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Conditions of Thermal Reclamation Process Realization on a Sample of Spent Moulding Sand from an Aluminum Alloy Foundry Plant

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Abstract

The results of investigations of thermal reclamation of spent moulding sands originating from an aluminum alloy foundry plant are presented in this paper. Spent sands were crushed by using two methods. Mechanical fragmentation of spent sand chunks was realized in the vibratory reclaimer REGMAS. The crushing process in the mechanical device was performed either with or without additional crushing-grinding elements. The reclaimed material obtained in this way was subjected to thermal reclamations at two different temperatures. It was found that a significant binder gathering on grain surfaces favors its spontaneous burning, even in the case when a temperature lower than required for the efficient thermal reclamation of furan binders is applied in the thermal reclaimer. The burning process, initiated by gas burners in the reclaimer chamber, generates favorable conditions for self-burning (at a determined amount of organic binders on grain surfaces). This process is spontaneously sustained and decreases the demand for gas. However, due to the significant amount of binder, this process is longer than in the case of reclaiming moulding sand prepared with fresh components.

Keywords: Spent moulding sands, Organic binders, Thermal destruction, Ignition losses, Mechanical and thermal reclamation

1. Introduction

The results of investigations of thermal reclamation of spent furan moulding sands applied in an aluminum alloy foundry plant are presented in this paper. During the production process, a grain matrix is subjected to mechanical reclamation. The mechanical grinding procedure in the case of an insignificant moulding sand burning causes only a negligible purification of matrix grains from the resin due to the relatively low pouring temperature. Under the given temperature conditions, Spent organic binders undergo degradation and thermal destruction only to a limited degree. Thus, the accumulation of significant amounts of bound binders occurs on grain matrix surfaces after each moulding sand circulation cycle. The too-high gathering of unburned binders on the grain surfaces can be a reason for casting defects related to an increased gas evolution rate of moulding sand [1]. The application of thermal reclamation constitutes a solution for such a situation. The performed investigations attempted to determine thermal reclamation conditions that would allow us to retain the applied grain matrix in the moulding sand circulation in a foundry plant.

2. Investigations methodology

2.1. Research stand and the realized investigations

Thermal reclamation tests were carried out in a laboratory thermal reclaimer whose principle of operation was presented in papers [2, 3]. The experimental device, together with the control and data recording systems, is shown in Figure 1.

Fig. 1. Thermal reclaimer

Spent moulding sands originating from an aluminum alloy foundry plant were first subjected to mechanical reclamation aimed at fragmenting and dedusting sand lumps. Two types of influences were applied in the vibratory reclaimer REGMAS [4, 5]: with additional crushing-grinding elements (RZ) and without (RB). The obtained reclaimed materials were then subjected to thermal reclamation at temperatures of 400° and 550°C. According to previous investigations by the author [3], the lower temperature is insufficient for the efficient purification of grain matrices from spent binders in the case of furan moulding sands of a determined burning degree. Meanwhile, the procedure performed the higher temperature warranted a total destruction of furan binders for the properly selected reclamation time. The charging of spent moulding sands was realized when the reclamation chamber was heated to the required temperature of the process and the air fluidization (bed mixing) temperature was app. 100°C. The spent moulding sand (a charge of 10 kg) was reclaimed by applying sequential bed mixing, supplying air in five-second impulses into individual zones of the chamber bottom (5s_5s_5s). During the reclamation process (after 60, 120, 240, 360, 420, 600, 900, and 1200 s), small portions of the reclaim were taken (through the outlet) to determine ignition losses.

Simultaneously, during the reclamation process, several parameters of the reclaimer were recorded: temperatures in various places of the device (chamber, heat exchanger, fluidizer, chimney) and gas consumption.

2.2. Mass decrements in dependence of temperature – ignition losses

Ignition losses are the most important criteria of assessing the quality of spent molding sand with organic binders or of the reclaim [6-9]. The taken materials were subjected to tests of temperature influence on the degradation and destruction of the binder applied in the molding sand (furan resin). Materials in loose form were roasted in a silite furnace. The temperature influence on the degradation and destruction was tested on two 30 g samples weighted into small quartz crucibles. The presented results are the average values of those obtained. Tests of ignition losses were carried out at a temperature of 950°C, which is considered adequate for burning all organic products. The roasting time of the samples was two hours.

