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## **THE RECLAMATION OF SPENT SAND BONDED BY POLYMERIC BINDER BioCo2**

### **REGENERACJA ZUŻYTEGO PIASKU ŁĄCZONEGO SPOIWEM POLIMEROWYM BioCo2**

#### **Abstract**

The paper presents the results of studies on reclamation of moulding sand with a new polymeric binder BioCo2. The polymeric binder of new generation – BioCo2 – is an aqueous solution of two-component polymeric composition of poly(acrylic acid) and dextrin. The aim of research was to show whether can recover sand (reclaim) from the used sand. The properties for reuse as a component of moulding sand were discussed.

Used sands and reclaim were subjected to analysis designed to show the degree of reclaimability. Assessment of process was based on the following indicators: the amount of dust released during reclamation, loss on ignition, WSR index and the surface morphology of the sand grains.

**Key words:** *polymer binders, moulding sands, used sand, reclamation*

#### **Streszczenie**

W artykule przedstawiono wyniki badań regeneracji zużytych mas formierskich wiązanych spoiwem polimerowym. Zastosowane do przygotowania masy formierskiej spoiwo to materiał wiążący nowej generacji: spoiwo BioCo2 – wodorozcieńczalna dwuskładnikowa kompozycja polimerowa na bazie roztworów poli(kwasu akrylowego) i dekstryny. Celem badań było określenie właściwości regeneratu odzyskanego z zużytej masy formierskiej wiązanej spoiwem BioCo2 i omówienie wpływu na właściwości masy formierskiej z jego udziałem.

Ocenę regenerowalności masy zużytej z polimerowym spoiwem BioCo2 oraz jakości otrzymanego regeneratu oparto na następujących wskaźnikach: ilości pyłu uwalnianego w czasie regeneracji, strat prażenia (LOI), skuteczności regeneracji (WSR) i morfologii powierzchni ziaren piasku.

**Słowa kluczowe:** *spoiwo polimerowe, masa formierska, masa zużyta, regeneracja*

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# 1. Introduction

New organic binders used in the foundry industry have a lot of advantages, primarily providing good properties of foundry molds and cores. However, organic binders are not indifferent to the environment and often pose a threat to workers [1÷2].

The prospect of stricter environmental regulations and the spectrum of the energy crisis encourages technologists to the development and application binders based on natural materials from renewable sources. Examples of those materials are GMBOND protein binder [3], the biourethanes to no-bake technology [4] and carboxymethyl starch-based binders [5]. Also in the Laboratory of Environmental have been developed BioCo binders consisting of biopolymers [6]. They are a mixture of water soluble polysaccharides and polyacrylates as aqueous solution. The crosslinking process can be conducted by physically or chemically [7]. To the advantages of using this binder should be included that it is non-toxic, safe for the environment, biodegradable and renewable bonding material. A moulds, which are consist of moulding sand with BioCo<sub>2</sub>, have a suitable strength properties and solid castings can be easier knocked-out form them after pouring molten alloys, because the BioCo<sub>2</sub> binder is degradable in high temperature [8]. The BioCo binders can be included to the group of eco-friendly binding materials for the foundry industry.

From the point of view of waste disposal is another important property of used masses – the possibility of recycling the used mass pouring breaking the mold and casting [9÷10].

In this paper, the initial reclaimability assessment of spent sand bonded by BioCo<sub>2</sub> binder is presented.

## 2. Research materials and the experimental stand

### 2.1. Research materials

There was tested spent moulding sand with a biopolymeric BioCo<sub>2</sub> type binder. The moulding sand composition was:

- silica sand: 100 parts per weight,
- BioCo<sub>2</sub> binder: 3 part per weight.

The moulding sand with BioCo<sub>2</sub> binder was used to prepare a mould for casting Y-shape ingots (12.7 mm) by ASTM A395, which was thermally cured. In this investigation spent sand was obtained after pouring by the ductile cast-iron into finished mould. The pouring temperature by the molten alloy was about 1400°C.

Used sand after casting knocking-out was preliminary crushed in a hammer mill and sieved through a sieve of 1.6 mm mesh then spent sand was subjected to a secondary reclamation process. After classification (pneumatic) the obtained in mechanical reclamation process material is called reclaim.

