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Investigations of the Reclamation Ability of Moulding Sands with the Modified Binding System and the Reclaim Quality Assessment

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Abstract

The investigation results of the reclaiming ability of a spent moulding sand with the geopolymer Geopol developed by the SAND TEAM Company as well as a moulding sand with a modified binding system based on the geopolymer binder and new hardener offered by the KRATOS Company, are presented in the paper. The basic aim of investigations was the comparison of the reclaiming ability of spent moulding sands with additions of hardeners supplied by various producers. All hardeners were of the same hardening rate. Amounts of the geopolymer binder and of the hardener was the same for both tested moulding sands.

Keywords: Moulding sand, Geopolymer binder, Reclaim, hardeners, Reclaimability

1. Introduction

Binders with inorganic binding systems are gaining more and more interest in the foundry industry. It is mainly caused by the fact that moulding sands with these binders are only minimally harmful for the environment, at comparable technological properties with moulding sands containing organic binders. A typical example of such binder can be the binding system called GEOPOL [1-4].

Investigations concerned the reclamation of two kinds of spent moulding sands obtained after knocking out industrial castings in one of the domestic foundry plants. This spent moulding sand mixture consisted of the moulding sand (app. 70%), which - in each case - constituted the sand with inorganic binder, and the core sand with organic binder (app. 30%). Such proportions of the moulding and core sand fractions are typical proportions occurring during the production process with the application of the mentioned materials.

The investigations performed in AGH were aimed at determining the reclaiming ability of spent moulding sands mixture, comparing reclaimability of sands with applications of hardeners of various producers together with the assessment of the reclaimed material quality. Tests were also to indicate the possibility of performing the reclamation process of these sands without their preliminary holding.

2. Investigated mixtures of spent moulding sands

Hardeners of symbols: KR 72 and SA 72, belonging to the group of slow-binding hardeners, were chosen for investigations. Such choice was caused, among others, by high temperatures being in foundry plants during tests, which constituted the reason of a very fast hardening of the moulding sand in the mould.

The reclaimability of spent sands mixtures prepared with the geopolymer binder GEOPOL hardened by the mentioned above hardeners. These spent moulding sands were named:

- spent sand with the KR 72 hardener;
- spent sand with the SA 72 hardener.

Pictures of spent moulding sands before the reclamation process are presented in Figure 1 and 2, while after the primary reclamation in Figure 3.

Fig. 1. Spent KR 72 sand before the reclamation process

Fig. 2. Spent SA 72 sand before the reclamation process

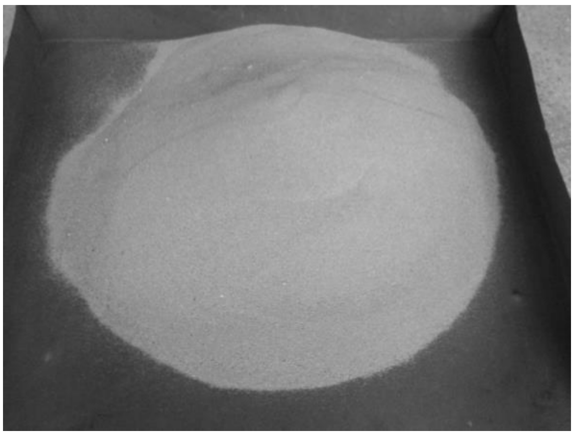

Fig. 3. Spent sand after the preliminary crushing process

3. Experimental stand

The prepared spent sands were subjected to the reclamation process in AGH, University of Science and Technology, with the application of the laboratory stand and the vibratory prototype REGMAS 1.5 reclaimer.

3.1. Laboratory stand

The laboratory stand constituted the experimental mechanical rotor RD-6 reclaimer, presented in Figure 4.

