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# Evaluation of Reclamability of Molding Sands with New Inorganic Binders

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## Abstract

One of the purposes of the application of chemically modified inorganic binders is to improve knocking out properties and the related reclamability with previously used in foundry inorganic binder (water glass), which allowing the use of ecological binders for casting non-ferrous metals. Good knocking out properties of the sands is directly related to the waste sands reclamability, which is a necessary condition of effective waste management. Reclamation of moulding and core sands is a fundamental and effective way to manage waste on site at the foundry, in accordance with the Environmental Guidelines. Therefore, studies of reclamation of waste moulding and core sands with new types of inorganic binders (developed within the framework of the project) were carried out. These studies allowed to determine the degree of recovery of useful, material, what the reclaimed sand is, and the degree of its use in the production process. The article presents these results of investigation. They are a part of broader research programme executed under the project POIG.01.01.02-00-015/09 "Advanced materials and technologies".

**Keywords:** Innovative Foundry Materials and Technologies, Inorganic Binders, Reclamation, Reclamability, Strength

## 1. Introduction

Soluble sodium silicate (water glass) is one of the most popular inorganic binders. Although the moulding sands with water glass are universal, relatively cheap and characterised by numerous advantages, their drawback is too high residual strength and hence poor knocking out properties and difficult reclamation of the used, ceramic sand grains. [1].

Some additives and modifiers, such as phosphates improve the sand collapsibility after hardening [2]. The used sand mixture knocking out properties and reclamability can also be improved with an addition of organic modifiers and curing agents [1-7].

The purpose of the executed structural project is to introduce to the production of foundry moulds and cores, new chemically modified inorganic binders to replace the sands commonly used for casting of non-ferrous metal alloys, i.e. the moulding sands with bentonite and resin binders. The waste materials from these technologies have a negative impact on the environment [8]. The

increasingly stringent environmental regulations and casting quality improvement increased the interest in the high quality moulding sands with non-toxic inorganic binders [3-6, 9].

The objective of introducing chemically modified inorganic binders is to reduce unfavorable characteristics (worse knock out properties, low collapsibility, and associated with this worse reclamability), previously used in foundry inorganic binder - water glass, thus allowing the use ecological binders for casting of the non-ferrous metals.

Good knocking out properties of the moulding sands is directly related to the reclamability of the waste moulding sands, which is a prerequisite for effective waste management.

Reclamation of the waste moulding and core sands is a fundamental and effective way to manage waste on site at the foundry, in accordance with the Environmental Guidelines, under which the waste, if possible, should be managed at source.

Therefore, during the implementation of one of the phases of the project was carried out examinations and reclamation tests of the waste moulding and core sands with new binders, for

determining the recovery of useful material molding (reclaimed sand) and the degree of its use in the production process.

## 2. Methods and materials used in the research

Selected as a result of physico-chemical studies and structure examinations [10, 11] the modified soluble sodium silicates were subjected to technological evaluation by applying them to prepare the testing moulds and determine waste sands reclamability. Binders were chosen:

- "A" modified 1% of synthetic thermoplastic polymer,
- "B" modified 1% of copolymer obtained by emulsion polymerization,

as potentially the most beneficial for non-ferrous casting. An attempt to reference was a binder labeled "O"- unmodified soluble sodium silicate.

The batches of the binders for laboratory tests were prepared by the manufacturer of inorganic binders - Vitrosilicon in Iłowa. The inorganic binders were cured by an ester - flodur 1.

As a comparative moulding sand with an organic binder, classic moulding sand with a furan resin binder X850 was used.

Molding sands were prepared using quartz sand from the Szczakowa mine (now DB Schenker) 1K with main fraction 0.20 / 0.40 / 0.315.

Laboratory reclamation was carried out using the waste molding sands with new inorganic binders, and furan resin, pouring aluminum and copper alloys. Moulding sands with new inorganic binders, and furan resin binder, pouring aluminum and copper alloys, were used in laboratory studies of reclamation.

The investigations were carried out according to the diagram below

- Preparation of moulding sands based on green sand
- Investigation of technological properties in ambient conditions
- Preparation of moulds and cores from the moulding sands based on green sand.
- Pouring and knock out of the castings.
- Reclamation of used moulding sands
- Physical and chemical examinations of the reclaim
- Preparation of moulding sands with reclaim
- Investigation of technological properties in ambient conditions

## 3. Trials and own research

### 3.1. Preparation and technological evaluation of the laboratory batch of modified binders

Using modified binders ("A", "B") and unmodified binder ("O") and the hardener diacetate ethylene glycol (flodur1), molding sands containing 2.5 parts by weight of binder and 10% hardener (in respect of the binder weight) were made. As a comparative moulding sand with an organic binder, the

traditional moulding sand with X850 furan resin binder added in an amount of 0.9 parts by weight, hardened with 100T3 hardener added in an amount of 0.45 parts by weight was prepared. The reference sand was designated by symbol "Z".

