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Influence of the Reclaim from the Cordis Technology on the Core Sand Strength

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Abstract

The investigation results of the mechanical reclamation of spent moulding sands from the Cordis technology are presented in the paper. The quality assessment of the obtained reclaim and the influence of the reclaim fraction in a matrix on the core sand strength is given. The reclaim quality assessment was performed on the basis of the determination of losses on ignition, Na_2O content on reclaim grains and pH values. The reclaim constituted 100%, 75% and 50% of the core sand matrix, for which the bending strength was determined. The matrix reclamation treatment was performed in the experimental rotor reclaimer RD-6. Spent sands were applied in as-delivered condition and after the heating to a temperature of 140 ^{o}C. Shaped samples for strength tests were made by shooting and hardening of sands in the warm-box technology.

Keywords: Core sand, Matrix recycling

1. Introduction

Higher and higher ecological requirements concerning moulding materials cause the necessity of introducing into the foundry market new technologies, allowing to obtain more environmentally friendly materials. From the point of view of the rationalisation of the moulding materials circulation, moulds preparation and liquid metal pouring as well as castings knocking-out, one of the most important features is the reclaiming ability, which decides on the binder and moulding sand modernity. The possibility of management of spent moulding and core sands by recycling of used in them matrices is especially important from the point of view of the technology, ecology, environment protection and economy, being of great importance in the properly functioning foundry plant. The Cordis technology belongs to the group of modern and ecological technologies of inorganic binders, in which a core (moulding) sand is shot into the core box heated to a temperature: 120 – 160 ^{o}C and is there thermally hardened. The hardening process can be significantly accelerated by an additional blowing hot air through the thickening core. This technology is currently being introduced, mainly in automotive foundry shops, where its technological properties and the environment influence are investigated, while the detailed tests in an aspect of the matrix recycling are not performed.
The aim of the hereby paper is the presentation of the results of the performed investigations of the mechanical reclamation of spent moulding sands from the Cordis technology, ways of quality assessments of the obtained reclaim and analyses of the reclaim fraction in the matrix on the prepared core sand strength.

2. Investigations proceedings

Spent sands from the Cordis technology, supplied by the foundry plant were crushed, deprived of metallic contaminations and preliminarily dedusted. The appropriate reclamation treatment

was carried out in the experimental rotor reclaimer RD-6 of a special profile of the reclaiming element. The fragment of the device is presented in Figure 1.

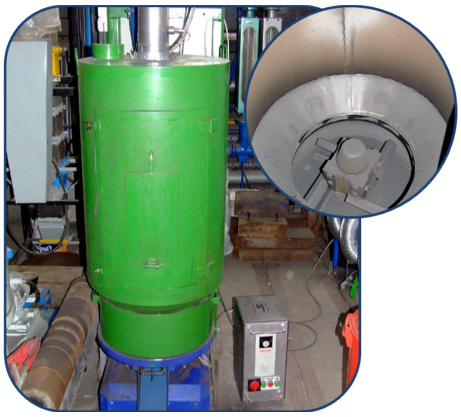

Fig. 1. Fragment of the experimental rotor mechanical reclaimer RD-6 with an internal system of grinding elements

The secondary reclamation process was performed according to the scheme presented in Figure 2.

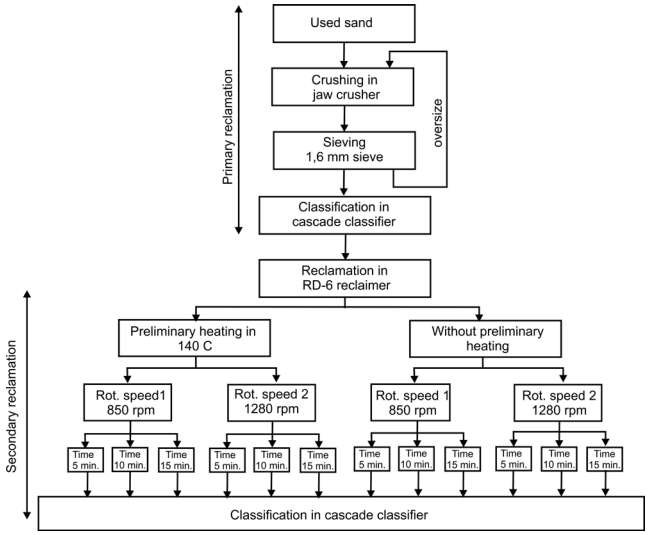

Fig. 2. Scheme and scope of the performed tests of the reclamation treatment of spent moulding sands from the Cordis technology

