Investigating the reclamability of moulding sand with new, ecological inorganic binders

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Abstract
The article presents the results of investigations, which make a fragment of the broad-scale studies carried out as a part of the statutory activity on optimising the foundry sand technology using new, modified, inorganic binders.
The results of investigations regarding the effect of multiple reclamation on the technological properties of foundry sands with inorganic binders were presented in a concise manner. The reclaim sand were introduced to moulding sands prepared with the new, modified, inorganic binders bonded by the chemical reaction or by blowing with gaseous CO₂.
Attention was focussed on the effect of multiple reclamation on the residual strength and bench life properties of moulding sands prepared with the new types of inorganic binders.

Keywords: Innovative foundry materials and technologies, protection of environment, inorganic binders, multiple reclamation, bench life, residual strength

1. Introduction
The growing demands of ecology and economy promote continuous interest in the non-toxic and cheap, compared to organic, inorganic binders. Sands prepared with these binders emit no toxic gases over the whole casting production cycle.

Of course, along with some obvious benefits, sands with hydrated sodium silicate have also a number of drawbacks, which can make the casting production process difficult and restrict the scope of sand application.

Among these drawbacks, the most important is the high residual strength of the sand (the secondary strength). It considerably deteriorates the sand knocking out properties and makes sand reclamation process very difficult, especially if compared to sands with resin binders.

This is the reason why numerous scientific and research centres carry out intense research on the new or modification of the so far existing, inorganic binders

The investigations carried out by numerous research centres in Poland [1,2] and abroad [3-7] mainly focus their attention on extending further the applicability range of these binders to replace totally resin systems.

The main aim of the research is the improvement of knocking out properties and reclamability of moulding sands with these binders.

The, developed by Foundry Research Institute in Cracow, silicate binder modified chemically with morphoactive additives of the type of polymers and copolymers enables reducing the binder content in moulding sand by nearly 20%, while maintaining the good technological properties (the residual strength) at ambient and high temperatures [8,9].

The research carried out under the statutory work programme in year 2007 aimed mainly at optimising the composition of sands with new inorganic binders and, in the case of self-setting sands, at obtaining full control of the binding time, as having an immediate and important effect on the time when casting can be knocked out from mould [10,11].

In 2008, these studies were continued to find out, among others, if it is possible to subject the sand mixture to repeated reclamation [12,13].
The process of reclamation was considered in context of possibility of multiple reclamation and the quality of the reclaim after multiple cycle of circulation, in moulding sand hardened with both liquid and gaseous hardeners.

2. Background and aim of the research

Apart from the factors of strictly economical and ecological character and the quality requirements imposed on foundry moulds and cores, there are two other factors very important and always considered by foundry in the choice of casting-making technology. These two factors are the knocking out properties of moulds and cores and their reclamability [12,14,15].

From the point of view of its usefulness to reclamation and second utilization, the behavior of the moulding sand during longer application of the reclaim, is of prime importance, as far as its strength proprieties are concerned, as well as, in case of self-setting moulding sand, the length of binding time.

Therefore, under the statutory work [10,12], some studies were undertaken to explain, among others, the effect of multiple reclamation on the technological parameters of moulding sands with new inorganic binders.

The investigations were carried out on moulding sands with inorganic binders based on hydrated sodium silicate modified with morphoactive additives (150MC and 145MC water glass), hardened with both liquid and gaseous hardeners (liquid self-setting sands and CO₂ process, respectively).

3. Tests of multiple reclamation of moulding sands with new inorganic binders

The reclamation process was carried out on laboratory stand at Foundry Research Institute (fig.1).

Fig.1. Laboratory stand of mechanical reclamation at Foundry Research Institute

The investigations were carried out according to the pattern below.

- Preparation of moulding sand based on green sand
- Investigation of technological properties in ambient conditions
- Investigation of residual strength

<table>
<thead>
<tr>
<th>1 cycle</th>
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<tbody>
<tr>
<td>Preparation of moulding sand based on green sand</td>
</tr>
<tr>
<td>Investigation of technological properties in ambient conditions</td>
</tr>
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<td>Investigation of residual strength</td>
</tr>
</tbody>
</table>

In the result of mechanical reclamation regains from near 90 to almost 95% useful material, what the reclaimed sand is.

3.1. Effect of multiple reclamation on the quality of sand with new inorganic binders

The investigations of the physics - chemical properties were carried out for products of reclamation process and in comparison to new sand. Investigations were subjected after every cycle of circulation.