Figure 1 show the bench life values of the examined moulding sands, while Figures 2 and 3 shows the mean values of compressive strength and bending strength of the molding sand samples prepared with the investigated binders.

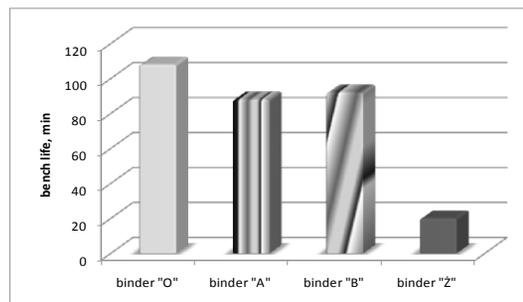


Fig. 1. Bench life of moulding sands with studies types of soluble sodium silicate and furan resin

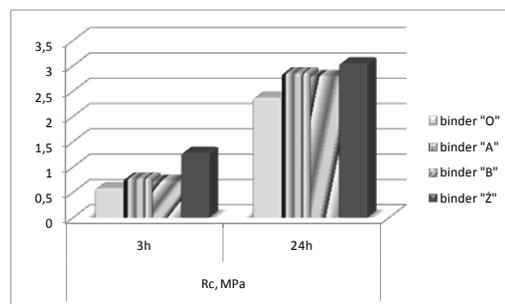


Fig. 2. Compressive strength of moulding sands with studies types of soluble sodium silicate and furan resin

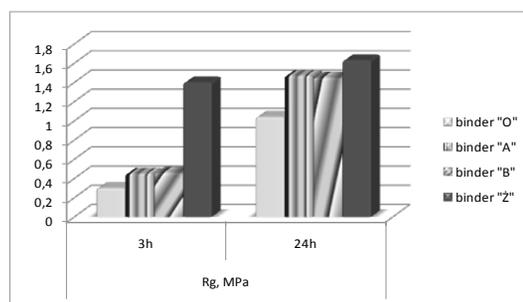


Fig. 3. Bending strength of the moulding sands with studies types of soluble sodium silicate and furan resin

Strength properties of the moulding sands with chemically modified inorganic binders are higher in comparison to the parameters obtained for the moulding sands prepared with unmodified binder and comparable to the values obtained for the moulding sands with furan resin X850. A very important

parameter, which is the bench life, is much longer in comparison to the moulding sands with furan resin, but is reduced in comparison to the moulding sands with unmodified inorganic binder. It is beneficial from the foundry operation process point of view. This time can be further reduced by using other hardeners (higher content of the glycol).

### 3.2. Tests of the laboratory reclamation

In parallel with the preparation moulding sands for technological research, are carried out test moulds, which - after pouring of aluminum and copper alloys and breaking, were the starting material for the tests of the laboratory reclamation.

The reclamation process was carried out on laboratory stand reclamation, which scheme shows the photograph below (Figure 4).



Fig. 4. Laboratory stand of mechanical reclamation, installed at Foundry Research Institute

The materials obtained at different stages of the reclamation were subjected to quantitative assessment.

In the result of mechanical reclamation regains about 90% of useful material, what the reclaimed sand is.

### 3.3. Physical-chemical study of the sand reclaimed in the laboratory reclamation test

Reclaimed sands from waste moulding sands was subjected to laboratory testing. The results of physical-chemical tests are presented below in the form of graphs.

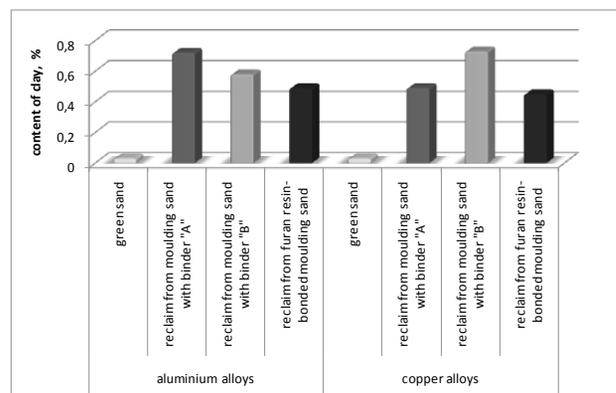


Fig. 5. Content of clay in the reclaim moulding sand poured aluminum and copper alloys

