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# Analysis of the Selected Parameters of the Thermal Reclaimer

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## Abstract

The investigation results of the influence of the selected parameters of the thermal reclaimer operations on the temperature changes in the combustion chamber and the process energy consumption, are presented in the hereby paper. The analysis of the heat treatment was performed with the application of a fresh foundry sand, since it was assumed that the dominating energy part was used for the grain matrix heating and due to that, the energy used for burning small amounts of organic binder remained on sand grains could be omitted. Thermal treatment processes performed under various conditions were analysed from the point of view of a gas consumption and temperatures obtained in the experimental reclaimer. The recorded data allowed to point out the parameters having essential influence on the process of the quartz matrix heating in the combustion chamber as a gas consumption function.

**Keywords:** Thermal reclamation, Spent sands, Thermal reclaimer, Test equipment

## 1. Introduction

An important problem of the thermal reclamation of spent moulding and core sands is the proper, rational selection of its realisation method which would allow to achieve the aim with the satisfactory economical efficiency. Thus, modern constructional solutions, which could meet the challenges mentioned above, are looked for [1 – 7]. Work parameters of devices are selected in such a way as to make the process more efficient and the energy demands as low as possible. The thermal reclamation process is the most often realised in devices in which the energy, needed for the matrix grains purification from spent binder coatings, is obtained from burning of natural gas. The successive stage of the technological cycle - after burning out of an organic binder - is cooling of the obtained reclaimed material to an ambient temperature. An application of unjustified, high reclamation temperature range or long time of this operation increases process costs, making the purification of matrix grains uneconomic.

The determination of the influence of individual work parameters of the given structural solution of the thermal reclaimer is of a crucial importance leading to limiting the process energy consumption at simultaneous providing the efficient purification of matrix grains from the spent organic binder.

## 2. Experimental stand

The analysis of the influence of the thermal reclaimer selected work parameters on the realisation conditions of the thermal reclamation was performed in the developed and built by the author the experimental thermal reclaimer presented in Figure 1. The thermal reclaimer is of a rectangular prism built. In order to warrant an efficient treatment within the whole device chamber three burners - equally distributed along the reclaimer length - were installed. Investigations were performed for various variants of burners operations (all three burning, two active at the ends of the reclaimer chamber and one heating the bed of the treated material in the middle part of the device). The basic element of the experimental stand constitutes the combustion chamber made of the steel body, thermal insulation and lining of creep-resisting concrete. The heat source constitute the mentioned three burners introduced into the chamber via articulated seats. Such structural solution allows controlling their operation zones and placements at the determined distance above the bed of the treated moulding sand matrix. The application of three independent burners allows also variability of places supplying heat into materials inside the reclaim chamber.

Fig. 1. View of the experimental stand for the thermal reclamation – control panel

The fluidised bed applied in the reclaim chamber was divided into three sectors, which enabled a different fluidisation e.g.: the whole bed is supplied with air, or individual sectors are supplied sequentially (Fig. 2). The application of such fluidisation mode is aimed at decreasing an excessive cooling of the whole bed, which can prolong the thermal reclamation time. At the chamber outlet the heat exchanger is installed (Fig. 1) to recover the heat used for heating the air for the fluidisation. As it was already mentioned, the fluidisation of the reclaimed moulding sand bed by the cold air decreases the temperature in the chamber and prolongs the reclamation time [8].

The developed experimental thermal reclaimer is equipped with the automatic system of measuring and controlling of parameters. Thermocouples are placed in the bed of the reclaimed moulding sand in the device body within the burners operation zone. These thermocouples are connected to the temperature controllers, due to which it is possible to perform the reclamation process at the determined, required temperature. Signals from the controllers are sent to the ignition automatic machines of burners (Fig. 3a). In dependence on the set temperature the control system - for each burner - actuates the ignition system and controls the flame formation, which is very important from the point of view of safe operations of the device supplied by natural gas. As the process progresses, the ignition automatic machine controls operations of electro-valves in installations supplying the air and gas for burners. The device is also equipped with the independent module allowing various ways of the bed fluidisation (Fig. 3b).

