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# Influence of Reclamation Process on the Ecological Quality of Reclaim Sand

M. Dereń<sup>a</sup>, M. Łuczczak<sup>a,\*</sup>, A. Rocznik<sup>a</sup>, A. Kmita<sup>b</sup>

<sup>a</sup>University of Science and Technology, Faculty of Foundry Engineering  
ul. Reymonta 23, 30-059 Kraków, Poland

<sup>b</sup>University of Science and Technology, University Center of Materials and Nanotechnology,  
al. A. Mickiewicza 30, 30-059 Kraków, Poland

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

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## Abstract

In this article, there were presented results of research on influence of reclamation process on the ecological quality of reclaim sand with furan resin used in nonferrous foundry. The quality of reclaimed sand is mainly define by two group of chemical substances from elution of reclaimed sand: Dissolves Organic Carbon (DOC) and Total Dissolves Solids (TDS). Reclaimed sand used in test was prepared in experimental thermal reclaimer and mechanical vibration reclaimer REGMAS installed in Faculty of Foundry Engineering at University Of Science and Technology in Krakow. The reference point is molding sand shaking out and crumble in jaw crusher. Test of elution was made in accredited laboratory in Center For Research and Environmental Control in Katowice up to the standard with Dissolves Organic Carbon (DOC) - PN-EN 1484:1999; Total Dissolves Solids (TDS) - PN-EN 15216:2010. The standard for elution test is PN-EN 12457-4:2006. Except that we were made loss of ignition test, to check how many resin was rest on sand grains.

**Keywords:** Thermal reclamation, Loss of ignition, Molding sand, Elution analysis, Environment protection

## 1. Introduction

Thermal reclamation is one of the recovery method of sand matrix from waste foundry molding sand with organic binder, especially if we considerate the reclamation sand quality as a material for reuse in production of moulds and cores. Thermal reclamation should be preceded by pre-reclamation process like e.g. crushing, dedusting. The way to have better and more efficient thermal reclamation process where this technique would be the only regeneration technique, the molds should be so designed that the weight ratio of the molding weight to the weight of the cast is as small as possible. Except very good quality of reclamation sand as a material used for molding there is another very important factor – influence on environment in aspect of dangerous substances elution. It is a significant factor because

environmental regulations are becoming more restrict. Also there is economic aspect – requirement for new silica sand, waste management and energy demand [1].

The pouring temperature of aluminium alloys is much less than iron alloys, so the auto-reclamation process during pouring is not so effective. The mold sand is burn out only for several mm depth from surface of casting – this process does not have much impact for reclamation.

The reclamation process of molding and core sand shall be performed with the lowest cost of energy, simultaneously to get the best quality of reclamation sand and to have the lowest level of dangerous substances in reclaimed material. In case of thermal reclamation one of the method to decrease the energy demand is optimization of temperature which is sufficient to clean sand grain from organic binder. This temperature range can be defined by using the thermal analysis [2-4]. In this article, there were

presented results of research on influence of reclamation process on the ecological quality of reclaim sand with furan resin from nonferrous foundry.

## 2. Experimental stands and investigation methods

### 2.1. Waste molding sand

A testing sample of used molding sand was collected from material taken from one of the non-ferrous metal foundry. This material was from sand mold made by 100% reclamation sand after pouring non-ferrous alloy. Material was subdivided into the following 4 types of samples:

- ❖ **Sample I:** crushed in a jaw crusher and sieved through a sieve 0.8 mm size.
- ❖ **Sample II:** material was reclaimed in REGMAS vibratory reclaimer.
- ❖ **Sample III:** material was reclaimed in REGMAS vibratory reclaimer and dedusted in a fluidised bed. After reclamation process the material has been revived by adding the 20% fresh silica sand 0.80% furan resin (relative to molding sand) and hardener in an amount of 0.25% (relative to resin). This revived material after hardening has been reclaimed in REGMAS.
- ❖ **Sample IV:** reclamation sand prepared in vibratory reclaimer REGMAS and dedusted, then material was reclaimed in experimental thermal reclaimer at 650°C

### 2.2. Reclamation process

Figure 1 shows the REGMAS vibrating reclaimer in which the mechanical reclamation process was performed.