### 2.2. The experimental stand

Reclamation treatment was carried out by using the pilot rotor-type reclamation unit AT-2. The device realizes grinding-reclaiming treatment within the range of rotor rotational speed in the range of 460÷1760 rot./min. The rotations of properly shaped rotor enable to perform the elementary operations of dry mechanical reclamation process: abrasion, crushing and grinding.

- The conditions of secondary reclamation treatment of spent sand were:
- rotor rotational speed: 460, 960, 1760 rot./min,
- reclamation time: 5, 10, 15 min for each rotor rotational speed.

### 3. The research scope

The investigation was performed to determine the reclaimability of spent sand with the BioCo2 binder. The reclaimability assessment of this sand was performed on the basis of measuring:

- loss of ignition (LOI) (PN83/H-04119),
- degree of liberating sand grains from binding material ( $W_{SR}$  index),
- dust content in reclaimed material, before the final dust removal,
- the morphology of the reclaimed sand grain surface (PN-83/H-11078).

## 4. Results

### 4.1. Ignition loss and the degree of liberating sand grains from binders ( $W_{SR}$ index)

The loss of ignition was defined on the basis of the weight loss of the 20 g of used sand samples burned in a silt furnace for 2 h at a stable temperature of 900°C. Figure 1 shows the obtained values of the loss of ignition.

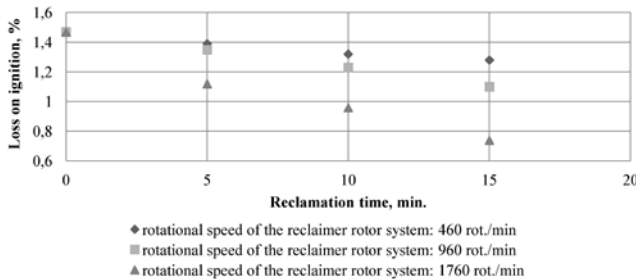


Fig. 1. Ignition loss (LOI) of the reclaim from the spent sand with BioCo2 binder

Increasing the time of the mechanical reclamation improves the quality of the obtained reclaim.

On the basis of the obtained LOI results the degree of liberating sand grains from binder left-overs ( $W_{SR}$  index) was determined. The  $W_{SR}$  index was calculated from the equation (1):

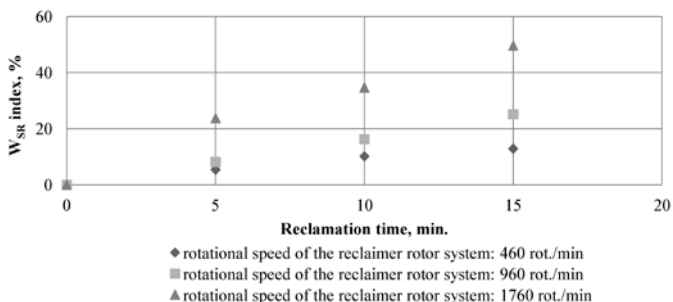
$$W_{SR} = (1 - U_C / S) \cdot 100\% \quad (1)$$

where:

- $U_C$  – weight loss of the 30 g sample of reclaim due to burning in a silica furnace for 2 h at a constant temperature of 900°C, %,
- $S$  – total content of the combustible substances (removable at high temperature) determined by the total burning of 100 g moulding sand sample before reclamation, %.

The calculated values of  $W_{SR}$  index are presented in Figure 2.

Based on the obtained results (Fig. 2) of the investigated spent sand with the BioCo2 binder, it can be stated that this moulding sand is characterized by a good susceptibility for the mechanical reclamation processes.



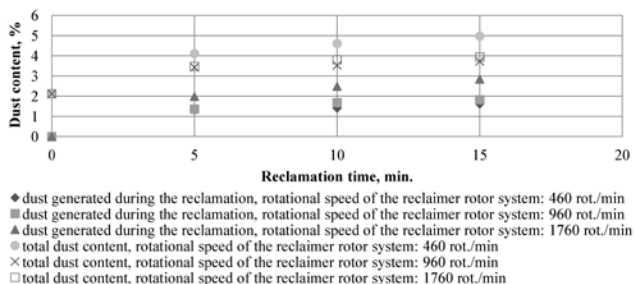
**Fig. 2.** The degree of liberating sand grains from binder left-overs ( $W_{SR}$  index) of used sand after reclamation

The calculated  $W_{SR}$  index after the longest reclamation time: 15 min were 12.95%, 25.17% and 49.95% for rotational speed 460, 960 and 1760 rot./min respectively. In comparison to the furan moulding sand the degree of the liberating sand grains, which was obtained for the moulding sand with a BioCo2 of grain is much higher.

