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THE EFFECT OF MECHANICAL RECLAMATION ON THE WEAR OF SILICA SAND GRAINS

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Preliminary Note – Prethodno priopćenje

The wear effect of silica sands is usually joined with many foundry processes during the fresh sand preparation. The significant effect of silica grains destruction by means of crushing, abrasion and attrition is caused by most of mechanical reclamation treatments, which leads to a higher sand consumption. The experimental reclaimer was equipped with two different peripheral rings, which enabled both impact and impact-free way of the reclamation treatment of silica grains. In each case the duration of treatment and the rotational speed as well as the number of reclamation cycles were changed and effects were checked by multiple sieve analyses of the sand.

Key words: foundry, sand testing, mechanical reclamation

Utjecaj mehaničke regeneracije na trošenje zrna kvarcnog pijeska. Efekt trošenja silikatnog pijeska obično je povezan s mnogim ljevaoničkim procesima tokom pripreme svježeg pijeska. Značajan efekt razaranja silikatnih zrna uslijed drobljenja, abrazije I trošenja (trenja) uvjetovan je većinom obrada mehaničke regeneracije, što dovodi do veće potrošnje pijeska.Eksperimentalni uređaj za regeneraciju opremljen je s dva različita periferna prstena, koji omogućuju regeneracijsku obradu silikatnih zrna bilo s udarcem ili bez njega. U svakom slučaju duljina obrade i rotacijska brzina, kao i broj regeneracijskih ciklusa, bili su mijenjani, a utjecaj je provjeren višestrukom sitovnom analizom pijeska.

Ključne riječi: ljevarstvo, ispitivanje pijeska, mehanička regeneracija

INTRODUCTION

Undertaking the investigations of the influence of the mechanical reclamation intensity on the wear effect of silica sand grains results from the fact that experiments aimed at releasing the sand grains from binding agents are usually performed without any knowledge how that reclamation treatment influences the yield of the process. The emphasis is exerted on the liberation of sand grains from the binding material however, without any operations aimed at protecting sand grains themselves.

Thus, investigations of the intensity and manner of mechanical treatments, allowing to limit the quartz grains wear, which means increasing their recovery and environment protection at a simultaneous insurance of the proper liberation degree of sand grain from binding agents, are needed. Wear control is possible due to the determination – on the grounds of basic examinations – of the function describing wear versus time of operation for different conditions applied at the reclamation treatment. Recycling of used foundry sands is usually balancing at the verge of the profit (removal of binding agents from grain surfaces) and loss (abrasion or crushing of grain surfaces) calculations resulting from sand grains wear phenomenon.

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ASSUMPTIONS AND PERFORMING THE INVESTIGATIONS

The intensity of sand grains destruction was controlled by means of changing the disk rotational speed. The speed of the machine was set by means of the Mitsubishi inverter. Tests were performed in the rotational speed range from 2300 to 6500 rotations/minute. Simultaneously an influence of impact or impact-free peripheral ring shape on the effect of the mechanical treatment was checked. The conceptual description of the device operation is given in papers [1-3, 5].

To obtain more straightforward analysis of the destruction of individual fractions the tests in a centrifugal reclaimer were performed for the selected grain fractions of the sand, one of the most commonly used in the Polish foundry industry, collected on sieves: 0,8 mm, 0,63 mm and 0,4 mm. The two-stage segregation was applied. At first, the pre-fractionation of chosen fractions was done on a large classification screen, then the obtained material was precisely screened by means of the laboratory set for sieve analysis.

Tests were done in two separate series. The first series concerned the mechanical treatment of a single fraction of various sizes in a system of a diversified intensity of operations. The results are presented on the grounds of sieve analysis of individually selected fractions, which passed 5 times by the reclamation unit.

In the second series the influence of a multiple mechanical treatment of only one fraction was analysed. The results are presented on the grounds of sieve analysis of 0,8 mm fraction after many cycles of the reclaimer system of a various intensity of operation.

The centrifugal mechanical unit worked, during tests, with one rotational disk. After the determined number of passages - via the working chamber of the device - 4 sieve analyses were made (in both cases), which allowed obtaining two results, giving the average value presented in the paper. Such procedure was aimed at averaging of results and overcoming a segregation tendency of the material under testing both in the reclamation unit and during the sampling procedure for the sieve analysis. In the second series, after performing the sieve analysis, the material collected on sieves was being returned to the container with the remaining part of the sample and subjected to further reclamation cycles, up to 200 passages by the reclaiming system of the unit. Two parameters of the sand grains estimation: theoretical specific surface S_t and arithmetic mean diameter d_a, were taken into account in the investigations [4].

ANALYSIS OF THE RESULTS

Experiments of the first series were performed in order to estimate the threshold of the rotational speed of the disk causing or starting the wear process of quartz grains. The results obtained in the device with the impact-free peripheral ring are presented in Figure 1. The process of grain destruction starts at different rotational speeds – depending on the particle size and on its mass. The fraction selected on 0,8 mm sieve undergoes destruction already at the lowest speed applied. The higher the rotational speed the diminishing of the arithmetic mean diameter d_a more pronounced.