The matrix obtained in the reclamation treatment of the spent moulding sand from the Cordis technology were subjected to tests to determine:

- Losses on ignition,
- Na_2O content,
- pH value.

Successive core sands were prepared from the selected reclaims obtained after the reclamation treatment time of 15 minutes. The treatment was performed at two rotational speeds of the reclaimer rotor, with and without the application of the spent sand preliminary heating at a temperature of 140 ^{o}C. Shaped samples for bending strength tests were made by shooting and hardening of sands in the warm-box technology. The core box temperature was 150^{0}C, and time of holding samples in the core box was 40s. The bending strength tests were performed directly after samples taking out from the core box and after 1 and 3 hours of sand maturing at a temperature of 20^{0}C. Matrices of the prepared sands were as follows:

- fresh sand (100%),
- reclaim (100%),
- mixture 1 (reclaim 80%+ fresh sand 20%),
- mixture 2 (reclaim 50%+ fresh sand 50%).

The core sand was prepared in the ribbon mixer according to the following composition:
matrix – 100 parts by mass, Cordis binder – 2.2 parts by mass, powder – 1.2 parts by mass.

3. Obtained result

Reclaim quality investigations

The obtained results of the reclaim quality are presented in a graphical form in Figures 3-5.

The analysis of the results presented in Figure 3 indicates that the increased intensity of the reclamation treatment (increased rotational speed of the reclaim rotor system and the longer treatment time) causes a decrease of the reclaim losses on ignition, which is a measure of a better matrix purification from coatings of spent binder agents. It is worth to notice, that the moulding sand with the Cordis binder is - by nature - the sand of inorganic character, in which the organic component occurs in small amounts and is aimed only at improving knocking out abilities.

The reclamation treatment performed with the rotational speed of the reclaimer rotor system being 850 rpm for 15 minutes causes the loss on ignition decrease by 10.41%. Increasing the rotational speed to 1280 rpm, at the same treatment time decreases the loss on ignition by 25.2%. Even more favourable results can be achieved when spent sands, before the reclamation process, are heated at a temperature of 140^{0}C. In such case, at the given above rotational speeds, the loss on ignition decrease was 28.8 and 36.1%, respectively.

The analogous character of changes exhibits the analysis of the Na_2O content in spent sands and in reclaims, presented in Figure 4. On the bases of these results it can be pointed out that the reclamation of spent sand subjected to heating at a temperature of 140^{0}C, is the most efficient in the first 10 minutes, especially for the rotor rotational speed being 1280 rpm. A further continuation of the reclamation treatment indicates that the decrease of the Na_2O content is negligible, which means that the reclamation process is much less efficient.

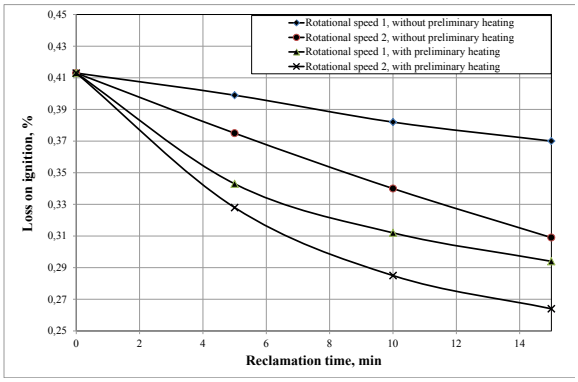

Fig. 3. Influence of the reclamation treatment time, rotational speed and the preparation of spent moulding sands on the reclaim loss on ignition