The universal REGMAS vibrating reclaimer functionally integrated with cascade flow classifier, is intended for mechanical regeneration of almost every dry waste molding sand. The reclamation was carried out a constant placement of unbalanced masses of rotodynamic motors corresponding to 75% of the maximum power with frequency of operation of electrovibrators with 60 Hz.

Thermal reclamation was carried out in an experimental thermal reclaimer. The principle of operation of this device has been described in publications [5-6]. Figure 2 shows the experimental device with the control and data recording system.

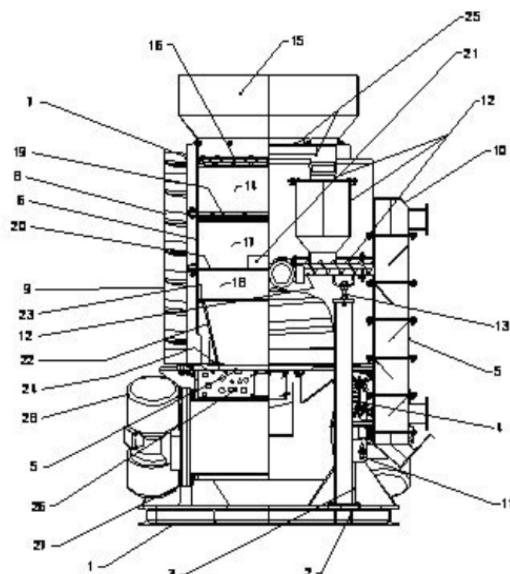


Fig. 1. Diagram of the prototypic REGMAS vibrating reclaimer: 1 – base frame, 2 – frame ledge, 3 – vertical brackets of oscillating supports, 4 – oscillating supports, 5 – device supporting structure plate, 6 – inner reclaimer column, 7 – cylindrical body, 8 – outer transport channel, 9 – channel (runner) cover, 10 – pneumatic cascade classifier, 11 – classifier support, 12 – auger feeder, 13 – feeder support, 14 – upper column segment, 15 – waste foundry sand container, 16 – grating for mould packages crushing 17 – central column segment, 18 – bottom column segment, 19 – upper flat sieve, 20 – central flat sieve, 21 – revision hole, 22 – bottom cone sieve, 23 – elastic sealing, 24 – fixing ring, 25 – covered channel, 26 – molding sand buffer chamber, 27 – connection pipes with flanges, 28 – rotodynamic motors

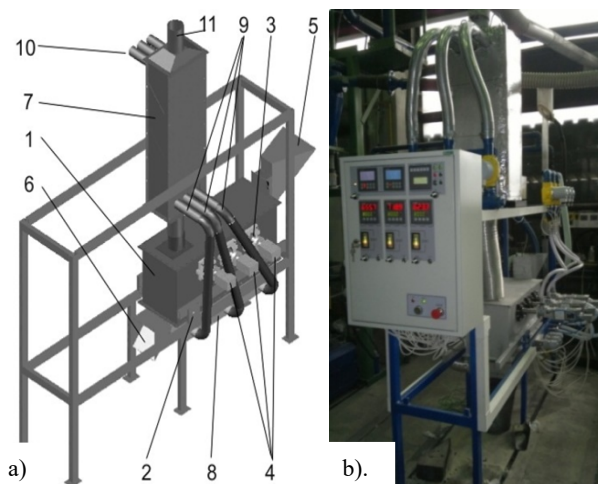


Fig. 2. Experimental thermal reclaimer: a) diagram: 1 – reclaimer chamber, 2 – support bearing for chamber inclination, 3 – articulated burner socket, 4 – burners, 5 – waste molding sand chute, 6 – reclaim discharge, 7 – recuperator, 8 – fluidizing chamber divided into sections, 9 – pipes supplying heated air to fluidization, 10 – fluidization air inlet, 11 – fumes outlet, b) view of reclaimer stand [8]

The developed experimental thermal reclaimer is equipped with the automatic system of measuring and controlling of parameters. Thermocouples are placed in the bed of the reclaimed molding sand in the device body within the burners operation zone. These thermocouples are connected to the temperature controllers, due to which it is possible to perform the reclamation process at the determined, required temperature. Signals from the controllers are sent to the ignition automatic machines of burners.