In the case of the fraction selected on 0,63 mm sieve a wear effect started being visible when the rotational speed exceeded 4 500 rotations/minute, while for the finest fraction no destruction was observed in the whole range of the applied speeds. Arithmetic mean diameter d_a was at the same level.

The results obtained in the device with the impact peripheral ring are presented in Figure 2. An influence of the rotational speed on the arithmetic mean diameter d_a, was of a similar character as in the case of the device with the impact-free peripheral ring. However, the wear effect was more dynamic due to impact forces, which caused more pronounced diminution of the fraction collected on 0,8 mm sieve. The fraction collected on 0,63 mm sieve exhibited irregular character of changes, however, in this device too the rotational speed exceeding 4 500 rotations/minute caused diminishing of the arithmetic mean diameter of grains. The theoretical specific surface S_t was not changing significantly neither in the reclaimer with the impact peripheral ring nor with the impact-free one.

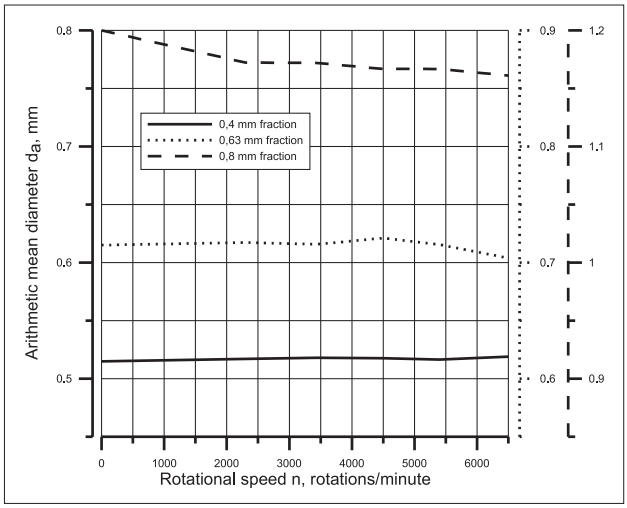

Figure 1. Arithmetic mean diameter of grains, d_a, as a function of rotational speed of the centrifugal reclaimer with an impact-free peripheral ring – for three selected fractions

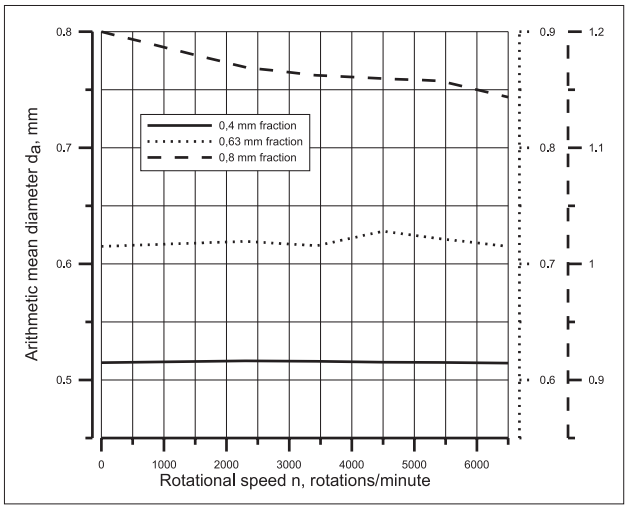

Figure 2. Arithmetic mean diameter of grains, d_a, as a function of rotational speed of the centrifugal reclaimer with an impact peripheral ring – for three selected fractions

In the second series of investigations an influence of the rotational speed on the wear of silica sand grains in an impact-free reclamation unit was analysed. Figure 3 presents the obtained results of a multi-cycle abrasion treatment, for two different speeds. In agreement with the expectations, the abrasion process of sand grains was more pronounced at the higher rotational speed of the device. Increasing value of the theoretical specific surface, S_t, indicates successive grain abrasion at the consecutive number of mechanical treatment cycles. However, a speed of 2300 rotations/minute of the rotating disk was too low to cause any abrasion of sand grains.