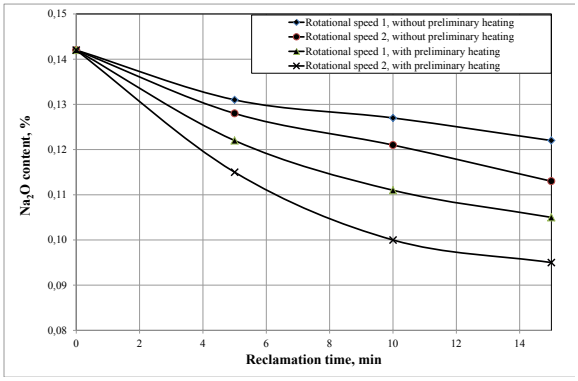

Fig. 4. Influence of the reclamation treatment time, rotational speed and the preparation of spent moulding sands on the Na_2O content in reclaims

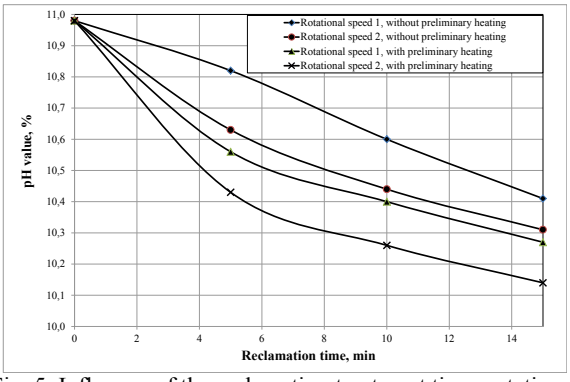

Fig. 5. Influence of the reclamation treatment time, rotational speed and the preparation of spent moulding sands on the change of pH values

The quality assessment of the obtained reclaims performed on the basis of the pH value, presented in Figure 5, indicates admittedly the influence of the variable parameters of the reclamation treatment on the analysed value, but the range of changes is quite small, being within 10 - 11. The pH value is decreasing when the treatment intensity increases and these changes are larger in case of preliminary heated spent sands. The spent moulding sand supplied for tests had pH equal 10.98. The most efficient reclamation treatment decreased this sand alkalinity to 10.14.

Summarising this aspect of investigations it can be stated, that the pH value analysis, although the least suitable for the quantitative analysis and reclaimability assessment of spent moulding (core) sands, has the qualitative meaning, especially can help in deciding whether the reclamation treatment should be applied for the spent sands mixture.

Bending strength tests of moulding sands prepared with the reclaim

The obtained results of bending strength tests of moulding sands prepared of the investigated reclaims are presented in Table 1. As it was stated above, the reclaimed materials obtained after 15 minutes of the reclamation treatment process and pneumatic classification were used for preparing core sands.

The bending strength of the moulding sand prepared of fresh high-silica sand was equal:

- directly after removal from the core box – 2.48 MPa,
- after 1 hour of maturing – 2.95 MPa,
- after 3 hours of maturing – 2.89 MPa.

Table 1.
The results of bending strength tests of moulding sands with reclaims obtained after 15 minutes of the reclamation treatment and pneumatic classification

	Holding time, h	Rot. Speed 1 (850 rpm) (percentage of the reclaim in the sand)			Rot. Speed 1 (1280 rpm) (percentage of the reclaim in the sand)		
		100	80	50	100	80	50
Bending strength, MPa Reclaim without preliminary heating	0	1,37	1,98	2,09	1,87	2,31	2,52
	1	2,11	2,17	2,56	2,30	2,46	2,75
	3	1,69	1,82	2,49	2,10	2,10	2,39
Bending strength, MPa Reclaim with preliminary heating	0	1,96	1,95	2,29	1,80	1,94	2,02
	1	2,33	2,65	2,91	2,27	2,58	2,85
	3	2,15	2,31	2,27	1,97	2,11	2,16

The results given in Table 1 are graphically presented in Figures 6 and 7. On account of the clarity of diagrams the following marks were applied:

Sand I – moulding sand with the reclaim obtained at the rotational speed 1, without the preliminary heating of the spent sand,

Sand II – moulding sand with the reclaim obtained at the rotational speed 1, with the preliminary heating of the spent sand,

Sand III – moulding sand with the reclaim obtained at the rotational speed 2, without the preliminary heating of the spent sand,

Sand IV – moulding sand with the reclaim obtained at the rotational speed 2, with the preliminary heating of the spent sand.