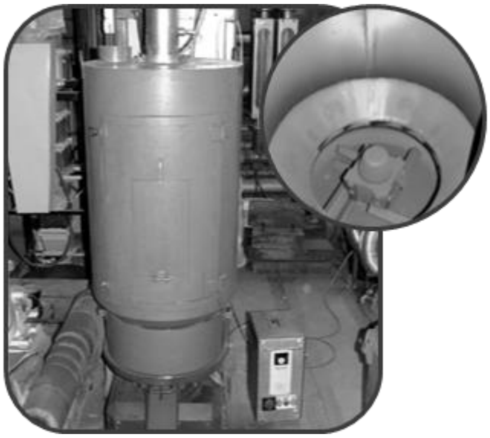

Fig. 4. View of the experimental mechanical rotor RD-6 reclaimer [5]

The set up of the stand is conceptually close to the solution developed by D. Boenisch [6], but the construction of the reclaiming element was different. Air was introduced into the chamber by the negative pressure way and the system of measuring after reclamation dusts, evacuated with air, was different.

3.2. Stand of the prototype REGMAS reclaimer

The industrial REGMAS reclaimer, applied in investigations, was designed, made and reported for the patent application within the realisation of the project POIG, task 1.3.1 [7-9].

The primary reclamation is realised on the crushing grid and set of 3 sieves. The lowest sieve is of a cone shape of a clearance between vertical palisade elements (slits) being 1.25mm. On the reclaimer bottom, in its buffer part, loose metal grinding elements (balls) are placed. Together with vibratory influencing they realise the secondary reclamation. A moulding sand sieved through the conical sieve is transported by the vibratory trough to the pneumatic cascade classifier fed from the bottom by the fan of a controlled air speed. The reclaimer is started by means of two rotodynamic engines of the controlled rotational speed and the set value of the vibrations excitation force.

4. Experimentl tests

Each tested spent sand was subjected to treatments in the laboratory reclaimer. The following work parameters were established:

- rotational speed of the reclaimer rotor system: 960 rpm, reclamation time: 5 min.,
- rotational speed of the reclaimer rotor system: 960 rpm, reclamation time: 10 min.,
- rotational speed of the reclaimer rotor system: 960 rpm, reclamation time: 15 min.

When tests were performed in the industrial reclaimer the following work parameters were established:

- electrovibrators frequency: 60 Hz,
- excitation force equal 70% of maximal force.

The spent moulding sand as well as the obtained reclaimed materials were subjected to the following tests:

- sieve analyses,
- loss on ignition measurements,
- Na_2O content on grain surfaces,
- pH value measuring,
- dusts amounts generated due to the reclamation.

5. The results of experiments

5.1. Sieve analysis of reclaimed materials

The sieve analysis was performed according to the Polish Standard PN-83/H-11077. The results of sieve analysis are listed in Tables 1-2.

As it can be seen in Tables 1 and 2 the prolongation of the reclamation time causes decreasing of the average grain size d_L, and this process is the most intensive in the first five minutes of the reclamation and in its last period. It can be also noticed, that with increasing reclamation intensity the theoretical specific surface value of the grains set increases. Both, decreasing grains diameters and increasing specific surface are related to the process of removing spent binders from matrix grains. Comparative examinations performed in the prototype REGMAS

Table 1. List of geometrical parameters of spent sands and of reclaims from the spent sands KR 72 and SA 72, before their final classification process (dedusting)

System of reclamation	**d_L**	**d_a**	**d_g**	**d_h**	**S_t**	**F_g**
	mm	mm	mm	mm	cm^2/g	%
KR 72 (spent Sand)	0,319	0,427	0,389	0,351	64,58	81,03
KR 72/5 min.	0,298	0,393	0,360	0,326	69,53	83,60
KR 72/10 min.	0,289	0,389	0,354	0,315	71,86	82,53
KR 72/15 min.	0,274	0,375	0,338	0,296	76,36	80,52
KR 72 REGMAS	0,279	0,385	0,348	0,303	74,72	80,88
SA 72 (spent sand)	0,341	0,452	0,417	0,380	59,62	81,68
SA 72/5 min.	0,298	0,398	0,365	0,327	69,11	83,95
SA 72/10 min.	0,293	0,401	0,365	0,322	70,29	82,41
SA 72/15 min.	0,284	0,383	0,349	0,310	73,13	82,18
SA 72 REGMAS	0,296	0,402	0,368	0,326	69,52	83,95

d_L – average grain diameter on the grain number basis, mm,
d_a - mean arithmetic grain diameter, mm,
d_g - mean geometric grain diameter, mm,
d_h - mean harmonic grain diameter, mm,
Z_t – number of grains, number/g,
S_t – theoretical specific surface, cm^2/g,
F_g, - main fraction content, %