The graphs below compare the contents of clay and the loss of ignition after every cycle of reclamation self-setting moulding sand for two type of reclaim (with binder 145 MC and 150MC).

**Fig.2. Changes in contents of clay for reclaims after multiple reclamation of self-setting moulding sands**

**Fig.3. Changes in loss of ignition for reclaims after multiple reclamation of self-setting moulding sands**

An analysis of the results of the investigations plotted in the form of diagrams shows that the level of physics properties of reclaim sands from multiple reclamation are good.

The physical properties of the self-setting moulding sands prepared with reclaim and new binders were compared to the
properties of the CO$_2$ hardened moulding sands.

Moulding sands based on green sand, and prepared with reclaim, were subjected to technological investigations i.e. compression strength, bending strength, permeability, and for self-setting moulding sands additionally bench life. The sand mixtures for technological examinations were prepared as follows:

**Self-setting moulding sand:**

<table>
<thead>
<tr>
<th>Cycle</th>
<th>New sand</th>
<th>Binder</th>
<th>Hardener</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.0 parts by weight</td>
<td>2.5 parts by weight</td>
<td>0.25 parts by weight</td>
</tr>
<tr>
<td>2-5</td>
<td>50.0 parts by weight</td>
<td>2.5 parts by weight</td>
<td>0.25 parts by weight</td>
</tr>
</tbody>
</table>

**Moulding sand hardened CO$_2$:**

<table>
<thead>
<tr>
<th>Cycle</th>
<th>New sand</th>
<th>Binder</th>
<th>Hardener</th>
<th>CO$_2$ time of blowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.0 parts by weight</td>
<td>2.5 parts by weight</td>
<td>0.25 parts by weight</td>
<td>40s.</td>
</tr>
<tr>
<td>2-5</td>
<td>50.0 parts by weight</td>
<td>2.5 parts by weight</td>
<td>0.25 parts by weight</td>
<td>40s.</td>
</tr>
</tbody>
</table>

The diagrams below show the bench life time and bending strength during trials of application of the reclaim to the self-setting moulding sand in function of the number of reclamation cycles.

![Fig. 4](image)

**Fig. 4.** The bench life of self-setting moulding sand in function of the number of reclamation cycles

![Fig. 5](image)

**Fig. 5.** The bending strength of self-setting moulding sand in function of the number of reclamation cycles.

The character of changes in bending strength for moulding sands hardened with CO$_2$ is similar.

On the basis of the results of the investigations it has been stated that the technological properties of moulding sands with reclaim from multiple reclamation, firstly decrease, but after next cycle again increase and keep constant.

To determine changes in the compression strength of moulding sand under the effect of temperature (residual strength), after 24 hours since the moment of having been made, the specimens for high-temperature tests were preheated for 0.5 hour at the temperatures from 100 to 900 °C. After preheating, the specimens were cooled to ambient temperature, and their compression strength $R$ was determined.

![Fig. 6](image)

**Fig. 6.** The residual strength of self-setting moulding sand with binder 150MC and reclaim sand after next cycles of circulation

![Fig. 7](image)

**Fig. 7.** The residual strength of moulding sand hardened with CO$_2$ with binder 150MC and reclaim sand after next cycles of circulation

The residual strength of moulding sands with reclaim from multiple reclamation cycles reach similar (or even better) values as moulding sands based on green sand.

The character of changes in residual strength for moulding sands with sodium silicate, grade 145MC is similar.

**4. Conclusions**

Prepared with modified inorganic binders and reclaim from multiple reclamation after first cycle of circulation moulding
sands get lower technological properties than moulding sands based on new sand, but after next cycles the quality of those sands improves and stabilize. Differences among studied reclamies are only insignificant. The characteristic of moulding sands with their binders after multiple reclamation is similar.

The valuable observation, useful for application works to industry, is the fact that the bench life time of these moulding sands keeps on permitting on preparing mould without loss of binding properties level, which was the obstacle in applying the reclaim sand from moulding sands with typical water glass. Additionally, the above presented results of investigations indicate a beneficial effect of the reclaim from multiple reclamation on the residual strength of the moulding sands.

The research concerning the improvement of technology of moulding sands with new inorganic binders in context of application to alloys of non-ferrous metals, are continued in the frames of Operating Project, entitled “Advanced materials and technologies”.

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