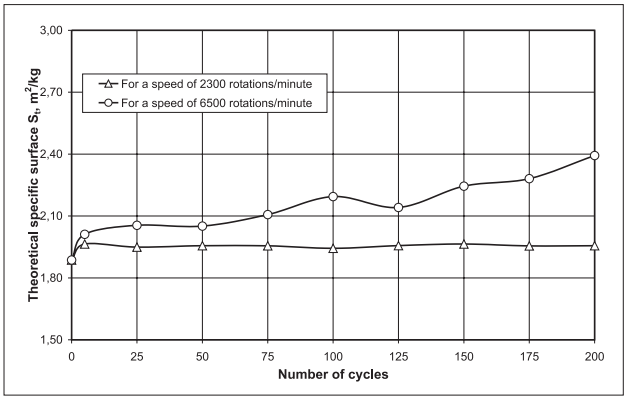

Figure 3. Theoretical specific surface S_t versus the number of reclamation cycles in an impact-free system of the centrifugal mechanical reclaimer – for two

A similar tendency was observed when an impact peripheral ring was applied in the device (Figure 4). A speed of 2300 rotations/minute of the rotating disk was again too low to cause any abrasion of sand grains (fraction collected on 0,8 mm sieve), even when impacting on the peripheral ring. However, at a speed of 6500 rotations/minute the momentum of particles was big enough to cause - in consecutive cycles - a destruction of silica sand grains, their diminishing and in consequence an increase of the theoretical specific surface S_t.

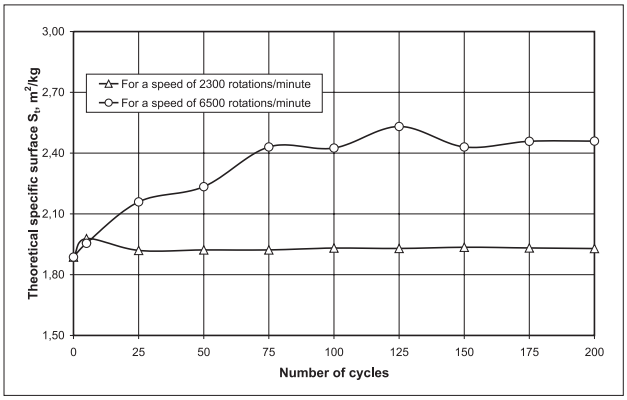

Figure 4. Theoretical specific surface S_t as a function of the number of reclamation cycles in the impact system of the centrifugal mechanical reclaimer – for two different rotational speeds

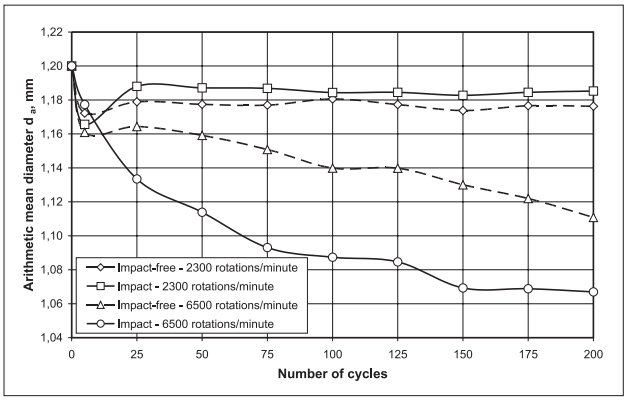

Figure 5. Arithmetic mean diameter, d_a, versus the number of cycles – for different rotational speeds and methods of the reclamation treatment of silica sand grains

When comparing the results presented in Figure 3 and 4, it was found that the wear process of silica sand grains was more intensive in the device with the impact peripheral ring at the applied speed of 6500 rotations/minute. The data shown in Figure 5 confirm those findings.

CONCLUSION

Aiming at sustaining – for as long as possible - quartz sand grains of the determined granulation in the foundry circulation, reclamation treatments should be performed with the balanced intensity allowing to remove the used binding material, however safe for the retaining the main granular fraction at the constant level. Tests performed on individual fractions of sand grains will serve this purpose. The experience gained and knowledge of the kinetics of sand grains wear will enable performing the reclamation treatments of the determined intensity, which ensures the proper quality of moulding and core sands at constant parameters of quartz sand grains.

The performed investigations indicated diversified character of grain destruction in the centrifugal mechanical reclamation unit depending on the kind of a peripheral ring. The destruction was slower in the reclaimer with an impact-free ring. When analysing the amounts of individual fractions formed after the mechanical treatment in the device with the impact peripheral ring no significant grain crushing was observed. It can be only assumed, that the grain surface is disturbed in areas where cohesion of sand grains is weaker.

REFERENCES

[1] M. Łucarz: Opracowanie podstaw konstrukcji regeneratorów odśrodkowych dla mas formierskich. Praca doktorska, AGH Wydział Odlewnictwa, Kraków 1996.

[2] J. Dańko, M. Łucarz: Theoretical backgrounds of designing impact-free centrifugal reclamation units. Metallurgy and Foundry Engineering, UMM, 22, (1996), 309-317.

[3] J. Dańko, M. Łucarz: Centrifugal reclamation units of new design. Acta Metallurgica Slovaca, 3, (1997), 207-213.

[4] L. Lewandowski: Materiały formierskie. Laboratorium. AGH, Skrypty Uczelniane 1008, Kraków 1986.

[5] M. Łucarz: The Condition of Silica Sand Grains Surface Subjected to Reclamation Treatment. Croatia, Metalurgija 45 (2006) 1, 37 – 40.

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Note: Author is responsible as language lecturer for English language.