Table 2. List of geometrical parameters of spent sands and of reclaims from the spent sands KR 72 and SA 72, after their final classification process (dedusting)

System of reclamation	d_L	d_a	d_g	d_h	S_t	F_g
	mm	mm	mm	mm	cm^2/g	%
KR 72/5 min.	0,306	0,395	0,365	0,335	67,63	85,33
KR 72/10 min.	0,304	0,392	0,362	0,332	68,18	84,88
KR 72/15 min.	0,293	0,380	0,349	0,318	71,20	83,20
KR 72 REGMAS	0,298	0,391	0,360	0,326	69,35	85,53
SA 72/5 min.	0,310	0,403	0,372	0,340	66,60	83,55
SA 72/10 min.	0,307	0,401	0,370	0,337	67,22	83,85
SA 72/15 min.	0,301	0,391	0,361	0,330	68,69	85,23
SA 72 REGMAS	0,303	0,395	0,365	0,332	68,94	88,68

5.2. Loss on ignition of spent sands and reclaimes

The loss on ignition (LOI) was used as the index characterising the regeneration degree, it means the purification of matrix grains from binders left-over. Investigations of ignition losses were performed according to the procedure No. 113-87-S (acc. AFS) [10].

The obtained loss on ignition for the tested reclaimed materials are presented in Figure 5.

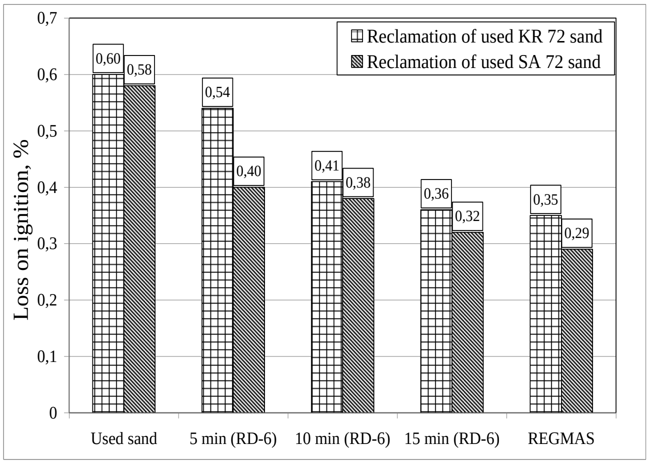

Fig. 5. List of the loss on ignition results of the reclaims obtained from the investigated spent sands

On the bases of the obtained losses on ignition it can be stated that the reclamation process occurs the most intensely during first ten minutes, after which this parameter stabilizes. At this first stage the largest amount of a binder is removed from the sand matrix surface. Processes of spent binder removal from matrix grains are more intensive in the REGMAS reclaimer than in the laboratory reclaimer. After the performed reclamation the obtained results are similar to the results obtained after 15 minutes in the RD-6 reclaimer.

5.3. Na_2O content of reclaims

The method based on heating the tested material sample with water and then titrating with 0.1 n HCl in the presence of phenolphthalein, was applied for the estimation of the Na_2O content on grain surfaces.

The results of the Na_2O content in the reclaimed materials are presented in Figure 6.

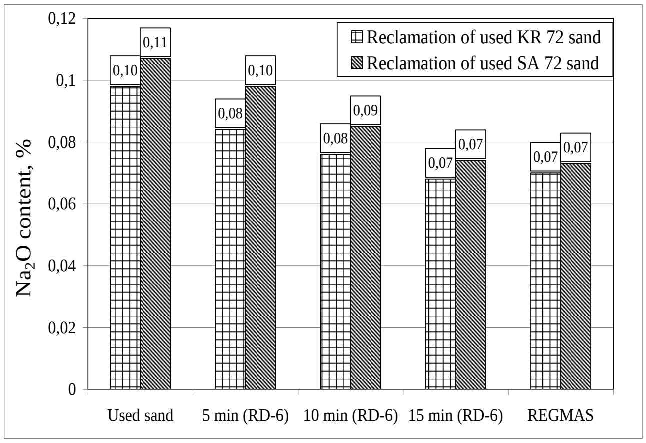

Fig. 6. Na_2O content on the surface grains of reclaims

The results presented in Figure 6 allow to notice, that the Na_2O content on reclaim grains surfaces decreases when the process intensity increases and is of a nearly linear character. The effects obtained in the REGMAS reclaimer are similar to the discussed above concerning sieve analysis and loss on ignition.

