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ARCHIVES
of
FOUNDRY ENGINEERING
DOI: 10.2478/afe-2013-0089
Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

VERSITA
ISSN (2299-2944)
Volume 13
Issue 4/2013
93 – 96

Reclamation of Mixtures of Spent Sands of Inorganic and Organic Type

M. Skrzyński, R. Dańko*, J. Kamińska
AGH - University of Science and Technology, Faculty of Foundry Engineering,
Reymonta 23 Str., 30-059 Kraków, Poland
*Corresponding author. E-mail address: rd@agh.edu.pl

Received 26.06.2013; accepted in revised form 02.09.2013

Abstract

The results of investigations of the reclamation of spent moulding and core sands, originated from one of the Polish foundry plants, are presented in the paper. Four mixtures consisting of two types of spent sands (spent moulding sand and spent core sand) were subjected to the regeneration process. Each tested mixture consisted of an inorganic type spent moulding sand and of an organic type spent core sand. Proportions of mutual fractions of spent moulding and core sands in mixtures was 70%-30% and was representative for the waste sands from the foundry, from which these sands originated.

Keywords: Reclamation of used foundry sands, Moulding sand, Environmental protection

1. Introduction

The regeneration process defined as the whole of processes allowing for the reclamation and reuse of matrices of spent moulding and core sands is still being improved, from the point of view of searching for more efficient methods. This problem becomes specially important when the regeneration process is applied for mixtures of spent sands, which often happens in a foundry practice, where after casting knocking out the spent moulding and core sands are directed for the reclamation process. In such case the reclamation process of mixed sands is considered and its product, applied usually as a fresh matrix substitute in preparations of moulding sands, should be specially controlled with taking into account its granulation characteristic, chemical reaction as well as the amount of spent binding material not removed from the grain surfaces during the reclamation process [1-2].

Since the regeneration of mixed spent sands of inorganic and organic type was investigated it was necessary – in order to assess the amount of spent binding materials remaining on matrix grains - to apply methods characteristic for the reclaims originated from the technology of organic sands and inorganic ones [3].

2. The research scope

The following mixtures of spent moulding and core sands were subjected to the reclamation process:

- SPENT SAND I, consisting in 70% of a spent moulding sand with the GEOPOL binder and in 30% of a spent core sand with the REZOLIT binder,
- SPENT SAND II, consisting in 70% of a spent moulding sand with the GEOPOL binder and in 30% of a spent core sand with the ESTROFEN binder,
- SPENT SAND III, consisting in 70% of a spent moulding sand with the GEOPOL binder and in 30% of a spent core sand with the AVENOL binder,
- SPENT SAND IV, consisting in 70% of a spent moulding sand with WATER-GLASS 145 and in 30% of a spent core sand with the ESTROFEN binder.

The obtained reclaimed materials were subjected to the following investigations:

- Determination of the amount of dusts generated due to the reclamation process,
- Sieve analysis of the reclaim,
- Determination of ignition losses of spent sands and reclaims,
- pH values and the acid demand value (ADV),
- Na_2O content in the reclaim,
- Tensile strength determination R_m^u of moulding sands samples (made after storing time of 1.5h, 3h and 24h), in which this reclaim was a matrix component.

3. Experimental stand

The regeneration process was performed in the prototype vibratory reclaimer REGMAS (Fig. 1). The set of sieves, in a vertical arrangement, was inside the reclaimer body. Under an influence of vibrations caused by the operation of two electric vibrators the spent sand is disintegrated and then goes to the lower part of the reclaimer, where the secondary regeneration occurs. Reclaimed materials together with a binder removed from the grains of spent sands (in a form of dusts) are transported by a spiral trough from the lower part of the device of discharge in the upper direction where it goes into the cascade classifier, in which a separation of the powdery fraction occurs.

Fig. 1. The prototype vibratory reclaimer REGMAS

Each mixture of spent sands was subjected to 3 reclamation cycles in the prototype device. Cycles occurred at different operational frequency of the roto-dynamic motors, cycle 1 at 50 Hz, while cycles 2 and 3 at 60 Hz.

