

Assessment of the reclamation of used sands from the alpha-set technology in the testing apparatus

R. Dańko ^{a*}, J. Kamińska ^a

^a Faculty of Foundry Engineering, AGH University of Science and Technology, Reymonta 23 str., 30-059 Kraków, Poland

*Corresponding author. E-mail address: rd@agh.edu.pl

Received: 26.02.2009; accepted in revised form: 30.03.2009

Abstract

The preliminary investigations of the mechanical-grinding reclamation of used sands from the alpha-set technology, belonging to a sand group difficult for reclamation, were performed. The new testing apparatus equipped with a rotor system enabling a change of intensity of grinding and crushing influences by selecting shapes of rotor elements and rotational speeds of a rotor system - was applied in the mechanical reclamation. This apparatus enables the used sand reclamation in a traditional vertical system of a rotor and apparatus system or the operation in out of plumb system (from 0 to 6°). This apparatus was made in order to create comparative conditions of used sands reclamations which constitute the basis for comparative assessment of reclaimability of various sands, at not changing reclamation influences. The effects of releasing matrix grains from coatings of binding agents obtained under these conditions are more reliable and the determined effectiveness of the matrix reclamation from various used sands are more likelihood.

Keywords: waste management, used sand, reclamation treatment.

1. Introduction

Reclamation effects of used moulding and core sands, which foundry practice considers specially difficult for this process, are based on several instrumental examinations allowing to assess technological usefulness of a matrix reclaimed in the given device. Applying mechanical reclaimers of various mechanisms influencing sands it is difficult to perform a comparative evaluation of reclaimability of different sands in case when they undergo changes.

Apart from used sands with alkaline phenol resin (alpha-set process) also spent sands with water glass (foster process) as well as sands with highly alkaline resins bonded by means of CO₂ are considered difficult for reclamation.

The alpha-set process, popular in foreign foundry plants, was developed in the fifties of the XXth century, however

utilised on an industrial scale barely in the eighties of the last century [1]. Moulding sands of this process contain phenol-formaldehyde resins of a cresol type and are hardened by esters. They are mainly applied for casting moulds for making cast steel castings. Experiences of foundry plants utilising these sands indicate essential problems related to their effective reclamation unless they are exposed to a thermal reclamation performed most often in thermal reclaimers with a fluidised bed. A mechanical reclamation of these sands, dominating currently and probably in the nearest future, does not come up to all expectations. It is realised in traditional devices where combined processes of grinding, rubbing and crushing remove coatings of spent binding material from matrix grains surfaces (most often quartz grains) [2, 7]. Low effectiveness of a classic mechanical reclamation of spent sands, prompts for continuous looking for new, more intensive processes aimed at the process

improvement. New testing apparatus allowing for the reclamation examination performed with various intensity - was applied in the presented hereby investigations.

2. Experimental Stand

Experimental tests were performed in the testing apparatus for an assessment of spent sands reclaimability, in which rotating impact-grinding elements were applied. Shape and structure of the rotor system undergoes intensive evolution in order to obtain the best reclamation effectiveness without the matrix degradation. Rotational speed of impact-grinding elements can be controlled in the range of 460÷1680 rpm. The innovatory feature of the new testing apparatus is the possibility of operation in out of plumb system which is advantageous for an internal sand circulation. The apparatus can be out of a vertical position in a range from 0 to 6°. The schematic presentation of the applied apparatus in cases of its operation in a vertical and in a deviated - by α angle - position is shown in Figure 1.

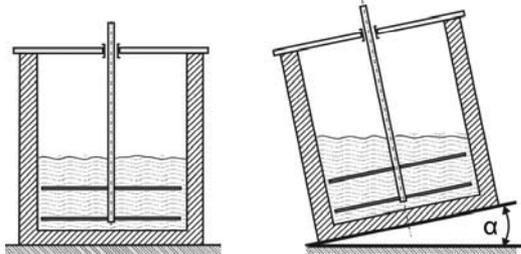


Fig. 1. Schematic presentation of the testing apparatus applied for the reclamation.

3. Experimental investigations

The presented hereby investigations were concentrated on assessment of reclaimability of sands from the alpha-set technology. Not overheated sands were applied in tests since it was assumed that such sands are more difficult for the reclamation than the overheated ones. Sands were prepared in the laboratory ribbon mixer according to recommendations of the resin producer. Phenol resin Sinotherm 8426 was used. Its density at 20° C equals 1.245 – 1.255 g/cm³, dynamic viscosity 70 - 110 mPas and pH>13. As an activator J120 was applied (trade names). The composition of the moulding sand was as follows:

- Dry high-silica sand 100 parts by weight,
- Resin 1.0 part by weight,
- Activator 0.5 parts by weight.