5.4. pH values of reclaims

The results of the pH reaction of the reclaims are presented in Figure 7.

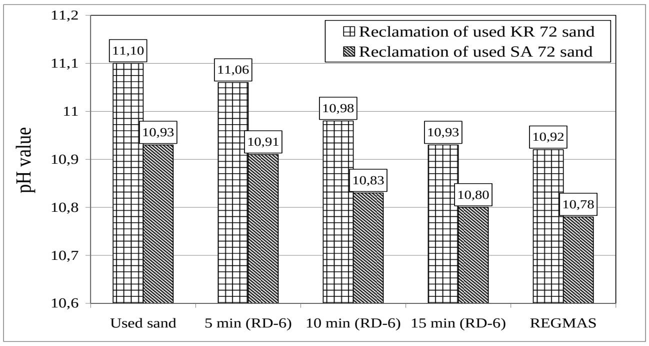

Fig. 7. pH values of the reclaims obtained from spent moulding sands

The analysis of the pH reaction values of the reclaims indicates, in a similar fashion as previously mentioned parameters, a similar effectiveness of the matrix reclamation process for spent sands KR 72 and SA 72. In case of these sands reclamation process pH values are decreasing and approaching the neutral reaction as the reclamation time increases.

5.5. Amounts of dusts generated in the reclamation process

The results of the determination of dusts amounts generated in the reclamation process are presented in Figure 8.

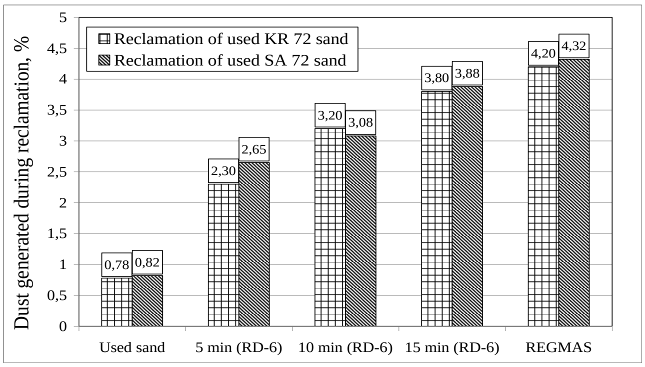

Fig. 8. Amount of dusts generated in the reclamation process

On the bases of the measured amounts of dusts generated by the reclamation process in the rotor reclaimer it can be noticed, that along the reclamation time increasing the dusts amount increases. This is related to the progressing process of removing spent binding material from matrix grains. However, the sieve analysis results indicate that in case of the longest reclamation time (15 minutes) the undesired effect of crushing quartz matrix occurs. The largest amount of dusts (4.32%) was removed in case of the spent sand SA 72 in the REGMAS device.

6. Conclusions

The final conclusions, arrived at on the bases of the performed investigations, are written below.

- The matrix regeneration process occurs slightly better for the spent sand with the new KR 72 hardener than for the sand with the SA 72 hardener.
- The matrix regeneration process of both investigated spent sands occurs correctly.
- The applied rotor mechanical reclamation method is the correct reclamation method of spent sands. However, other mechanical reclamation methods of these sands are also possible - e.g. in the vibratory reclaimer.
- The reclamation of spent sands in the prototype reclaimer provides results similar to the ones obtained in the laboratory reclaimer during 12-15 minutes, which coincides with the theoretically determined time - 11-13 minutes - during which the spent sand is in the reclaimer. It is worth to notice that when the reclamation process is performed in the prototype reclaimer the undesirable effect of a partial crushing of a matrix is not observed, while it is observed in case of the laboratory reclaimer.

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