4. The obtained results

The results of measuring the amount of dusts formed due to the reclamation process are presented in Figure 2. It can be noticed, that the highest amount of dusts was formed as the result of the regeneration process of spent sand II, slightly smaller at the regeneration of spent sand I and the lowest at spent sand IV. It is assumed, that the amount of dusts generated during the reclamation process has an essential influence on the purification degree of the reclaimed material [4-6], since these dusts contain large amounts of the spent binder rubbed out from grain surfaces.

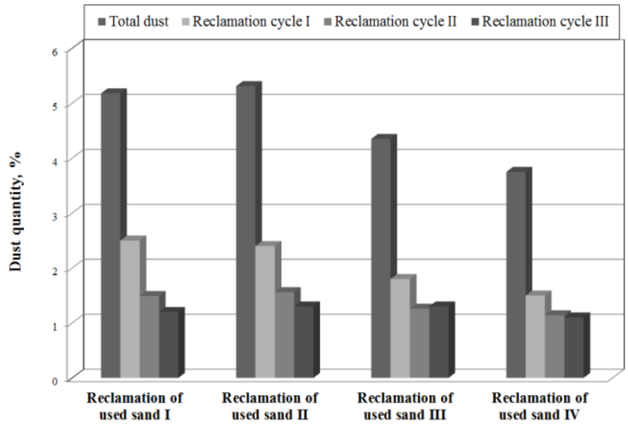

Fig. 2. Results of dusts amounts generated in the spent sands regeneration process, SPENT SAND I- SPENT SAND IV in the REGMAS reclaimer

The sieve analysis results of reclaimed materials before their dedusting in the cascade classifier are listed in Table 1. Samples for these tests were taken from the trough transporting reclaimed materials to the classifier. It can be noticed, on the bases of the obtained results, that successive regeneration cycles cause decreasing average grain diameters d_L (average logarithmic diameter) , d_a (average arithmetic diameter), d_g (average geometric diameter) and d_h (average harmonic diameter). In case of determining the theoretical specific surface of the sand grains set, it is seen that with the increased operational intensity of the reclaiming device this parameter is increasing. This is caused by increasing amounts of a fine, spent binding material (rubbed out from grain surfaces of the spent moulding sand), which is later removed during the pneumatic classification.

Table 1.
List of basic geometrical parameters of the reclaim of spent sands I, II, III and IV after 1, 2 and 3 cycles of the reclamation process

Cycle number	d_L mm	d_a mm	d_g mm	d_h mm	Z_t szt./g	S_t cm^2/g	F_g %
Spent sand I							
Cycle 1	0,340	0,440	0,410	0,379	22327	59,70	84,83
Cycle 2	0,321	0,412	0,386	0,357	37,331	63,44	88,56
Cycle 3	0,306	0,386	0,360	0,334	29670	67,71	88,08
Spent sand II							
Cycle 1	0,314	0,415	0,382	0,347	32786	65,21	84,22
Cycle 2	0,312	0,409	0,378	0,344	32869	65,78	84,69
Cycle 3	0,309	0,397	0,369	0,340	31275	66,55	88,03
Spent sand III							
Cycle 1	0,317	0,403	0,376	0,350	26280	64,69	89,24
Cycle 2	0,314	0,399	0,373	0,346	27413	65,39	88,78
Cycle 3	0,312	0,389	0,369	0,344	25207	65,77	95,50
Spent sand IV							
Cycle 1	0,380	0,494	0,463	0,430	15257	52,64	80,69
Cycle 2	0,312	0,397	0,371	0,345	27677	65,70	89,13
Cycle 3	0,306	0,389	0,363	0,337	30053	67,21	89,06

On the bases of the obtained results of ignition losses the effectiveness index of removing organic parts from spent sands W_{SR}, was determined. Its value was calculated acc. to Equation 1:

$$W_{SR} = (1 - \frac{U_C}{S}) \cdot 100\% \quad (1)$$

where:
U_c – ignition loss of the reclaim,
S – ignition loss of the spent sand.