#### 4.2. Dust content in the reclaimed spent sand

Dust content in the reclaimed spent sand were determined by blowing through 100 g samples in the fluidization column with an air blowing speed 1 m/s in time 4 min-utes. The acquired results are presented in Figure 3.

The obtained results gives important information about the efficiency of the elementary reclamation operations (abrasion, crushing and grinding). The analysis of the dust content in the reclaimed material indicates increase of dust content is caused by the increased intensity of the reclamation influence (time prolongation, higher rotational speed of the reclamation system), before the final de-dusting process. As expected, the more intensive the process is, the bigger the dust content is. In that case the dust content in reclaim was observed for the rotor rotational speed 1760 rot./min an reclamation time 15 min. It can be initially noted that, in this case the bigger dust content in the reclaim determined before the final de-dusting process is due to the better spent sand reclaimability.

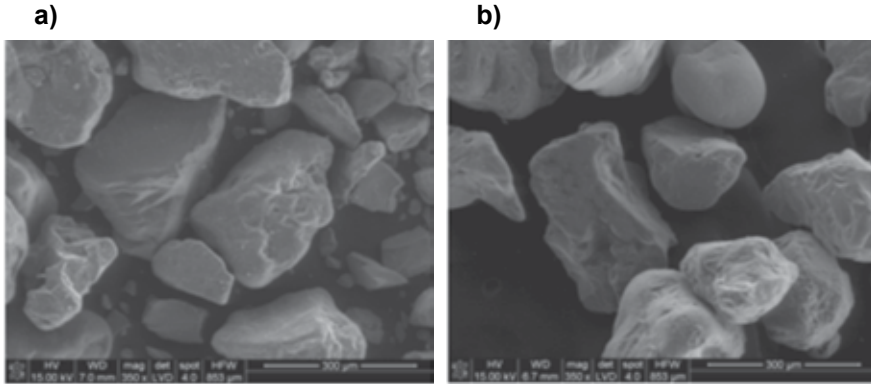


**Fig. 3.** The dust content in reclaim defined on the basis of blowing through an influidized column

In correlation to the LOI results and degree of liberating sand grains from the binder left-overs can be stated, that the highest dust content was noticed for reclaim propertyed the highest  $W_{SR}$  index value.

### 4.3. Morphology of sand grain surfaces

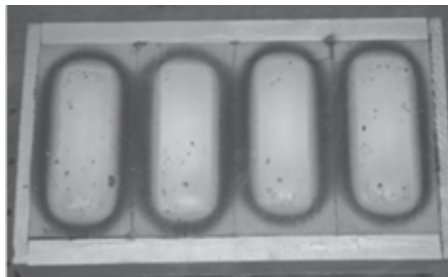
The reclamation process preformed that even after a very intensive condition of reclamation treatment (rotational speed 1760 rot./min and 15 min reclamation time) does not cause negative crushing of the sand grains. The morphology of the spent sand with the BioCo2 binder and the reclaim is presented in Figure 4.



**Fig. 4.** Surface morphology (SEM): a) spent sand, b) reclaim

### 4.4. The moulding sand self-reclamation effect

After pouring the molten alloy into a mould, it can be seen the moulding sand self-reclamation effect. This is due to the fact that the moulds made of sand with a polymeric binder BioCo2 have been burned out under the influence of a high temperature at a distance of about 20 mm from the surface of the solidification of casting. The macroscopic view of the self-reclamation effect is presented in Figure 5.



**Fig. 5.** The macroscopic view of the self-reclamation effect observed for the moulding sand with BioCo2

## 5. Summary

Based on the results it can be concluded that:

- the applied research proves that the moulding sand with the BioCo2 binder have a high ability for reclamation,
- prolonged reclamation time of mechanical reclamation improves the quality of the obtained reclaim,
- the dedusting of a reclaim after the mechanical reclamation is necessary to remove the harmful dust fractions, because dust content in sand is needless,
- grains of sand have been properly cleaned of residue using BioCo2 binder and the achieved effect is highly similar to the morphology of fresh silica sand.

In summary, it can be concluded, that the moulding sand bonded by new polymeric binder BioCo2 has a good sensitivity to the regeneration and the obtained reclaim are eligible for re-use as a component of moulding sands.

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