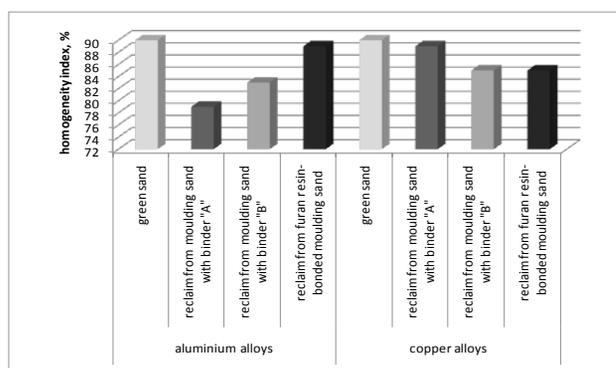


Fig. 6. Homogeneity index in the reclaim moulding sand poured aluminum and copper alloys

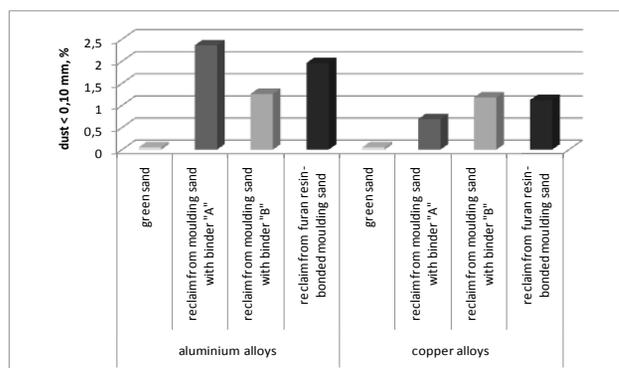


Fig. 7. Dust in the reclaim moulding sand poured aluminum and copper alloys

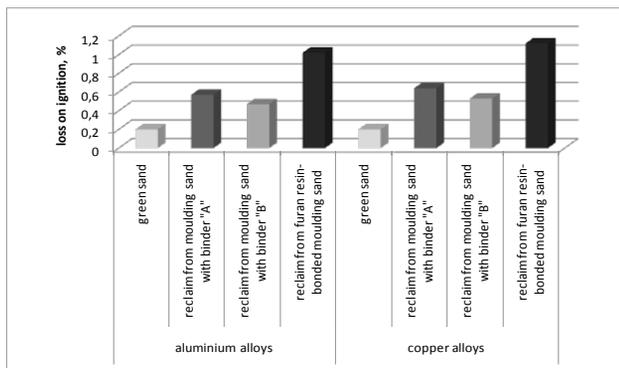


Fig. 8. Loss on ignition in the reclaim moulding sand poured aluminium and copper alloys

All the reclaimed sands characterized the same main fraction as that green sand. In the case of sand reclaimed from the waste moulding sands after pouring aluminum alloy, favorable properties (clay, homogeneity, loss on ignition) is obtained by using a binder "B". In the case of the reclaimed sands, which were pouring by brass, the better was to use adhesives "A".

### 3.4. Preparation and evaluation of industrial technological batches of the modified binders

The next attempt was prepared using an industrial batch of modified binders. They were made under production conditions in Vitrosilicon in Iłowa. These are marked, as in the case of laboratory tests, by the symbols "A" and "B".

With the participation of industrial binders batch were carried out technological research of the moulding sands. The results of technological research of the moulding sands with binders from the industrial production and, for comparison, with binders made in laboratory conditions, are presented in the form of graphs.

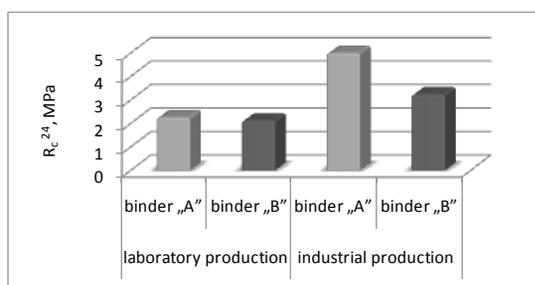


Fig. 9. Compressive strength of moulding sand with binders from laboratory and industrial production

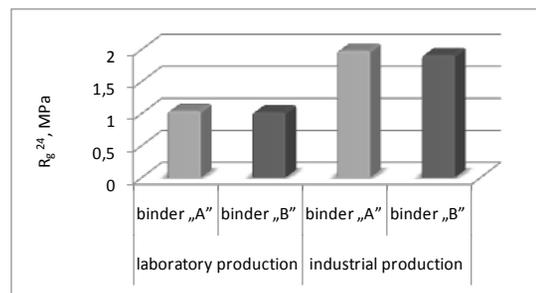


Fig. 10. Bending strength of moulding sand with binders from laboratory and industrial production

Technological properties of the moulding sands with industrial batches of binders are higher than moulding sands prepared with binders made in the laboratory. Obtained strength values are comparable to the values obtained for the moulding sands with furan resin.