Sands were hardened for 24 hours, after preparation, and then exposed to the primary reclamation process.

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

3. Instrumental investigations

After each finished stage of the secondary reclamation process, the obtained reclaimer was exposed to instrumental examinations, the main being: ignition loss, sieve analysis, grain shape and surface analysis. Such instrumental examinations are usually accepted indices of the degree of the used binding agent removal from the spent sands matrix [2].

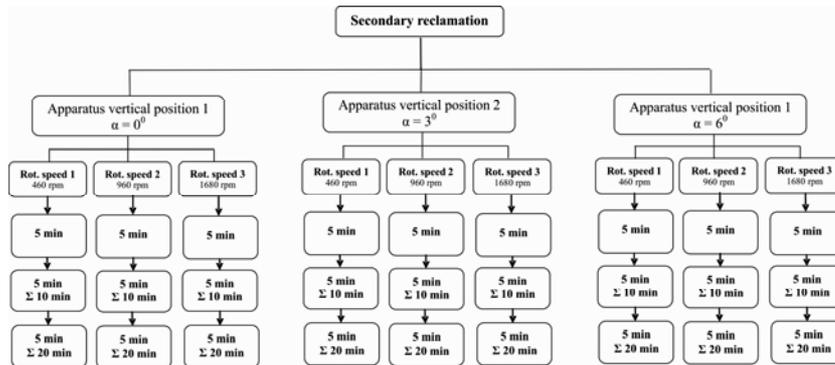


Fig. 2. Schematic presentation of the secondary reclamation process applied in examinations.

4. The obtained results

Sieve analysis

Sieve analysis of reclaimers, performed before their final dedusting, indicates:

Average grain diameters, represented in this case by diameter d_1 , are decreasing when a process time and a rotational speed of the rotor system are increasing. Grain diameters for the cases when the rotational speed was 460 rpm, 960 rpm and 1680 rpm are presented in Figure 3a. The results are presented in the same

scale for their legibility. It can be noticed that, for the rotational speed of the impact-grinding system of 460 rpm and 960 rpm the diameter d_1 values linearly decrease versus the reclamation time – for three applied inclinations of the testing apparatus. The reclamation performed with a speed of 1680 rpm has at the beginning similar character, while later on the decreasing of average diameters is less intensive.

It can be stated, on the basis of the sieve analysis, that increasing of the inclination angle of the testing apparatus causes - for all tested rotational speeds - increasing of the

reclamation treatment intensity. This phenomenon can be explained by a better sand circulation, easier falling into the lower part of the apparatus and by an increased, in this case, surface of grinding action of rotor paddles.

Increase of the theoretical specific surface of the set of reclaimed grains (Fig. 3b) - character of changes caused by the process intensity change together with an increase of the reclamation time is similar (naturally when making allowances for the fact that those phenomena are in opposition to each

other), as in the case of the discussed above changes of averaged diameters d_i . It is worth mentioning that the theoretical specific surface of reclaim determined on the basis of the performed sieve analysis is especially important when an estimation of energy consumption of reclamation processes is performed on the basis of the deterministic models of Rittinger and others [3-5]. In this case the theoretical specific surface is the determinant of the advancement degree of the removal of spent binding agents from matrix grains.