On the bases of the results presented in Figure 6 it can be shown, that all tested moulding sands obtain the highest bending strength after 1 hour of maturing time, which constitutes a certain rarity as compared to other, known moulding sands for which prolongations of maturing times cause the strength increase.

In case of moulding sands on the matrix of the reclaimed materials from the Cordis technology maturing of samples for

more than 1 hour causes a small strength decrease. The highest strength was obtained for Sand II, prepared with the reclaim obtained at the rotational speed being 850 rpm, when the spent moulding sand was heated at a temperature of 140^0C before the treatment process. Lower strengths were obtained for Sand IV treated more intensely. This was caused by undesired crushing of reclaim grains, which was confirmed by sieve analyses. The visible effect of the matrix grains degradation occurs between the 10-th and 15-th minute of the process, at a rotational speed of 1280 rpm.

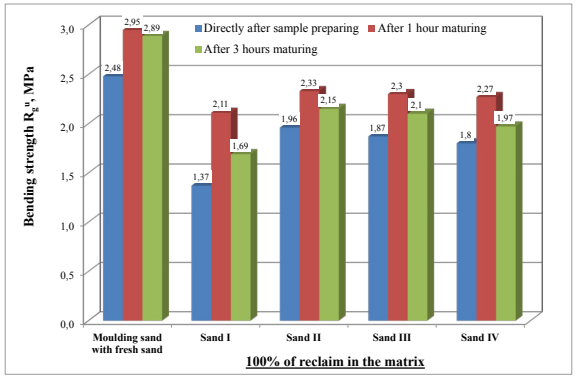

Fig. 6. Bending strength of samples of moulding sands I-IV prepared in 100% of the reclaimed materials and the moulding sand made of fresh components

It is shown in Figure 7, that the moulding sand strength increases with the fresh high-silica sand fraction increase in the matrix. In case of moulding sand II, at 50% reclaim fraction in the matrix the bending strength is similar as the one obtained for moulding sands made from fresh components.

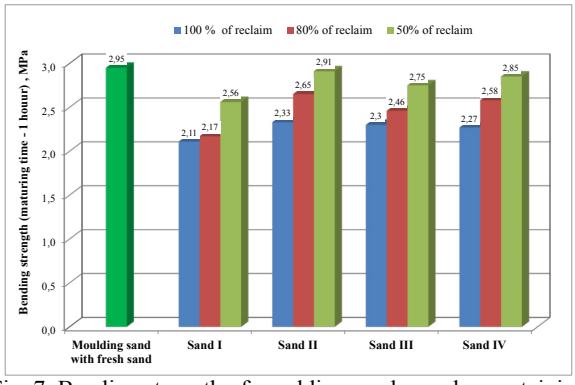

Fig. 7. Bending strength of moulding sand samples containing various fractions of the reclaim, after 1 hour maturing time

4. Conclusions

The performed investigations allowed to formulate several conclusions.

Application of an additional heating of spent moulding sands with the Cordis binder before the mechanical reclamation process, at a temperature of 150^oC, increases a brittleness of spent binder coatings on matrix grains, which improves the spent sand reclaiming ability.

Analyses of losses on ignition and Na_2O content of spent moulding sands without the reclamation treatment and of individual reclaims have approximately linearly decreasing character. In case of the reclamation of the spent moulding sand being preliminarily heated during the reclamation treatment the character of these changes is also linear. After exceeding a certain time, after which the matrix crushing occurs, losses on ignition decrease less intensely.

Bending strength tests of samples made with the reclaim, indicate that with increasing additions of the fresh sand the achieved strengths are also increasing. Analyses of the bending strength results indicate also that the highest values of this parameter were obtained for samples, which after removal from the core box were matured for 1 hour.

Acknowledgements

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