### 3.5. Technological studies of the moulding sands with new binders and with varying participation of reclaimed sand

With the participation of reclaimed sand, moulding sands for technological research and for moulds, were prepared. The moulding sands made from the participation of the reclaimed sands, were subjected to technology evaluation, including such parameters as: compressive strength, bending strength, permeability, and - very important in the case of self-hardening moulding sands, bench life.

Composition of the molding sand was as follows:  
 green sand - 50.0 - 30.0 parts by weight  
 reclaimed sand - 50.0 - 70.0 parts by weight  
 binder - 2.5 parts by weight  
 hardener flodur 1 - 0.3 parts by weight

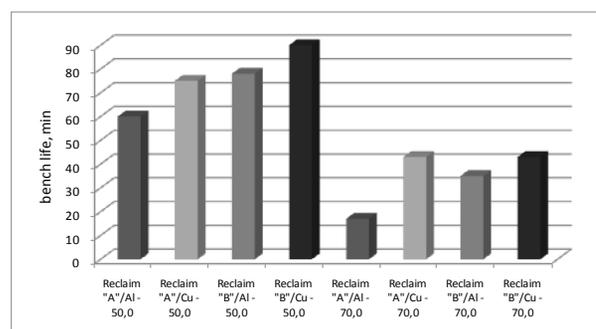


Fig. 11. Bench life of moulding sands with a variable participation of the reclaim grains

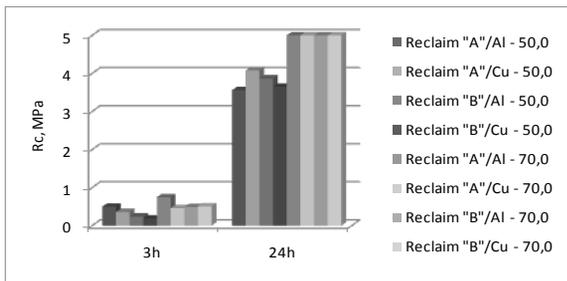


Fig. 12. Compressive strength of moulding sand with a variable participation of the reclaim grains

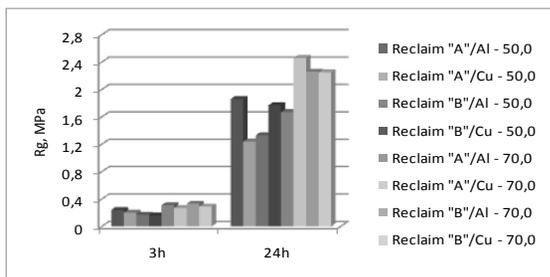


Fig. 13 Bending strength of moulding sand with a variable participation of the reclaim grains

Increasing share of reclaimed sand in the moulding sands affect the significant reduction of bench life, and growth strength properties of these moulding sands.

#### 4. Industrial tests of the reclamation and obtained products

In addition to the conducted in the Foundry Research Institute (FRI) tests of reclamation of waste moulding sands, have also been carried out the semi-industrial tests in the selected foundry, as a validation of the results obtained in conditions similar to real ones.

To carry out industrial test of reclamation of the moulding sands with new binders, Charsznica Hardtop foundry were selected. It is a simplified reclamation stand, equipped with a vibrating crusher and dust removal system. Waste moulding sands, designed to the industrial test has been prepared at the FRI. Sample was approximately 250 kg each of the moulding sands (with binders A and B). Reclaimed material was received directly into the "big-bag" and was transported to the FRI for further research.

Reclaimed sand from the industrial trial has been subjected to physical, chemical and technological research. These results are provided in the form of graphs. The graphs are shown, for comparison, the results of physico-chemical tests for both the reclaimed sand, obtained by the laboratory, as well as an industry.