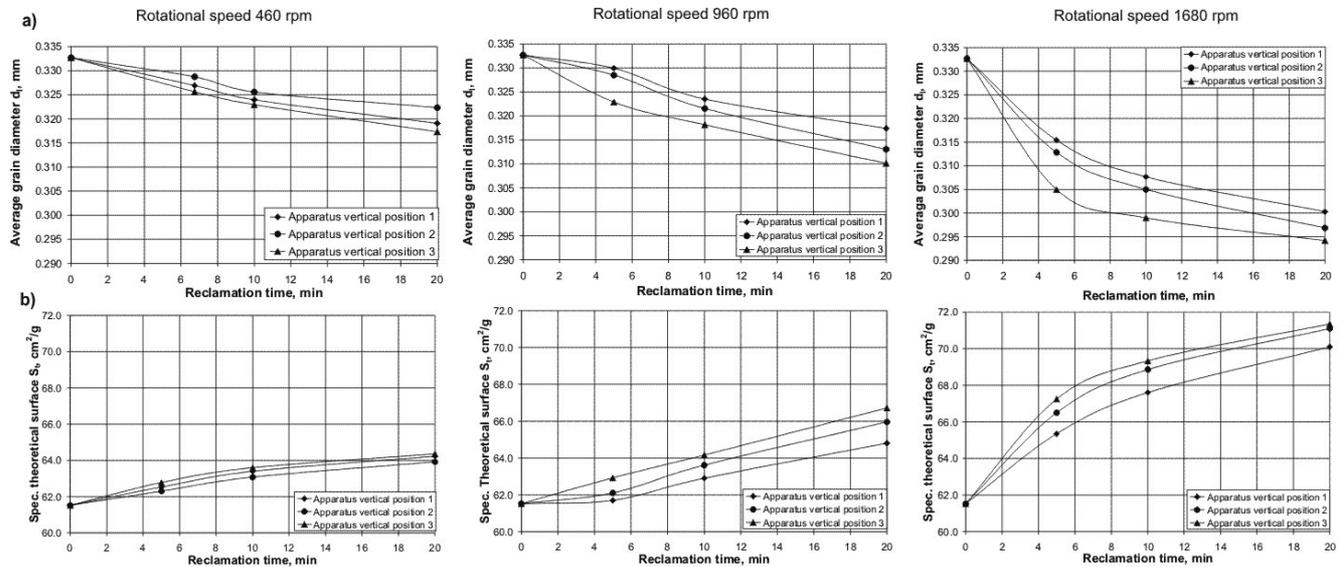


Fig. 3. Change of the average characteristic diameters d_i and the reclaim specific surface as a function of the duration time of the process.

Matrix degradation – grain shape index. In order to determine whether a negative and not wanted phenomenon of a matrix grains crushing, which often accompanies a mechanical reclamation, occurs during the performed reclamation process - examinations of the grain shape index W_k of the obtained reclaimers were done. The obtained results for the case when the testing apparatus was inclined at an angle of 6° , are presented in Figure 4. Since at this angle the reclamation effect is the highest, the grain damage probability should be also the highest. The obtained results indicate that in the case of two lower speeds a crushing process does not occur, however filleting and grinding of reclaimer grains takes place. When the process is carried on at a speed of 1680 rpm its course is diversified; the first 10 minutes of the reclamation cause lowering of the W_k index testifying that grains are becoming more spherical and that used binding agents are grinded off from their surfaces. After 20 minutes of the reclamation the grain shape index slightly increases due to crushing of matrix grains.

Loss of Ignition

Ignition loss, is the essential value for determining the degree of a grain liberation from organic components of binding agents. The results of ignition losses obtained after the determined time of the process and at the determined rotational speeds of the rotor system, decisive for the reclamation process intensity, are presented in Fig. 5a÷5c.

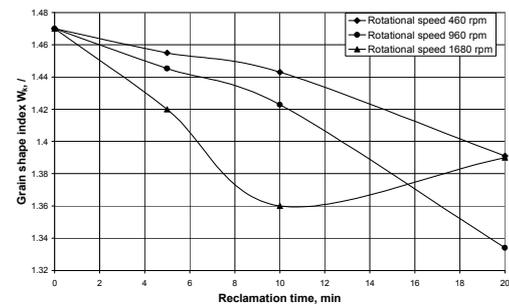


Fig. 4. Change of the grain shape index of the obtained reclaimers as a function of the reclamation time and the rotor rotational speed. Apparatus inclined at an angle of 6° .

Decreasing values of ignition losses with increasing rotational speeds of the rotor system are noticeable, however reclamation influences achieved in the testing apparatus are not very intensive. This can be seen in Figure 6, which illustrates ignition losses versus rotational speeds. The maximum ignition loss decrease obtained at the rotational speed of 1680 rpm, after 20 minutes of the reclamation and inclination of an angle of 6° , ensuring the best conditions for an operation of the impact-grinding system, equals 22.8%.