Thermal reclamation was carried out at the temperature of approximately 650°C. We choose temperature 650 C. The lower temperature, according to other studies [9], in furan binder is insufficient to effectively clean the grain matrix from the spent binder. The treatment at 650°C was better to have full destruction of the furan binder (with proper time of reclamation process).

The reclamation sand was loaded to the device after heating the reclamation chamber to the required temperature and reaching the air fluidization temperature (load mixing) of around 100°C. The used molding sand (load of 10 kg) was reclaimed sequentially: load mixing by air deliveries as pulses each 5 seconds given to the individual zones on the bottom of the chamber.

From each type of sample, we took a probes for the loss of ignition test, which were performed by heating in a silicate furnace at 950°C during 2 hours. The given LOI results are the arithmetic mean of the three samples.

Samples from I to IV were also tested for the elution of harmful substances. The measurement was made in the laboratory of the Center for Environmental Research and Inspection in Katowice in compliance with EN 12457-4: 2006 and norms for individual components: Organic Dissolved Carbon (DOC) acc. to PN-EN 1484: 1999; Soluble solids (TDS) acc. to PN-EN 15216: 2010. TDS and DOC constituents are the representatives of main components determining the type of waste and describing the sand waste classification [7].

### 3. Results analysis

Figure 3 shows the results of loss of ignition measurement for particular types of samples. The values show the level of cleansed from the binder for the sand matrix. Sample IV is the most purified, this sample is after thermal reclamation process performed at 650°C, which indicates the effective removal of the used binder. The highest losses of ignition showed samples I and II which indicates that the cleaning degree of the grain surface from the bonding material was the lowest.

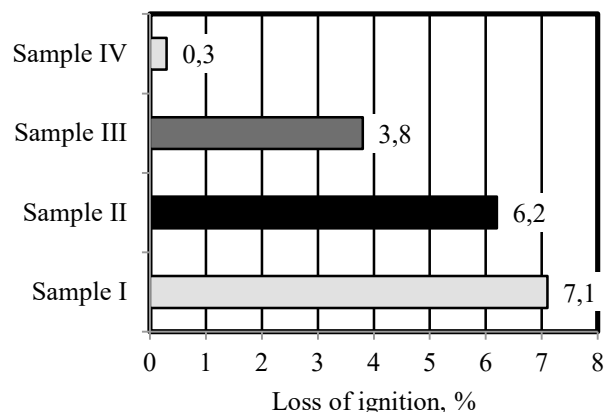


Fig. 3. Loss of ignition of each samples

Figures 4 and 5 present images of a sand surface made using microscope 50x magnification.



Fig. 4. Surface of the reclamation sand matrix after the thermal reclamation at 650°C (sample IV).

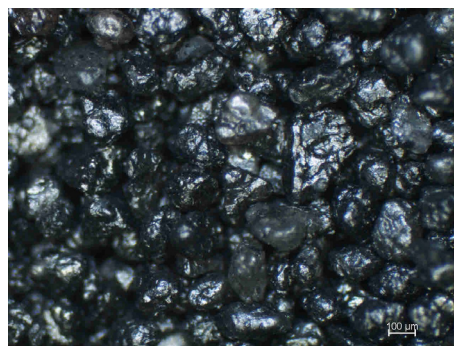


Fig. 5. The surface of the reclaim sand matrix after reclamation in the REGMAS vibratory reclaimer (sample II)

By analyzing the microscopic image of the reclamation sand in Fig. 5, a significant amount of resin is still on the surface of the sand grains.

Figure 6 shows the results of elution measurement of selected harmful substances (dissolved organic carbon DOC and dissolved solids TDS) from samples. The applicable regulations of the Minister of Economy (Journal of Laws 2015, No. 1277), the

maximum content for waste disposed on inert waste landfills is for DOC: 500 mg/kg and for TDS: 4000 mg/kg.