Fig. 2. The way of the air supplying into three independent sectors of the fluidised bed

a) 

b)

Fig. 3. System of controlling and recording operations of the thermal reclaimer a) General view, b) Control module of the fluidisation (bed mixing)

The thermal reclaimer is also equipped with recorders in which the main operation parameters are saved: temperature in the chamber, fluidising air temperature, pressure, energy and natural gas consumption. Due to the automatic data collection it is possible to verify, which variant of the reclaimer operation - when taking into account the quality assessment of the obtained reclaim - is the most efficient.

# 3. Purpose of investigations

The thermal reclamation process can be performed in various ways depending on the setting of the operational parameters of the reclaimer. It was assumed in these investigations that the dominating energy part - supplied during the thermal reclamation - is used for heating the grain matrix, which fraction in the spent moulding sand equals approximately 98%. Therefore investigations of the thermal treatment of pure sands were performed, omitting not essential influence related to burning out of small amounts of organic binder, and having simultaneously in mind the creation of the determined conditions necessary for performing the efficient thermal reclamation. The realisation of the thermal treatment process, with using the fresh high-silica sand as the matrix, widens the process analysis by imparting to it a more universal character, valid for the whole group of spent moulding sands prepared with using the determined grain matrix.

The investigations of the selected operational parameters of the thermal reclaimer, in order to indicate essential factors having influence on the efficient realisation and energy consumption of the process, are presented in the hereby paper.

# 4. Analysis of the obtained results

The thermal reclaimer is equipped with several sensors connected with recorders, which allow to trace the basic operational parameters. The investigations were focused on the course of the recorded temperatures and gas consumptions in dependence on the conditions of the process realisation. Examples of temperature values in the selected points of the thermal reclaimer as well as the gas consumption are presented in Figure 4.

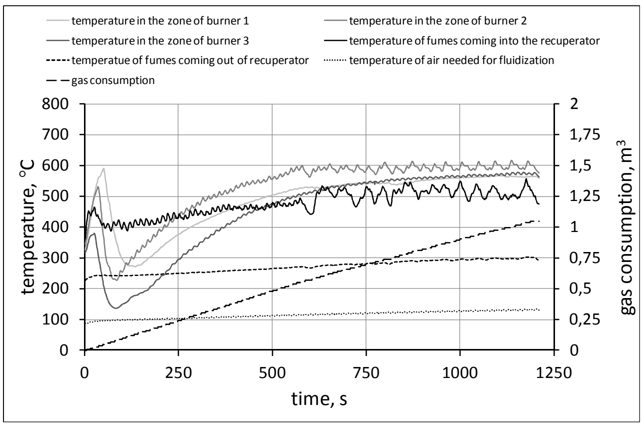


Fig. 4. Temperature values in the selected structural points of the thermal reclaimer

The temperature notation presented in Figure 4 allows to notice the characteristic feature of the device resulting from its structure. That is to say that the highest temperature values are obtained in the middle part of the bed. Lower temperatures observed in outermost zones of the reclaimer chamber are the result of a larger heat loss related to its easier flow to surroundings via mobile structural elements of the reclaimer realising functions of loading (charge) and unloading (dumping). Thus, in order to have more readable description of the obtained conditions of the process the temperature analysis is related to the middle part of the thermal reclaimer chamber.

The first parameter, essential from the point of view of the device operation, is the temperature range at which the thermal reclamation process is realised. The temperatures recorded in dependence on the temperature controller settings are presented in Figure 5.

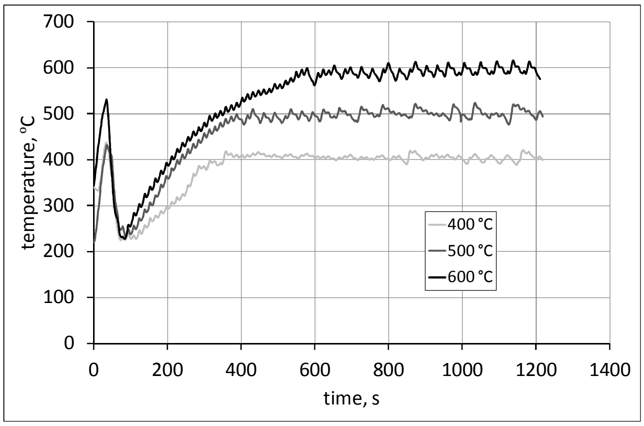


Fig. 5. Temperature of the bed in the middle part of the chamber of the experimental thermal reclaimer in dependence on the set operational temperature