The results of index W_{SR} values are listed in Table 3.

The results of testing ignition losses for each spent moulding sand and its reclaims are presented in Table 2 and in Figure 3.

Table 2.
Ignition losses of spent sands after successive reclamation cycles

Sample	Ignition losses, %			
	Used sand I	Used sand II	Used sand II	Used sand IV
Spent moulding	1,17	1,06	1,02	0,89
Spent core	1,32	1,21	0,93	0,75
Conversion of ignition losses before reclamation process	1,22	1,11	0,99	0,85
1 reclamation cycle	0,87	0,81	0,77	0,83
2 reclamation cycle	0,79	0,74	0,73	0,77
3 reclamation cycle	0,69	0,60	0,68	0,70

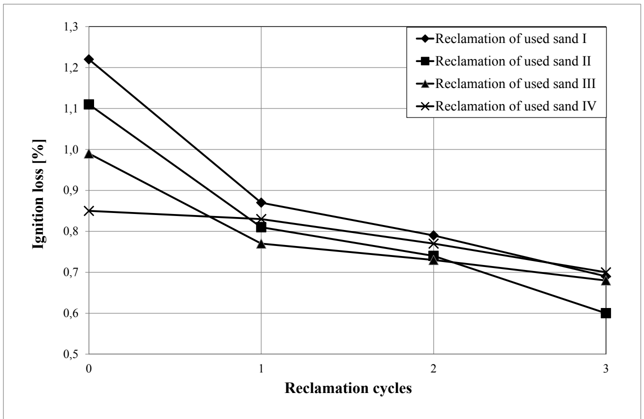

Fig. 3. Ignition losses of the tested mixtures of spent sands and their reclaims

Table 3.
Values of the W_{SR} index

Sample	Values W_{SR}, %			
	Used sand I	Used sand	Used sand III	Used sand IV
1 reclamation cycles	28,69	27,03	22,22	2,35
2 reclamation cycles	35,25	33,33	26,26	9,41
3 reclamation cycles	43,44	45,95	31,31	17,65

It can be noticed, on the bases of the obtained results, that organic components of spent moulding sands are the most effectively removed in case of the regeneration of spent sand II and I. Slightly worse values of the W_{SR} index were obtained in case of the regeneration of spent moulding sand III, while the worst in case of spent moulding sand IV.

The results presented in Figure 4 indicate that the Na_2O content on the reclaim grains surfaces decreases when the process intensity increases. This process occurs the most intensely in case of the reclamation of spent sand II, the Na_2O content decreases slightly less intensely in case of spent sand I, while the smallest decrease of this index was observed in case of the regeneration of spent sand III and IV.

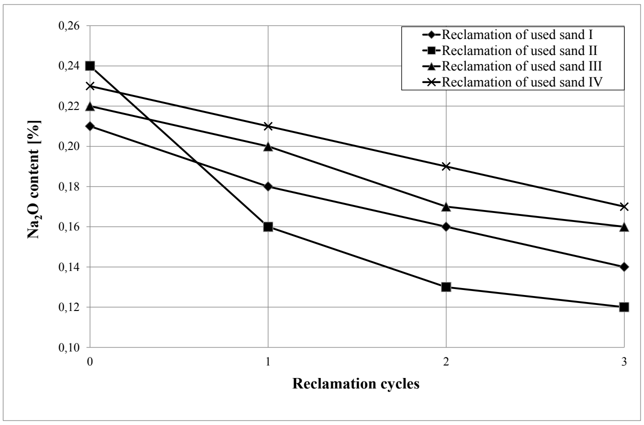

Fig. 4. Na_2O content on surfaces of the reclaimed material grains

The performed tests of the pH reaction and acid demand values of the obtained reclaimed materials are presented in Table 4. They indicate that the best results were obtained for the reclaims originated from sands I - III, while the reclaim obtained from sand IV is characterised by slightly worse parameters.