It can be stated that the results of the elution measurement of these substances correlate quantitatively with the loss of ignition of particular sample. The lowest amount of harmful substances is washed in sample which shows the lowest loss of ignition and after thermal reclamation process (sample IV). The operation of refreshing reclamation sand by adding fresh silica sand (sample III) affected beneficially on the quality of reclamation sand (reduction of LOI level and the elution of harmful substances). Second thing that is very important for quality of reclamation sand is dedusted process. Most of the used binder is in the dust formed during mechanical regeneration.

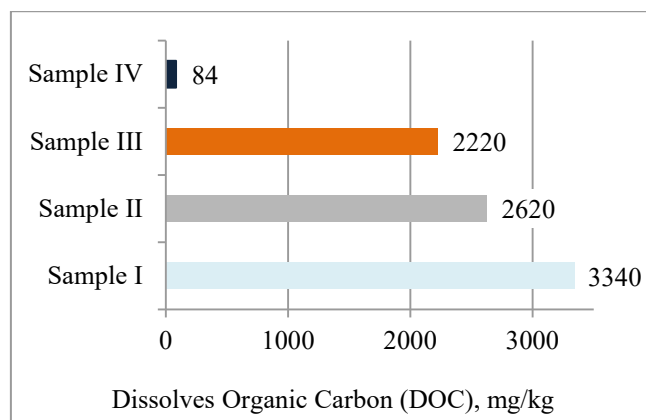


Fig. 6. Dissolved organic carbon (DOC) content for a particular samples

The similar effect in comparison to DOC is for soluble solids (TDS). The smallest content of TDS occurs in the case of regenerate after thermal reclamation.

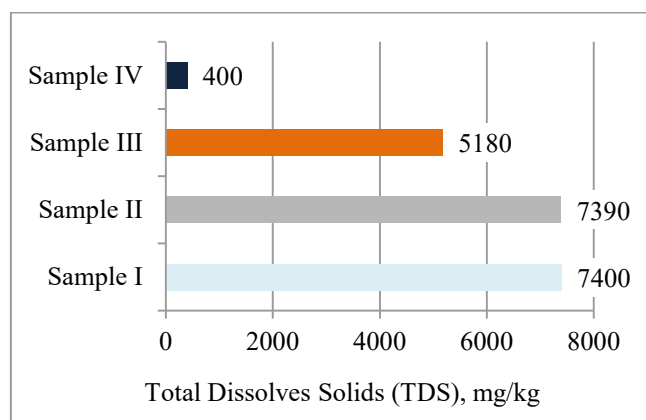


Fig. 7. Solids content (TDS) for each type of sample

By analyzing the results of the measurement of the LOI, the microscopic image of the grains and the elution of reclamation sand, it can be concluded that only the thermal destruction of the hardened resin significantly reduces the amount of material eluted from the reclamation sand and thus reduces its negative impact on the environment.

## 4. Conclusions

Various types of reclamation processes were performed to identify the most effective technique to obtain regenerate from the used molding sand in non-ferrous foundry in terms of negative environmental impact. The quality of the reclamation sand was verified by performing the loss of ignition tests, the microscopic image of the sand grains, and the elution of substances such as DOC (dissolved organic carbon) and TDS (solid dissolved compounds). The carried out researches comprise a selected part of a broader analysis of the development of an efficient method of thermal reclamation, taking into consideration the economic aspect (reduction of energy demand while still keeping the high quality of reclamation process) and ecological (cleaning reclamation sand of harmful substances, neutralization of gases produced during thermal destruction of the binder). Of course there is problem with gases arising during mass regeneration. These gases can be burned in the afterburning combustion chamber, which requires additional energy. Therefore, in the next research, the aim will be to achieve the optimum process for neutralizing gases with the least amount of energy.

As demonstrated by the research of the thermal reclamation process, it effectively cleans the grains of sand from the used binder, making the reclamation sand more environmental friendly.

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