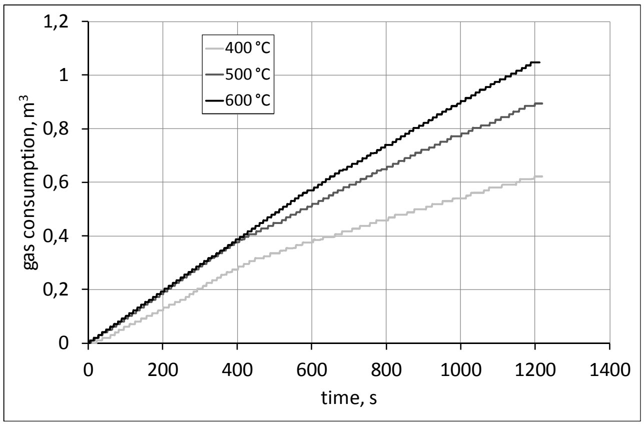


Fig. 6. Gas consumption in the thermal reclaimer in dependence on the set operational temperature

The presented results were obtained at retaining constant values of other parameters, which could eventually influence the recorded temperature. It means that, the same amount of the fresh sand was in the chamber, the reclaimer chamber was heated to the same level of the heat accumulation, the bed was mixed in the same way, etc. It was noticed, that the higher the set temperature the longer time was required to obtain the given temperature ceiling, but simultaneously the sand bed in the chamber was heated faster. A higher intensity of the process requires increased gas amounts, which is illustrated in Figure 6. Tests were performed for 10 kg of the thermally treated material portion. For such small sand amount the essential differences in gas consumptions of the device - to achieve the determined operational conditions - were noticed.

The next analysed parameter was the air pressure applied for mixing of the thermally treated material. The thermal reclamation realised in the fluidised bed is justified from several reasons: bed mixing by its liquefying causes the uniform burning out of a binder in the whole layer and the air needed for this process is supplied. The influence of the pressure of the air applied for the fluidising the thermally treated material bed is shown in Figure 7.

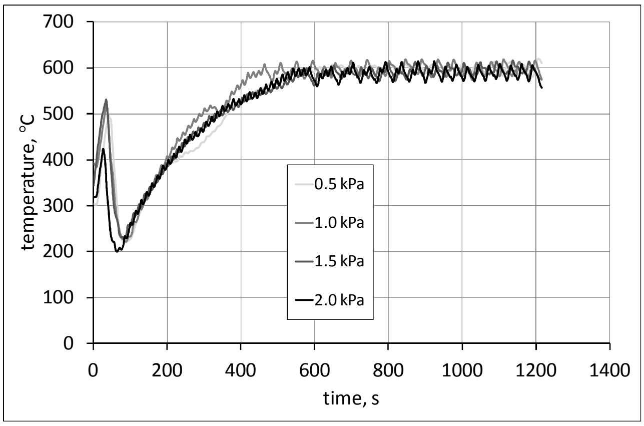


Fig. 7. Temperature in the middle part of the thermal reclaimer chamber in dependence on the set temperature and the air pressure applied for mixing

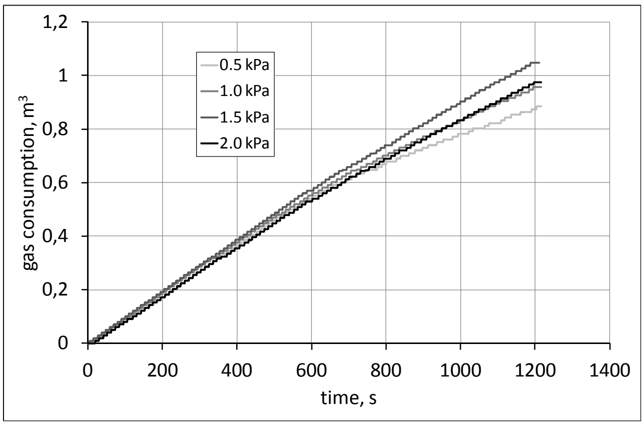


Fig. 8. Influence of the temperature and air pressure applied for bed mixing on the gas consumption in the experimental thermal reclaimer

