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THE CONDITION OF SILICA SAND GRAINS SURFACE SUBJECTED TO RECLAMATION TREATMENT

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The results of investigations are concerned on evaluation of new silica sand grains surface condition after mechanical reclamation treatment as well as on the conditions of reclaimed sand grains surface subjected to thermal and thermo-mechanical reclamation processes. The purpose of research was to answer the question how the applied methods have influenced the surface condition of reclaimed sand grains which was tested by means of bending strength determination of sand samples prepared with resin binder and reclaimed sand. The immediate aim of the research was to explain the mechanism of impurities cleaning on the sand grains surface after thermal reclamation, when the sand is used several times in preparation of a foundry mixture, and to determine what effect these impurities may have on the technological properties of the ready sand mixture. The task of the additionally applied mechanical reclamation was to remove the accumulated inorganic compounds from the sand grains surface and confirm if further improvement of the reclaim quality is possible.

Key words: *used silica sand, thermal reclamation, mechanical reclamation, sand testing*

Stanje površine zrna silicijskog pijeska izloženog postupku obnavljanja. Rezultati ispitivanja se odnose na novo stanje površine zrna silicijskog (kvarcnog) pijeska nakon mehaničkog obnavljanja kao i stanja površine zrna obnovljenog pijeska izloženog toplinskim i toplinsko-mehaničkim procesima obnavljanja. Svrha istraživanja bila je odgovoriti na pitanje kako su primijenjene metode utjecale na stanje površine obnovljenih zrnaca pijeska, što je ispitivano određivanjem savojne čvrstoće uzoraka pijeska, prethodno pripremljena smolnim vezivom i obnovljenim pijeskom. Neposredni cilj istraživanja je objasniti mehanizam uklanjanja nečistoća s površine zrnaca pijeska nakon topinskog obnavljanja, pri čemu se pijesak rabio više puta za pripremanje lijevarske mješavine, te odrediti kakav učinak te nečistoće mogu imati na tehnološka svojstva pripremljene mješavine pijeska. Zadatak dodatnog mehaničkog obnavljanja bilo je ukloniti nakupljene anorganske spojeve s površine zrnaca pijeska i možebitno daljnje poboljšanje kvalitete obnovljenog pijeska.

Ključne riječi: *rabljeni silicijski pijesak, toplinsko obnavljanje, mehaničko obnavljanje, ispitivanje pijeska*

INTRODUCTION

More and more common application of synthetic resins in the foundry industry as a binder of core and moulding sands causes a need to apply thermal reclamation. Such a state occurred as a result of the constantly increasing share of resin binders in the foundry production not only in the core sands, but also in the moulding sands.

In the process of thermal reclamation some elements (Pb, Cd, Fe, Cu, Mn, Zn) as well as other inorganic compounds which do not undergo combustion (for example phosphorus and potassium compounds) can remain on the surface of the grains. The above mentioned elements and chemical compounds together with the chemical admixtures, contained in the silica sand, can be accumulated in the sand mixture and form impurities in it as a result of the repeatedly applied process of thermal reclamation and renewed use of the same base sand grains to prepare successive batches of moulding or core sands. The commonly known recommendation with regard to the application of the reclaim in the same technology favours the gathering of the same impurities in the base sand [1].

The impurities formed on the surface of the grains, which consist of incombustible components, can be removed by dry mechanical reclamation method and by air separation. The movable parameters of the mechanical reclaimer decide on the effects of abrasion treatment. The above mentioned

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parameters should ensure the suitable reaction of cleaning of the grain surfaces, but without the excessive destruction of the base sand itself. The air separation should create conditions to separate the abrasion products from the surface of the base sand grains.

In such a case the proper evaluation of the received reclaim is very important.

The problem of evaluating the quality of the recovered base sand, as a result of the reclamation process, is unfortunately complicated because according to the currently prevailing conviction any of the physico chemical properties of the reclaimed material cannot individually constitute the basis of evaluating its usefulness to the renewed application. Each time a group of at least several various factors (depending on the binder type), which are considered together, make a reliable picture of the quality and possibility of using the reclaimed material again.