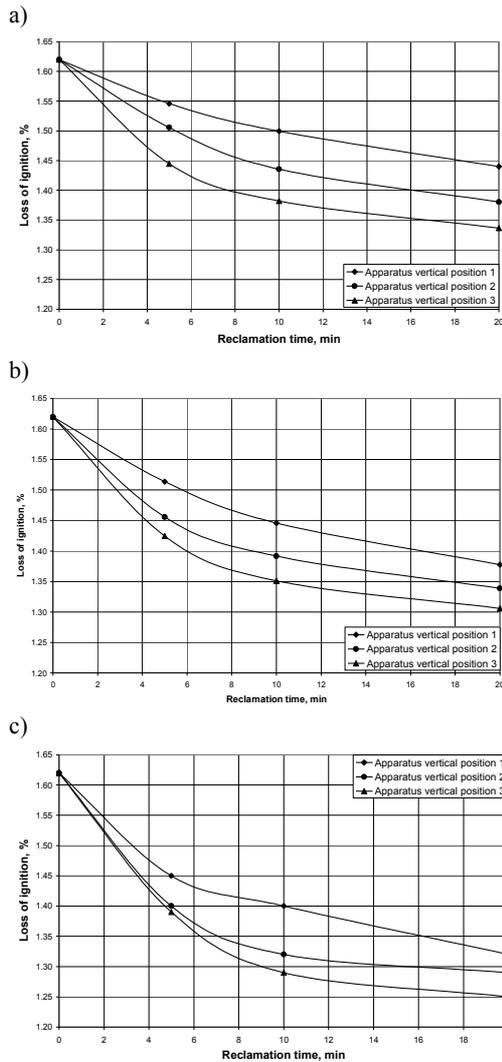


Fig. 5. Ignition losses of reclaimers as a function of the reclamation time and the inclination angle of the testing apparatus: rotational speed of the rotor system: a) 460 rpm, b) 960 rpm, c) 1680 rpm.

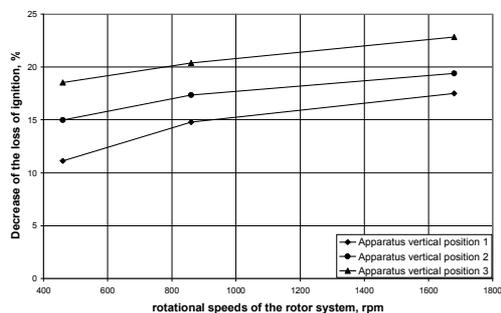


Fig. 6. Decrease of ignition losses as a function of rotational speeds of the rotor system of the testing apparatus.

5. Conclusions

The following conclusions can be drawn on the bases of the performed examinations:

- The newly introduced testing apparatus allows to perform a reclamation treatment of various grades of used sands under the comparable conditions. This enables to exhibit a significant diversification of their reclaimability being estimated by means of different methods based on basic criteria of assessing the matrix quality.
- Examinations confirmed the opinion, existing in foundry practice, that spent sands from the alpha-set technology are difficult for a reclamation. The obtained results of ignition losses of these sands indicated that, at the highest reclamation intensity obtainable in the testing apparatus, only 20% of used binding agents was removed from matrix grains, which is significantly below the level obtained for other sands with resins.
- Reclamation of used sands from the alpha-set technology by mechanical means does not forecast a proper grain cleaning from resin leftovers and the resulting final high value of ignition losses is decisive for the reclaimer application for matrix backing sands, especially of large moulds. The situation significantly changes in the case when sands are exposed for thermal reclamation (e.g. in the Hot Pot system, known from references [2]).
- It is planned, in further investigations, to perform tests of a mechanical reclamation of used sands from alpha-set technology at low temperatures [6], in order to establish rationally justified technology of these matrix reclamation.

Acknowledgements

Scientific paper financed by the scientific grant in years 2008÷2011 as a Research Project No N N507 369735

References

1. Lewandowski L.: Core and moulding sands. Warszawa 1991, Wydawnictwo Naukowe PWN.(in Polish)
2. Dańko J., Dańko R., Łucarz M.: Processes and Equipment for Used Sand Reclamation.. Scientific Edition „Akapit”, ISBN 978-83-89541-88-8, 2007, 291 pp.
3. Tumidajski T.: Application of Statistic Methods in Analysis of Raw Materials Processing. Śląskie Wydawnictwo Techniczne, (Katowice 1993. (in Polish)
4. Rittinger P.: Lehrbuch der Aufbereitungskunde. Ernst und Korn, Berlin 1867.
5. Dańko R.: Development of energetic model for dry mechanical reclamation process of used foundry sands. International Journal of Cast Metals Research. British Cast Iron Research Association. 2007 vol. 20 no. 4 s. 228–232.
6. Tordoff W. L. , Miller J., Tremblay J.: New development in sand reclamation. CIATF Technical Forum, 1999, pp. 377-386.
7. Leidel D.S.: The influence of sand and binders on reclaimability. Foundry Trade Journal, Issue 3497, v. 168, 1994, pp. 384-387.