A higher pressure is related to a larger air flow - through the fluidised bed - to the device. Since the air supplied to the fluidising chamber is of a lower temperature than the heated material bed, it can cause the chamber cooling. An insignificant pressure influence on the bed heating rate was noticed within the applied pressure range, especially for the lowest values of the analysed parameter. The air pressure applied for mixing of the bed (within the tested range) does not essentially influence the gas consumption, which is illustrated in Figure 8.

In general, it can be stated that the yield of devices for the thermal reclamation of spent moulding sands is related to the energy demand. The experimental reclaimer was designed for the material charge being 10 kg.

The fresh sand treatment at a temperature of 600 ºC was performed for the portion of 5 kg – smaller than the nominal, for the nominal portion of 10 kg and for the portion of 15 kg - larger than the nominal one. The temperature pathways in the middle part of the reclaimer in dependence on the charge mass, are presented in Figure 9. It can be noticed, that increasing the material charge for the thermal reclamation causes more intensive cooling of the reclaimer chamber and - in consequence - prolongs the process of the bed heating to the required temperature. From the point of view of the process time rationalisation it is an essential factor of a reference to the process efficiency as well as to its yield.

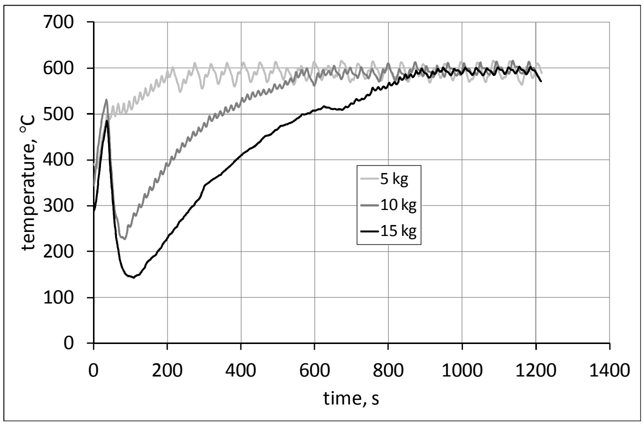


Fig. 9. Temperature pathways in the middle part of the reclaimer chamber in dependence on the mass of the treated material portion

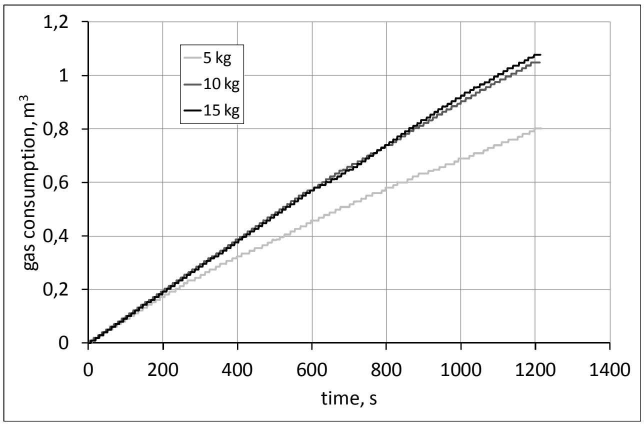


Fig. 10. Gas consumption in the thermal reclaimer in dependence on the mass of the treated material portion

The gas consumption in dependence on the material portion - subjected to the thermal treatment - is shown in Figure 10. The small portion is heated fast at a small gas demand. For larger portions, of 10 and 15 kg, the gas consumptions are quantitatively comparable, however the process was realised with a different intensity. Thus, various reclamation effects can be expected for a shorter thermal purification of the matrix from the spent organic binder.

The rectangular shape of the combustion chamber causes temperature differences in the central part and in part adjusting to it. Temperatures recorded in the middle part of the reclaimer in dependence on the number of operating burners are presented in Figure 11.