3. Analysis of the results

Before starting our thermal reclamation investigations, the ignition losses of the initial moulding sand (made of fresh components), spent moulding sand, and the reclaimed materials obtained as the result of various influences in the REGMAS reclaimer were tested. As a result of multicyclic usage, by the Company, of the same sand matrix subjected only to mechanical reclamation, which was reduced to crushing of the knocked-out moulding sand, the successive accumulation of spent binders on these reclaim surfaces occurred ince the temperature of the alloys poured into the mould made of circulating sand was not higher than 780°C, its burning degree was small. Multicyclic using of the same grain matrix subjected only to mechanical reclamation did not cause the efficient removal of spent resin from the grain surface. This is confirmed by the results presented in Figure 2. Ignition losses of the knocked-out moulding sands are high (approximately 7%). Application of the mechanical reclamation procedure of various intensities (without RB or with crushing-grinding elements RZ) removes bound binders to a small degree only (at a level of app. 0.3%).

The initial moulding sand (which, after binding, was crushed and sieved through the sieve mesh of 0.8 mm) was subjected to thermal reclamation as with the first one. The process was realized at the required temperature of 550°C. The results of the recorded parameters are presented in Figure 3.

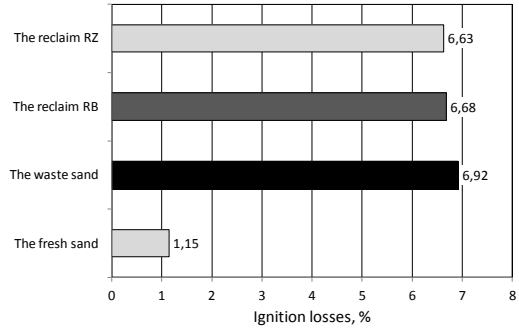

Fig. 2. Ignition losses of the spent molding sand and of reclaims subjected to thermal reclamation

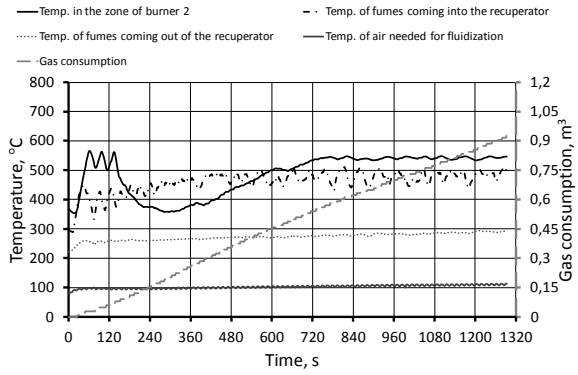

Fig. 3. Recorded work parameters of the device when spent molding sand (prepared of fresh components) was subjected to thermal reclamation (realized at a temperature of 550°C)

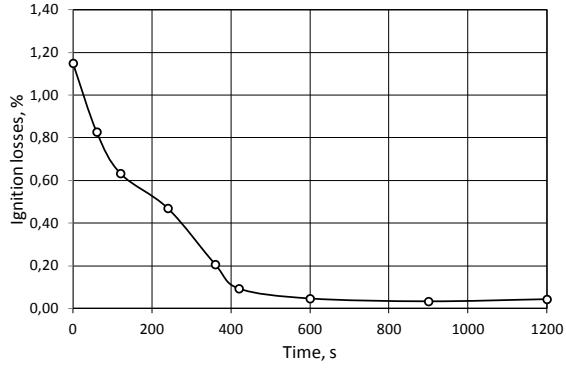

Fig. 4. Ignition losses of the reclaim obtained after thermal reclamation of the initial molding sand

Since the spent moulding sand supplied to the thermal reclaimer is at an ambient temperature, a temperature decrease in the reclaimer chamber (the highest in the charge zone) can be noticed in Figure 3. During thermal reclamation of the initial moulding sand containing 1.15% of bound binder, the time of the tested material heated to the reclamation temperature was app. 720 s (Fig. 3). Portions of the material taken during the thermal reclamation procedure and subjected to roasting indicate that 600 seconds is a sufficient amount of time for the efficient burning of the binder (ignition losses: app. 0.04%).

Temperature and time are the basic parameters of the efficient realization of the thermal reclamation process. However, it occurs that the realized process is also influenced by the bound binder amount in the spent moulding sand. The parameters recorded during thermal reclamation of the grain matrix obtained after mechanical reclamation performed without additional crushing-grinding elements are presented in Figure 5. The procedure was realized at a temperature of 400°C (lower than required). Gas burners influencing by flames significant amounts of spent moulding sands on the grain matrix, at a continuously supplied air via the fluidal bottom, started a spontaneous burning process of the binding material. This caused a temperature increase above the set one; as a consequence, the burners switched off. It can be seen in Figure 5 that the gas demand significantly decreased (there is a change of the gas consumption inclination curve), since the process was spontaneous. The temperature in the bed of the reclaimed moulding sand - within one of the phases - increased by 140°C as related to the set one.

