamation processes. The following determinations of the reclaimed material were performed: pH reaction, acid demand, ignition loss and Na2O content. The obtained reclaim was used as a matrix component of moulding sands with water-glass in the Floster S technology, in which it constituted 60% and 50% of the sand matrix. The strength properties of the prepared moulding sands were determined (bending strength R_g^u, tensile strength R_m^u) after samples storing times: 1h, 2h, 4h and 24 hours.

Keywords: Loose self-hardening moulding sands, Floster S process, Modification of sodium silicate, Reclamation

1. Introduction

Self-hardening moulding sands with water-glass hardened by liquid esters are applied in several foundry plants for making moulds for the production of heavy steel and iron castings. The main good point of this process is a low cost of moulding sands. However, due to their weak suitability for the matrix reclamation, the fraction of sands originated from the reclamation process is limited [1-2]. It was proofed by the investigations, that the most efficient improvement of the quality of moulding sands with water-glass can be obtained by the binder modification [3-4]. Up to the present, multimolecular components, such as e.g. polyphosphates and polyacrylamides differing in a polymerisation degree, molar mass, kind and number of functional groups, were applied as modifiers. Last decades brought a development of a new group of materials the so-called nanoparticles, among others, nanoparticles of ceramic materials (e.g.: SiO_2, Al_2O_3, $CaSiO_3$, ZnO, MgO, aluminosilicates etc. [5-9]). These nanoparticles introduced into the matrix (binder) form new systems, the so-called nanocomposites. Reclamation effects of spent moulding and core sands, which are specially difficult for submitting to this process, are based on several instrumental examinations allowing to assess the technological suitability of the matrix reclaimed in the given device. Applying mechanical reclaimers of different operational mechanisms it is difficult to compare reclaimabilities of various sands, since the system leading to the liberation matrix grains from binding coatings is different [10-15]. Apart from spent sands with water-glass (floster process) and CO_2, moulding sands with alkaline phenolic resin (alpha-set process) and sands with strongly alkaline resins bound by means of CO_2 belong to the moulding sands difficult for the reclamation process [10, 11].

2. Experimental stand

To assess the reclaiming ability of spent moulding sands the reclamation process was performed with using the special test apparatus, in which impact-abrasive rotational elements were applied. The rotational speed of impact-abrasive elements was 700 r.p.m. and the reclamation time of moulding sands samples was 5 minutes.

The view of the test apparatus is presented in Figure 1.

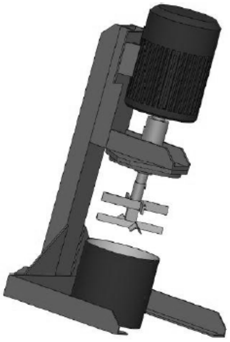

Fig. 1. Pictorial diagram of the test apparatus: AT-2 [16-17]

3. Applied materials and investigation methods

The binder modification was performed for sodium water-glass „R 145 " of a modulus M = 2.5, density d^{20} = 1470 kg/m^3, pH = 11.2.

The water-glass modifier constituted the suspension of ZnO nanoparticles in propanol of a constant concentration, c=0.3 M and nanoparticles size within a range: < 61 – 981 nm > (Fig. 2 and 3). The applied ZnO nanoparticles were obtained by the thermal method.

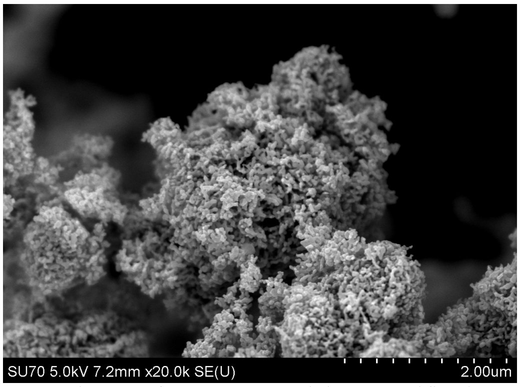

Fig. 2. SEM image of ZnO nanoparticles, magnification: 20 [4]

The moulding sand for testing was prepared in the laboratory ribbon mixer. Preparations of Sand 1 and 2 were performed in accordance with the recommendations of the binder producer. Compositions of moulding sands, prepared on the matrix of the fresh high-silica sand are presented in Table 1.

