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EFFECT OF MECHANICAL RECLAMATION CYCLE ON STRENGTH PARAMETERS OF LOOSE SELF-HARDENING SANDS BASED ON FURFURYL RESIN

The results of mechanical reclamation of waste moulding sands with furfuryl resin and activators of new generation are presented. The aim of the research described in this study was to determine what effect the addition of reclaim obtained in the process of dry mechanical reclamation could have on the properties of furan sands.

The sand supplied by one of the domestic foundries was after the initial reclamation subjected to a two-step proper reclamation process. The following tests were carried out on the obtained reclaim: pH, S and N content, loss on ignition and comprehensive sieve analysis. The obtained reclaim was next used as a component of moulding sands with furfuryl resin, wherein it formed 50% and 80% of the base moulding material, respectively. The strength properties of the ready sand mixtures (bending strength R_g^u and tensile strength R_m^u) were determined after the hardening time of 0.5, 1, 2, 4 and 24 hours.

Keywords: loose self-hardening sands, furfuryl resin, mechanical reclamation

Introduction

According to the Waste Act [1], the basic principle of conduct is to prevent the occurrence of the waste or, if this is not possible, to ensure a recovery of the useful secondary material consistent with the rules of environmental protection. The waste storage process should be treated as a last resort [2].

In the foundry industry we constantly strive to reduce the consumption of raw materials and to make maximum use of them. One of the methods that makes the foundry industry more ecological and economical is the reclamation of moulding sands [3-7].

In the case of self-hardening sands, which include sands with furfuryl resin, reclamation is the basic and effective way of on site waste management in the foundry [8,9].

Reclamation of waste moulding and core sands can be defined as the technological processing of used refractory moulding materials for the purpose of their re-use in the production of foundry moulds and cores [10]. Reclamation treatment is understood as a complex of operations that are successively performed on the waste moulding sand. The reclamation process includes pre-treatment (initial reclamation) of the sand and proper reclamation leading to the manufacture of final product, i.e. the recovery of at least one of the waste sand components with properties similar to the new component, which can be re-used in the manufacture of foundry moulds and cores [11,12].

1. Test programme

Part of the research programme included the process of mechanical reclamation of the waste moulding sands with furfuryl resin and activators of new generation, supplied by one of the domestic foundries. The research was aimed at determining the recovery rate of useful moulding material as well as the degree of its re-use in subsequent production processes.

The tests were carried out under laboratory conditions on a pilot station for the reclamation of moulding and core sands (Fig. 1). The device with a capacity of up to 600 kg/h installed

Fig.1. Mechanical reclamation station installed at the Foundry Research Institute

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at the Foundry Research Institute comprises a jaw crusher and hammer-impact crusher, a vibration sieve, disk-type and multi-section reclamation units and a suction installation.

After initial reclamation, the waste, burnt moulding sand was subjected to proper mechanical reclamation carried out in a single-cycle and double-cycle process. After the completion of each reclamation cycle, the following physical and chemical tests were carried out on the reclaimed material: the amount of dust produced as a result of reclamation, pH, S and N content in the reclaim, loss on ignition, sieve analysis, and shape index [13,14].

The obtained reclaim was used as a component of loose self-hardening sand mixtures with furfuryl resin, wherein it formed 80% and 50% of the base sand material, respectively. Moulding sand mixtures were prepared in a laboratory ribbon mixer of LMR-2 type. The sands were subjected to technological evaluation, including the determination of their tensile strength R_m^u and bending strength R_g^u after 0.5, 1, 2, 4 and 24 hours of hardening of the moulding sand samples. The new base sand was medium-size silica sand from the Szczakowa 1K mine (currently DB Cargo Polska) with a main fraction of 0.20 / 0.40 / 0.315.

2. Test results

The first stage of the research was proper reclamation carried out in both single-cycle and double-cycle process. The device enables a very thorough dust removal from the reclaim, and the efficiency of this operation depends on the speed of the air flowing through a cascade classifier. In practice, this speed is 1.0 m/s. The amount of dust generated as a result of the waste sand reclamation is compared in Table 1.

After completion of the reclamation process, the reclaimed materials were examined for the surface morphology using a SCIOS FEG scanning electron microscope (Fig. 2). From the results of these examinations it follows that the obtained reclaims are characterized by a high degree of purification from the remains of waste binding material and clay. This proves that the recovery process due to reclamation treatment has been conducted in a very efficient manner.

TABLE 1

The amount of dust generated as a result of the waste sand reclamation

Material tested	Dust formed by reclamation, %
Waste burnt sand reclaim (after 1 cycle)	1.26
Waste burnt sand reclaim (after 2 cycles)	1.43
Waste burnt sand reclaim (TOTAL)	2.69

Table 2 contains data on physicochemical properties and sieve analysis results of the tested reclaims.