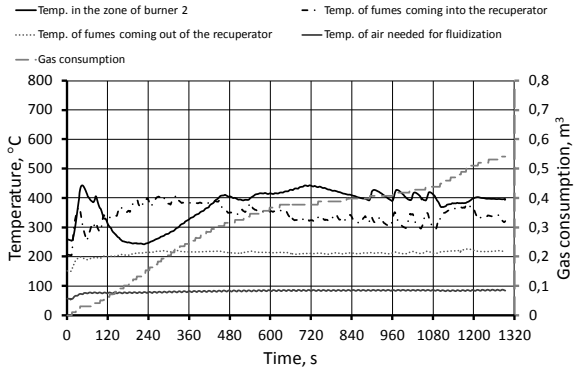

Fig. 5. Recorded work parameters of the device when the spent molding sand after mechanical reclamation without crushing-grinding elements (RB) was subjected to thermal reclamation (realized at a temperature of 400°C)

In the case of thermal reclamation at a temperature of 550°C, the spontaneous burning effect was even more intensive. The application of the required reclamation temperature in the reclaimer caused very intensive burning of the spent binder, and the temperature in the whole volume of the thermally reclaimed bed increased to 700°C. It can be observed in Figure 6 that, for a certain time, this process was realized without supply, and gas consumption was of a constant value. This situation had an influence on the total demand for the medium realizing this process.

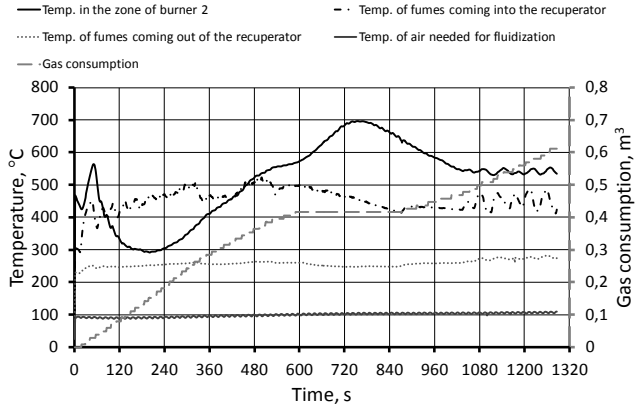

Fig. 6. Recorded work parameters of the device when the spent molding sand after mechanical reclamation without crushing-grinding elements (RB) was subjected to thermal reclamation (realized at a temperature of 550°C)

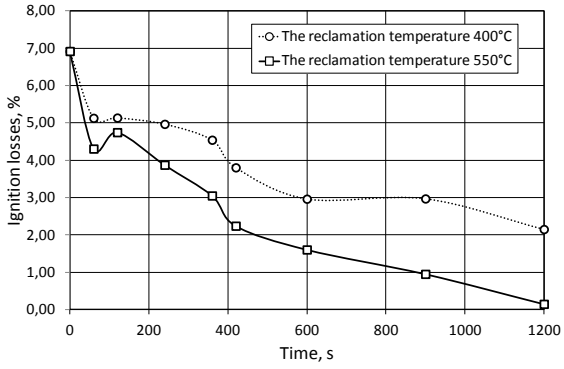

Fig. 7. Ignition losses of the reclaim obtained after thermal reclamation of the spent molding sand after mechanical reclamation without crushing-grinding elements (RB)

Ignition losses of the material samples taken during the thermal reclamation process realized at temperatures of 400° and 550°C are presented in Figure 7. The previous statements are confirmed that a reclamation temperature of 400°C is too low to efficiently remove spent binders from the grain surfaces. This happens regardless of the fact that, for a certain time, the process proceeded spontaneously at a higher temperature than the set one. The second applied temperature was sufficient for the efficient realization of the process; however, realization time was longer than in the case of the initial moulding sand due to the larger amount of a binding material for burning.

Changes in the parameters of thermal reclamation of the reclaimed material obtained by mechanical reclamation performed with the application of additional crushing-grinding elements (RZ) are shown in Figures 8 and 9. In the case of this reclaim, the procedure realized at the given temperature (400°C) was more intensive. The more-favorable conditions of thermal reclamation formed within the reclaimed bed were the reason that the process was spontaneously realized over a longer time and at a higher temperature. To that effect, it caused a lower consumption of gas, since the temperature in the chamber was higher than the one set on the controller while the burners were switched off.