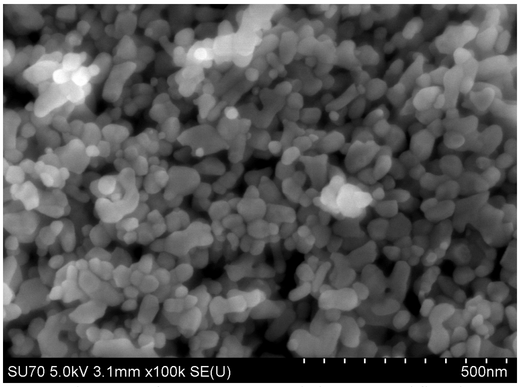

Fig. 3. SEM image of ZnO nanoparticles, magnification: 100 [4]

Table 1.
Composition of moulding sands

Molding sand 1	Molding sand 2
high-silica sand– 100 parts by mass	
water-glass R 145 – 3 parts by mass	
Flodur 1 – 0,3 parts by mass	
----	ZnO modifier – 1mass % in relation to the binder amount

In successive stages of investigations 60% and 50% of the reclaim and 40% and 50% of the high-silica sand were respectively applied as the matrix.

4. The obtained results

Data concerning physical and chemical properties of the investigated moulding sands on the fresh high-silica sand matrix and after the reclamation matrix are given in Table 2. Investigations comprises: ignition losses, chemical reaction, acid demand value and Na_2O content.

Table 2.
Physical and chemical properties of the investigated moulding sands

Investigated matrix	Moulding sand with water-glass		Moulding sand with modified water-glass	
	before the reclamation	after the reclamation	before the reclamation	after the reclamation
LOI	0,971	0,931	0,983	0,942
pH	10,84	9,72	10,87	9,64
Z_K	28,4	21,3	23,6	20,7
Na_2O	0,26	0,23	0,28	0,21

On the grounds of the results listed in Table 2, it can be noticed that spent moulding sands with the modified water-glass have slightly larger ignition losses than moulding sands from the Floster S technology. As a result of the matrix reclamation process performed in the test reclaimer AT-2, in both cases a decrease of ignition losses of reclaimed materials occurred.

The moulding sand with the modified water-glass is characterised by a lower pH value than the moulding sand without the modification. Mechanical reclamation processes of these moulding sands lead to a small decrease of pH, being caused by the removal of a part of a spent binding material from matrix grains. Analysis of results indicates a low Na_2O content on grains of spent sands. Reclamation processes cause decreasing its content to the level allowing the reuse of the obtained reclaims. The dependence of the samples tensile strength on their hardening time is presented in Figure 4. It can be seen, that in the whole tested hardening time, the moulding sand with the modified binder is characterised by a higher strength.

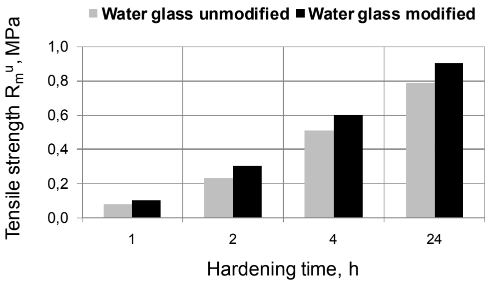

Fig. 4. Tensile strength of moulding sands with water glass, unmodified and modified

The dependence of the bending strength of the samples on their hardening time is presented in Figure 5. The investigated samples strength increases with their hardening time increasing, achieving maximal values after 24 hours, being 1.9 and 2.1 MPa for the moulding sand with not modified and with the modified binder, respectively.

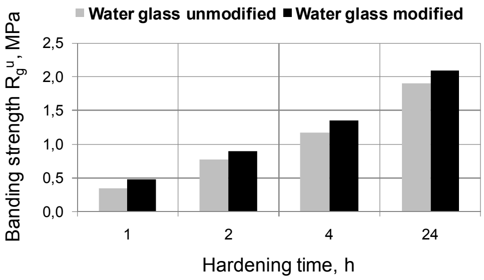

Fig. 5. Bending strength of moulding sands with water glass, unmodified and modified

Figure 6 presents the tensile strength, while Figure 7 the bending strength of moulding sands on the matrix consisting in 60% of the reclaimed materials and in 40% of the fresh high-silica sands. The strength values of the moulding sands containing 60% of the reclaim are nearly 10-times lower than the strength values obtained by the moulding sands on the matrix of the fresh high-silica sand. The moulding sand with the modified water-glass is characterised by a higher strength than the classic moulding sand from the Floster S technology. After one hour of hardening the moulding sand on the matrix of the reclaim from the moulding sand with not modified water-glass did not have any tensile strength.