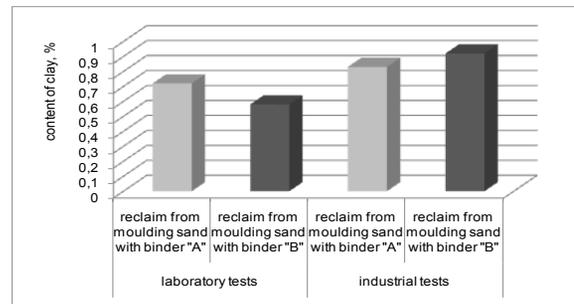


Fig. 14. Content of clay in reclaim moulding sands with binders from the laboratory and industrial production

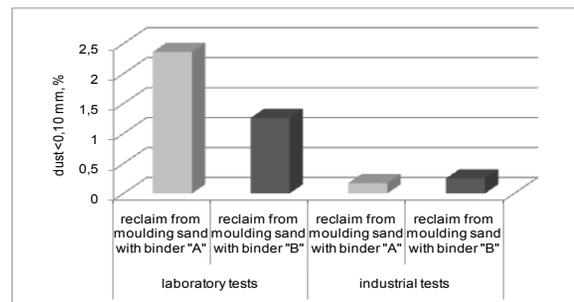


Fig. 15. Dust in reclaim moulding sands with binders from the laboratory and industrial production

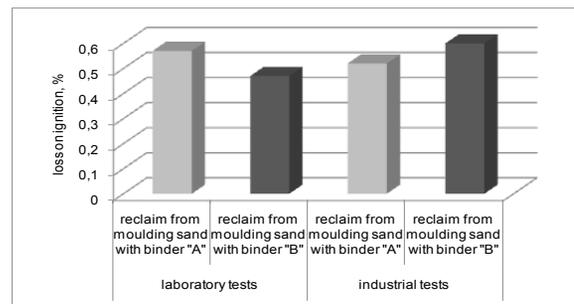


Fig. 16. Loss on ignition in reclaim moulding sands with binders from the laboratory and industrial production

As shown, the reclaimed sands from the industrial trial, while being worse rubber from coating binder (simplified reclamation), but much better dust-free, which is beneficial on technological properties of the moulding sands with reclaim.

With reclaimed sands obtained from the industrial trial, moulding sands for technological research were made. The results of these investigations show the graphs below.

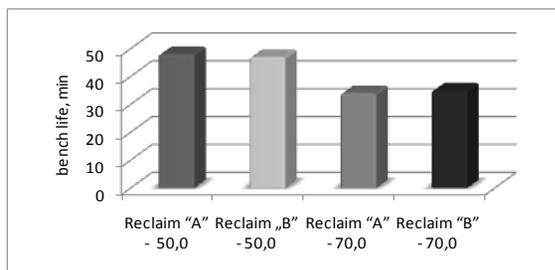


Fig. 17. Bench life of moulding sands with a variable participation of the reclaim obtained in the industrial reclamation test

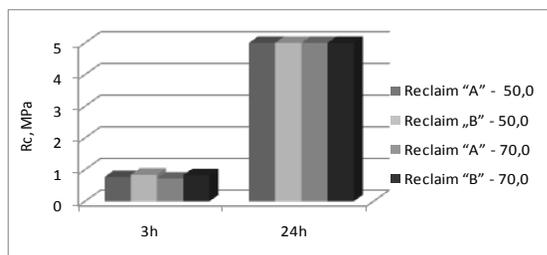


Fig. 18. Compressive strength of moulding sands with a variable participation of the reclaim from the industrial reclamation test

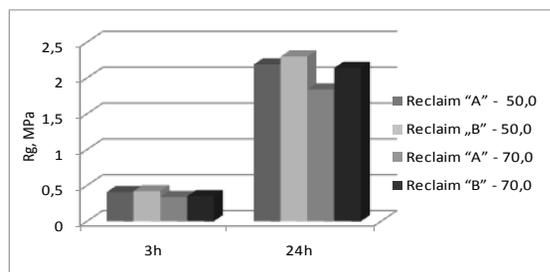


Fig. 19. Bending strength of moulding sands with a variable participation of the reclaim from the industrial reclamation test

Industrial tests confirmed the possibility of using reclaimed sand in amounts up to 70% in place of green sand.

## 5. Conclusion

- Chemical modification of the inorganic binders is beneficial for the reclaimability of the moulding sands made with these binders.
- Carried out tests allow the conclusion that the amount of useful material obtained from reclamation, possible to re-apply to the preparation of molding sands is up to 70%.
- Validation results of laboratory tests under industrial conditions confirmed the desirability of the reclamation process, not only for environmental reasons but also because of the favorable effect on bench life of moulding sands, a very important from the production cycle point of view.

## Acknowledgements

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