The last element of the presented investigations constituted the determination of strength properties of moulding sands prepared with the reclaimed materials present in the matrix in the given below amounts. Properly prepared samples of moulding sands were subjected to tensile strength tests R_m^u, which were determined after 1.5h, 3h and 24h of the storing time.

Table 4.
Acid demand values and pH reactions of the reclaimed materials in individual regeneration cycles.

	Used sand I		Used sand II		Used sand III		Used sand IV	
	pH	Z_K	pH	Z_K	pH	Z_K	pH	Z_K
0 reclamation cycles	11,12	35,3	10,64	36,4	10,81	36,4	11.02	36,2
1 reclamation cycles	10,95	32,2	10,55	32,4	10,76	31,4	10,98	35,6
2 reclamation cycles	10,91	30,8	10,51	30,6	10,69	30,9	10,85	33,9
3 reclamation cycles	10.78	27,4	10,40	26,5	10,55	29,6	10,69	30,9

The composition of the applied moulding sands was as follows: For the reclaims I - III from the regeneration process of spent sands I - III:

- matrix 100 parts by weight mas.,
- GEOPOL binder 2.4 parts by weight mas.,
- PRSTAL activator 0.38 parts by weight mas..

For the reclaim IV from the regeneration process of spent sand IV:

- matrix 100 parts by weight mas.,
- water-glass 145 3.3 parts by weight mas.,
- MACH 3 activator 0.38 parts by weight mas..

Two kinds of matrices were applied:

- Matrix 1 – mixture of the appropriate reclaim (50%) and fresh high-silica sand Biała Góra (50%),
- Matrix 2 – mixture of the appropriate reclaim (80%) and fresh high-silica sand Biała Góra (20%).

The results of tensile strength tests are listed in Table 5.

Table 5.
Results of tensile strength tests R_m^u

	reclaim /sand	Tensile strength R_m^u, MPa		
		1,5 h	3h	24 h
Used sand 1 (of reclaimed I)	Matrix 1-50/50	0,160	0,306	0,602
	Matrix 2 - 80/20	0,143	0,225	0,636
Used sand 2 (of reclaimedII)	Matrix 1-50/50	0,263	0,388	0,512
	Matrix 2 - 80/20	0,193	0,236	0,571
Used sand 3 (of reclaimed III)	Matrix 1-50/50	0,119	0,332	0,659
	Matrix 2 - 80/20	0,167	0,273	0,502
Used sand 4 (of reclaimed IV)	Matrix 1-50/50	0,103	0,194	0,618
	Matrix 2 - 80/20	0,026	0,036	0,132

On the bases of the tensile strength tests performed for the prepared moulding sands, it can be noticed that the best results were obtained by sands I - III (however sand III was characterised by slightly worse strength parameters), while the worst were obtained by sand IV. In case of the investigated compression strength of moulding sands I – II, after 3 hours of storing time their compression strength was beyond the measuring range of the equipment, which caused the necessity of applying tensile strength investigations (which are presented in Table 5). These investigations indicated that moulding sands I - III achieve high strength values, which allows to apply sands with 80% fraction of the reclaim. It is different in case of sand IV, which matrix was the reclaim from spent moulding sand IV. The safest proportion of the applied mixture of the reclaim-high-silica sand is 50-50.

5. Conclusions

The performed investigations allow to present the following conclusions:

– Out of the applied mixtures the best regeneration susceptibility characterises sands I – III, while the worst sand IV. The vibratory reclamation method can be successfully applied for sands I – III. In case of sand IV the spent sand should be probably preheated at temperatures 140-200°C before the regeneration process. This heating should increase brittleness of the spent binder coating and facilitate its removal from the matrix surface in the reclamation process.
– Reclaims obtained from spent sands I - III, can be successfully applied as components of moulding sands matrices in relation: 80% of a reclaim - 20% of a fresh sand, while in case of reclaims prepared from spent moulding sand IV the application of the matrix mixture containing 50% of a reclaim and 50% of a fresh high-silica sand seems to be safer.

Acknowledgements

This study was realized within the NOT project ROW-III-220/2012

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