TABLE 2

Physicochemical properties and sieve analysis of the tested reclaims

Test	Reclaim after initial reclamation	Reclaim (after 1 cycle)	Reclaim (after 2 cycles)
pH	3.75	3.83	3.96
S, %	0.114	0.112	0.102
N, %	0.261	0.241	0.210
LOI, %	2.537	2.340	2.093
Clay content, %	0.52	0.25	0.23
Homogeneity index, %	94	94	95
Mean grain size, mm	0.29	0.28	0.27
Shape index W_k	1.38	1.32	1.26

Based on the results summarized in Table 2, it can be noticed that mechanical reclamation slightly decreases the pH value and the content of S and N as a result of partial removal of the used binding material from the sand grains. Due to the recovery of sand grains in the process of mechanical reclamation, with the increasing number of reclamation cycles, the loss on ignition of the reclaim is reduced. The reason for the value of W_k decreasing with increasing number of the reclamation cycles is most likely crushing of the binder envelope present on the sand grains.

The next stage of the research was the preparation of loose self-hardening sands with the addition of the obtained reclaim. As a reference material, the mixture with furfuryl resin based entirely on the new sand was used.

a) b)

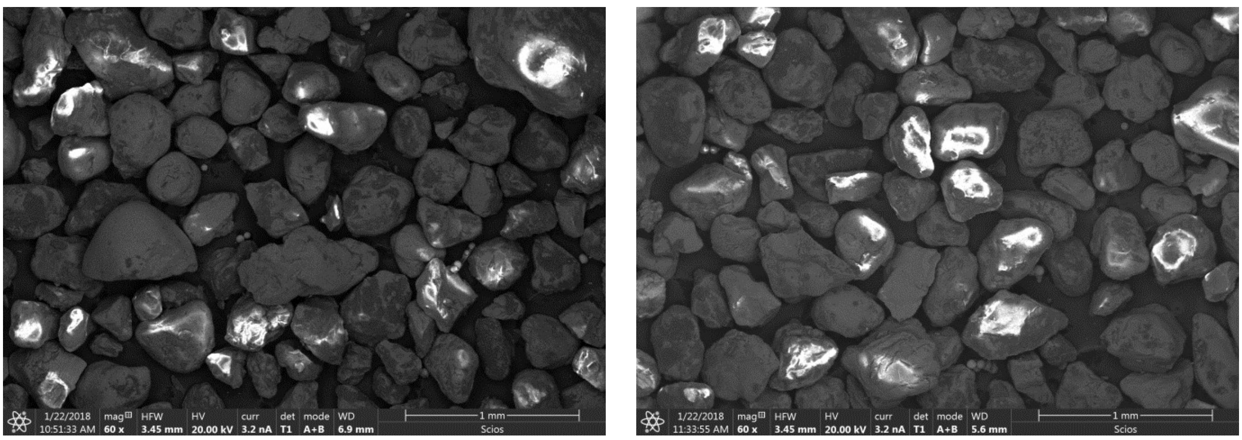

Fig. 2. Surface morphology of reclaim: after single reclamation cycle (a), after double reclamation cycle (b). 60×

The bending and tensile tests were carried out on samples of the moulding sand mixtures based on:

Sand mixture 1 – new silica sand,

Sand mixture 2 – reclaim after initial reclamation (50%) + new silica sand (50%),

Sand mixture 3 – reclaim after initial reclamation (80%) + new silica sand (20%),

Sand mixture 4 – waste burnt sand reclaim after 1 reclamation cycle (50%) + new silica sand (50%),

Sand mixture 5 – waste burnt sand reclaim after 1 reclamation cycle (80%) + new silica sand (20%),

Sand mixture 6 – waste burnt sand reclaim after 2 reclamation cycles (50%) + new silica sand (50%),

Sand mixture 7 – waste burnt sand reclaim after 2 reclamation cycles (80%) + new silica sand (20%).

The composition of the moulding sand mixture was as follows:

– base sand – 100 parts by weight,
– furfuryl resin – 0.9 part by weight,
– slow-acting hardener – 11% in relation to the amount of resin,
– fast-acting hardener – 38% in relation to the amount of resin.

Figures 3 and 4 illustrate the results of the tensile (Fig. 3) and bending (Fig. 4) tests carried out on the loose self-hardening sand mixtures with the addition of the tested reclaim (sand mixtures 2-7). As a reference material, the sand mixture based entirely on the new sand (sand mixture 1) was used.