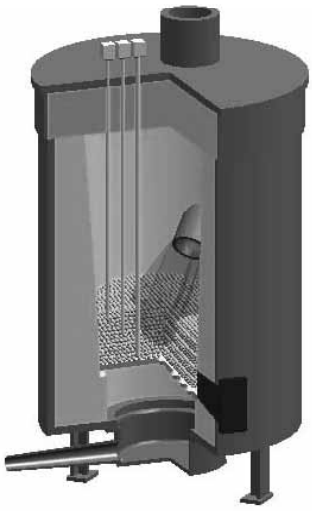

Figure 1. **Experimental thermal reclaimer unit**
Slika 1. **Ispitna jedinica za toplinsko obnavljanje**

Figure 2. **Experimental centrifugal reclaimer with an impact free circumferencial side surface unit**
Slika 2. **Ispitni centrifugalni uređaj s obodnim dijelom**

RESEARCH PROBLEMS

The investigations consisted of 9 cycles of using the same silica base sand to the preparation of the green sands, obtained as a result of thermal reclamation. For the chosen number of the thermal reclamation cycles an additional operation of the centrifugal impact free mechanical reclamation was carried out.

The thermal reclamation was carried out in an experimental reclaimer (RT) (Figure 1.) with a gas burner directed towards the surface of the sand mixture with the periodically switched on fluidisation in order to intermix a batch weighing 5 kg. The temperature obtained in the reclaimer was 750 - 800 °C. The time of reclamation was 25 minutes.

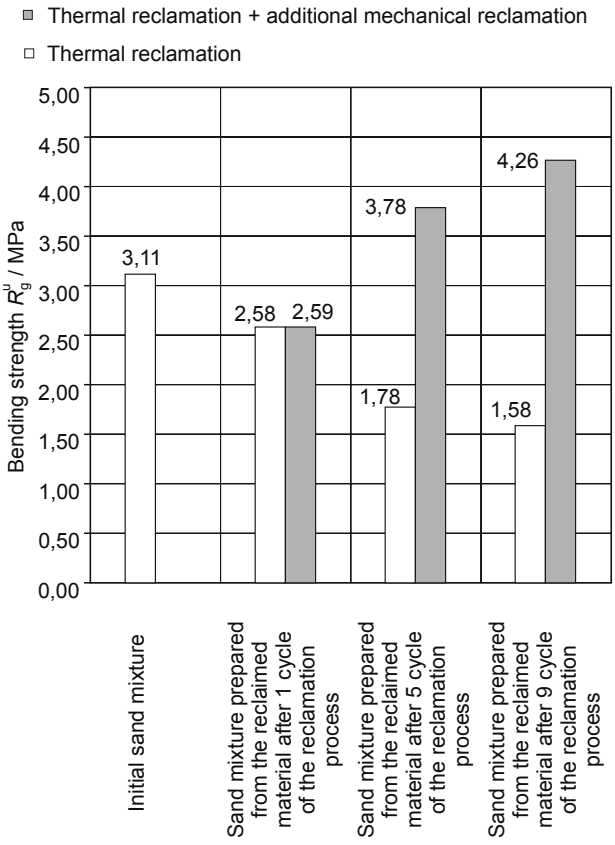

Figure 3. **Bending strength of the samples prepared from the sand mixture on the base sand grains and the reclaimed material after the definite number of cycles of thermal reclamation and after the application of additional mechanical reclamation**
Slika 3. **Savojna čvrstoća uzoraka pripremljenih od mješavine pijeska na osnovi pješčanih zrnaca i obnovljenog materijala poslije određenog broja ciklusa toplinskog obnavljanja i nakon primjene dodatnog mehaničkog obnavljnja**

The mechanical reclamation, which completed the burning process, was realised in an experimental centrifugal reclaimer with an impact-free circumferencial side surface (Figure 2.) [2].

Each time the reclaim was subjected to 10 cycles in the three-segmented system of the installation.

The main trends of research were focused on the explanation of the degree of the impurities accumulation on the surface of the thermally reclaimed base sand grains, used in several successive cycles of the preparation of the green sand mixtures, and on the possible removal of the impurities as a result of application of the additional mechanical reclamation treatment.

ANALYSIS OF THE RESULTS

The results of the mechanical properties tests of the sand mixture prepared of the base sand of the reclaim, as the number of the cycles of the thermal reclamation increases, show a decrease in strength of the sand mixture prepared from the reclaimed material, what is illustrated in Figure 3. The application of the mechanical reclamation after the thermal reclamation not only improves the mechanical properties of the anew prepared sand mixture,

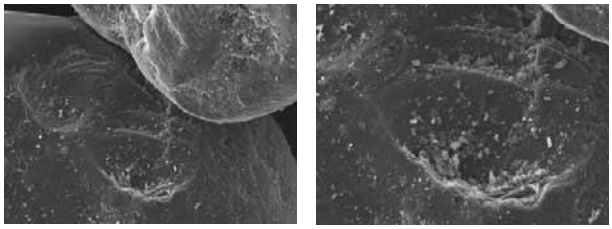

Figure 4. **Samples morphology of the reclaimed material after 9 cycles of the thermal reclamation (left: SEM mag. 500×; right: SEM mag. 1000×)**
Slika 4. **Morfologija uzorka obnovljenih materijala nakon 9 ciklusa toplinskog obnavljanja (lijevo: SEM pov. 500×; desno SEM pov. 1000×)**

but these properties increase the more, the longer the grains of the used base sand are in circulation and are each time subjected to the thermal reclamation [3].