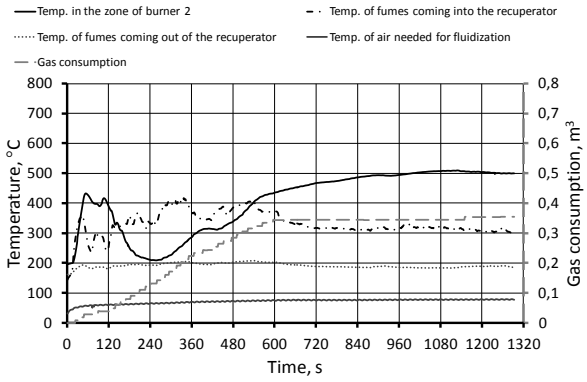

Fig. 8. Recorded work parameters of the device when spent molding sand after mechanical reclamation with crushing-grinding elements (RZ) was subjected to thermal reclamation (realized at a temperature of 400°C)

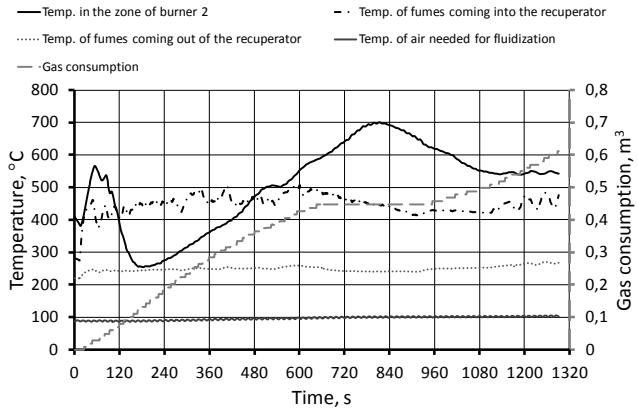

Fig. 9. Recorded work parameters of the device when spent molding sand after mechanical reclamation with crushing-grinding elements (RZ) was subjected to thermal reclamation (realized at a temperature of 550°C)

The parameters recorded during thermal reclamation (realized at a temperature of 550°C) of the reclaimed material obtained by mechanical reclamation performed with the application of additional crushing-grinding elements (RZ) are shown in Figure 9. In the case of this process, the procedure was very similar to the one of the reclaim that was not subjected to the influences of additional crushing-grinding (RB) elements (compare Figs. 6 and 9). The more-intensive running process of the reclaim (RZ) at a temperature of 400°C caused the burning of a larger amount of the binder found on the matrix grain surfaces. After 1200 seconds, the ignition loss values equalized for both applied temperatures of thermal reclamation. This is illustrated in Figure 10.

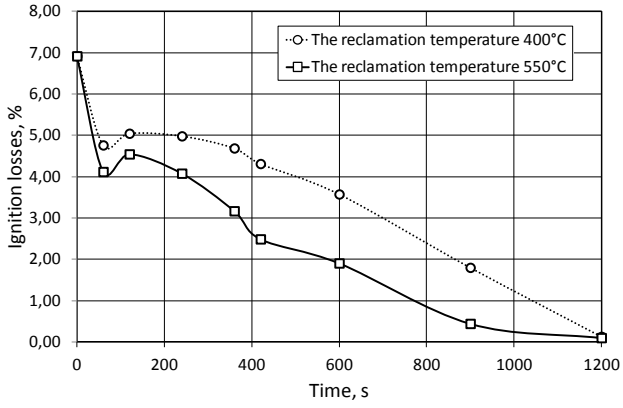

Fig. 10. Ignition losses of the reclaim obtained after thermal reclamation of spent molding sand after mechanical reclamation with crushing-grinding elements (RZ)

4. Conclusions

The investigations presented in this paper indicate that many factors influence the thermal reclamation process. Apart from the reclamation temperature (which can be selected for a given binder

by its thermal analysis, for example), the essential parameter is reclamation time.

It is shown that reclamation time depends not only on the burning rate of a given resin (resulting from its chemical composition) but also on the amount of organic binders gathered within the spent moulding sand subjected to thermal reclamation.

The determined binder content in spent moulding sands (after starting the burning by means of gas burners) can initiate spontaneous realization of the process (at favourable conditions and at sufficient air amounts) without any external energy source (gas burning) sustaining the process. Due to this effect, gas demand decreases.

Investigations of thermal reclamation at a temperature lower than the required one indicated the influence of the preliminary preparation of the spent sand. A more-intensive moulding sand refining favors thermal reclamation realization.

Mechanical reclamation applied to spent moulding sands in which binder accumulation occurred (due to multicyclic circulations) does not provide satisfactory purification. Its activity is reduced to crushing spent sands and their dedusting from eventual dusts formed during crushing. This confirms the thesis that thermal methods are the best for removing organic binders from matrix grain surfaces.

A high content of binding material in moulding sand generates problems with the gassing of casting surface layers, even with aluminum alloy casting (metal temperature: app. 780°C). Therefore, to avoid eventual casting defects and to retain the grain matrix in the production cycle as long as possible, applying the thermal reclamation is recommended.

Acknowledgements

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