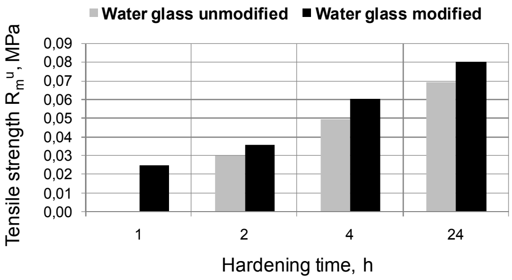

Fig. 6. Tensile strength of moulding sands with the modified and not modified water-glass on the matrix containing 60 % of the reclaim

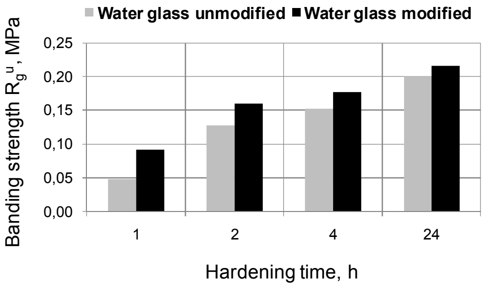

Fig. 7. Bending strength of moulding sands with the modified and not modified water-glass on the matrix containing 60 % of the reclaim

Figure 8 illustrates the tensile strength results, while Figure 9 the bending strength of moulding sands on the matrix consisting in 50% of the reclaimed materials and in 50% of the fresh sand.

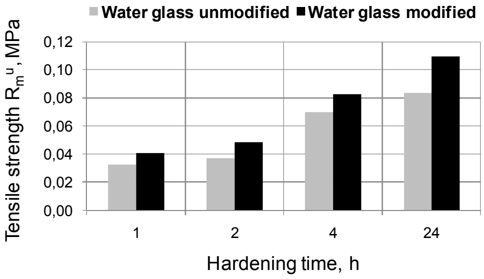

Fig. 8. Tensile strength of moulding sands with the modified and not modified water-glass on the matrix containing 50 % of the reclaim

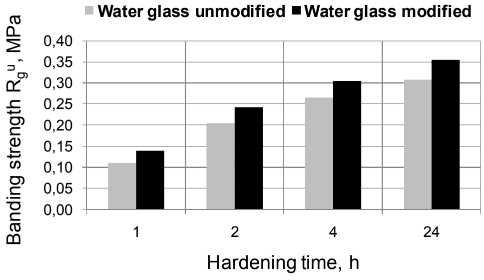

Fig. 9. Bending strength of moulding sands with the modified and not modified water-glass on the matrix containing 50 % of the reclaim

In accordance with the expectations, the moulding sand containing 50 % of the reclaim and 50 % of the fresh sand has a higher strength than sands containing 60 % of the reclaim and 40% of the fresh high-silica sand. In addition, the moulding sand on the matrix of the reclaim of spent sands with not modified water-glass has lower strength values than the moulding sand containing the reclaim originated from the moulding sand with the fraction of the binder modified by nanoparticles of zinc oxide.

4. Conclusions

On the grounds of the performed investigations the following conclusions can be drawn:

- Ignition loss values of the reclaim are decreasing in both analysed cases. An average decrease of the reclaimed samples at a temperature of 850°C equals app. 4 %.
- The dry, mechanical reclamation process causes alkalinity decrease of the tested moulding sands.
- The reclamation process leads to decreasing of the Na_2O content in the reclaimed matrix.
- The highest tensile strength R_m^u and bending strength R_g^u – in the tested range of the hardening time - characterises moulding sands on the matrix of the fresh high-silica sand with water-glass modified by nanoparticles of zinc oxide.
- Moulding sands prepared on the matrix of the reclaimed material are characterised by low strength values caused mainly by active hardeners cumulating in these reclaims and radically decreasing their service life.
- The water-glass modification process favourably influences physical and chemical as well as strength properties of moulding sands prepared on its matrix. Already a small addition of the modifier, being 1mass% in relation to the binder amount, causes an improvement of the sand reclaiming ability, however - from the technological point of view - this result is not satisfactory. This suggests the necessity of the continuation of investigations in order to determine optimal additions of the modifier.
- A noticeable improvement of the reclaiming ability of the moulding sand with the modified hydrated sodium silicate is the most probably related to the influence of zinc oxide nanoparticles on physical and chemical properties and the structure of the tested binder.

Acknowledgements

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