During the investigations photographs were taken with a scanning microscope for various magnifications. The

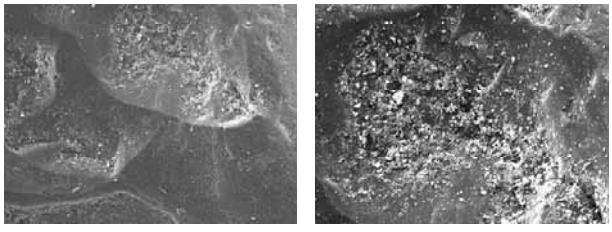

Figure 5. **Samples morphology of the reclaimed material after 9 cycles of the thermal reclamation and after additional mechanical reclamation (left: SEM mag. 500×; right: SEM mag. 1000×)**
Slika 5. **Morfologija uzorka obnovljenih materijala nakon 9 ciklusa toplinskog obnavljanja i nakon dodatnog mehaničkog obnavljanja (lijevo: SEM pov. 500×; desno SEM pov. 1000×)**

chosen photographs present the phenomenon of the accumulation of impurities around the grains, on their surfaces and especially in the irregularities of their surfaces after the reclamation treatments. A larger amount of impurities together with the abrasion products can be observed in the base sand grains after the additional mechanical reclamation (compare Figures 4. and 5.).

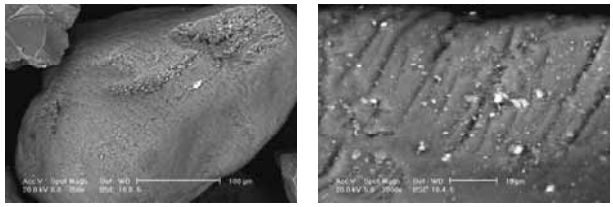

Figure 6. **Samples morphology of the reclaimed material after 9 cycles of the thermal reclamation and after additional mechanical reclamation (left: SEM mag. 500×; right: SEM mag. 1000×)**
Slika 6. **Morfologija uzorka obnovljenih materijala nakon 9 ciklusa toplinskog obnavljanja i nakon dodatnog mehaničkog obnavljanja (lijevo: SEM pov. 500×; desno SEM pov. 1000×)**

CONCLUSIONS

The investigations carried out confirmed the possibility of accumulation of inorganic compounds in the reclaimed material provided that they generate in the technological processes, or are gradually introduced to the sand mixture with its components. Their increasing presence around the base sand grains (on and in the surface irregularities) changes the strength of the sand mixture which was prepared on the base of the reclaimed material. Additional treatment of mechanical reclamation carried out after the thermal reclamation increases the strength of the sand mixture prepared on the base of the reclaimed material.

The observation of the surface topography of the base sand grains after the successive cycles of processing (preparation of the new sand mixture on the base sand of the reclaimed material and after the thermal reclamation) indicate the increasing amounts of impurities in the irregularities of the sand base grains. The additionally applied treatment of the mechanical reclamation abrades the surface of the grains, which is revealed by a greater amount of impurities. It proves that the applied air separation is of small effectiveness.

The increased strength of the sand mixture on the base sand of the reclaimed material, after the additional mechanical reclamation, is caused by the homogenization of the base sand grains as a result of air separation. The second factor which influences the strength increase, revealed during the evaluation of the chemical composition in the microareas of the reclaim samples by means of the of X-ray microanalyser EDS, is the fact that some grains of the base sand are characterised by scratches formed as a result of the

abrasion processes in the impact-free centrifugal reclaimer. The destruction of the grain surface visible in Figure 6. is caused by abrasion processes. It structurally resembles the material erosion under the action of external forces. According to it, the stated increased strength of the cores, prepared from the base sand of the reclaimed material after the treatments of additional mechanical reclamation, result from the surface activation as a consequence of the treatments of abrasive cleaning.

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