The increasing content of reclaim in the moulding sand mixture significantly reduces the sand bench life (mouldability)

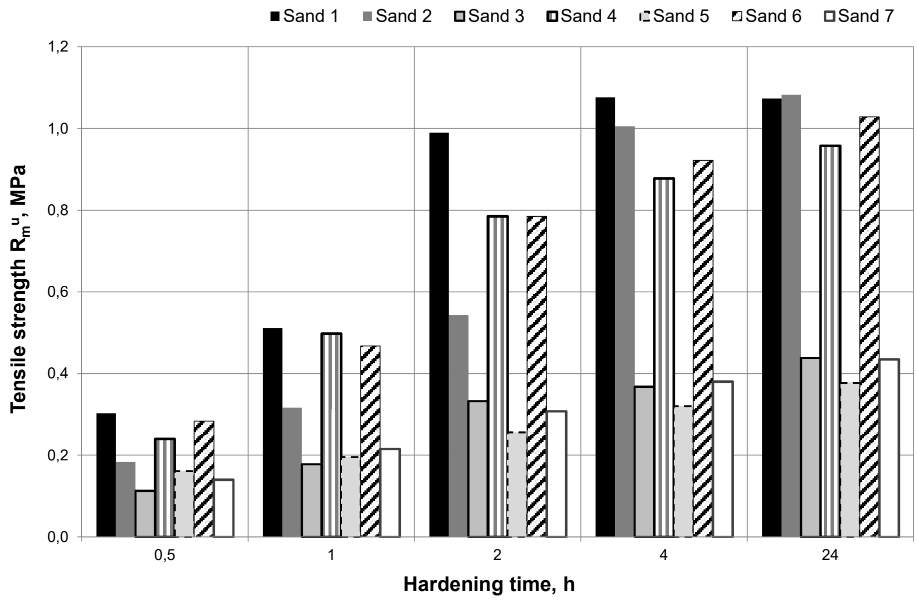

Fig. 3. Tensile strength of moulding sands with furan resin

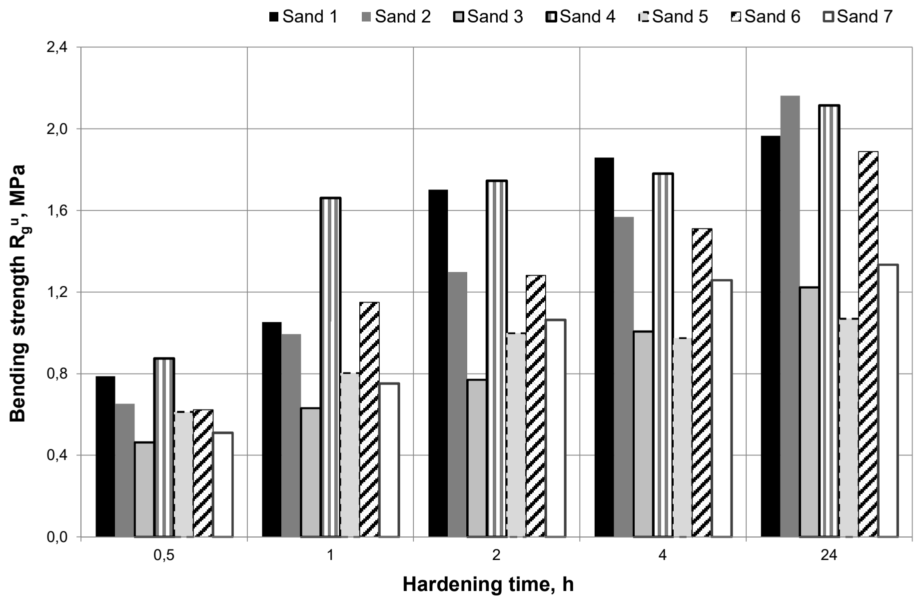

Fig. 4. Bending strength of moulding sands with furan resin

and its strength properties. The reclaim content exceeding 80% has reduced the sand bench life to values such that made the preparation of samples with appropriate technological parameters impossible. The strength of the sand mixtures containing 50% of the reclaim was comparable with the results obtained for the mixtures based entirely on the new silica sand. Increasing the reclaim content in the sand up to 80% made the sand strength drop nearly two times within the tested period of hardening.

3. Summary

The conducted research enables drawing the following conclusions:

- The mechanical reclamation process reduces the pH value and the content of S and N.
- The values of the loss on ignition of the reclaim decrease with subsequent reclamation cycles. Compared to the weight after initial reclamation, after proper mechanical reclamation at 900°C, the average weight loss of the samples of reclaim was 8% after the first cycle and 18% after the second cycle of reclamation.
- Within the tested time range of hardening, the moulding mixtures based on the new sand and reclaim in a ratio of 50/50 (sands nos. 2, 4 and 6) had the tensile strength R_m^u and the bending strength R_g^u comparable to the mixture based entirely on the new silica sand.
- The sand mixture containing the addition of the reclaimed material in an amount of 80% was characterized by low strength values, mainly due to the accumulation of active hardener drastically reducing the bench life.

The results of the research have indicated that the mechanical reclamation of sands based on furfuryl resin with hardeners of new generation improves the physicochemical properties of reclaimed materials to the degree that enables them to be returned to the production cycle and added in appropriate percent to the new sand mixture without any risk of deteriorating its properties.

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