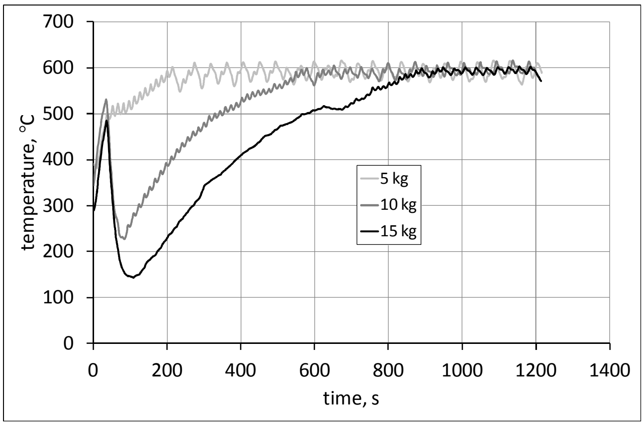


Fig. 11. Temperature pathways in the middle part of the thermal reclaimer chamber in dependence on the number of operating burners

The uniform distribution of heat sources inside the reclaimer chamber causes efficient heating of the bed to the set temperature. In the situation when burners were heating the bed only in outermost zones of the combustion chamber the temperature resulting from the control setting was not obtained in the middle zone of the device (in the tested time range). The single burner situated in the central part of the device was also unable to heat the bed to the set temperature.

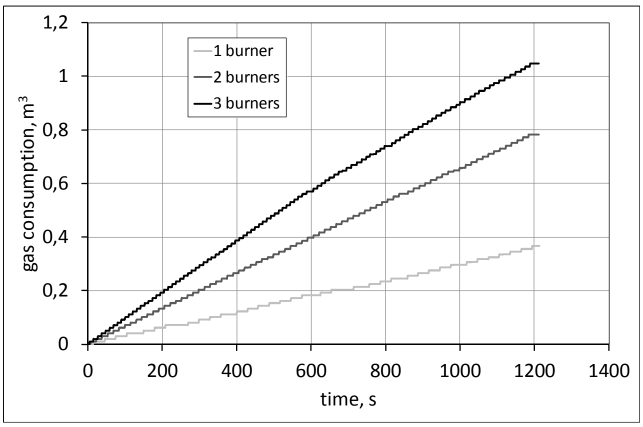


Fig. 12. Gas consumption in the thermal reclaimer in dependence on the operating burners

The number of the installed heat distribution sources in the thermal reclaimer decides on the gas consumed for heating the treated material (Fig. 12). It was found that the gas consumption during the process was not proportional to the number of operating burners.

Temperature pathways in the thermal reclaimer in dependence on the bed mixing method are shown in Figure 13. Two ways of the air distribution in the reclaim chamber were applied in tests. The first one was based on the air supply for 5 seconds into three zones of the reclaimer bottom. It was done in the sequence: at first the first zone, then the middle part and at the end the third zone. It is illustrated in Figure 13 by marking: 5_5_5. This cycle was repeated in the loop for the whole time of the reclaim operations. The second method was based on a simultaneous mixing of the treated material bed by the air distribution through the whole bottom surface for 5 seconds, followed by 5 seconds without mixing. That is why the process is marked: 5_5.

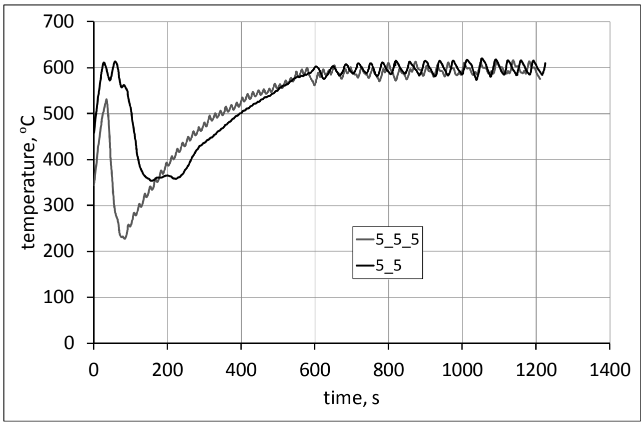


Fig. 13. Temperature in the middle part of the thermal reclaimer chamber in dependence on the way of the bed mixing

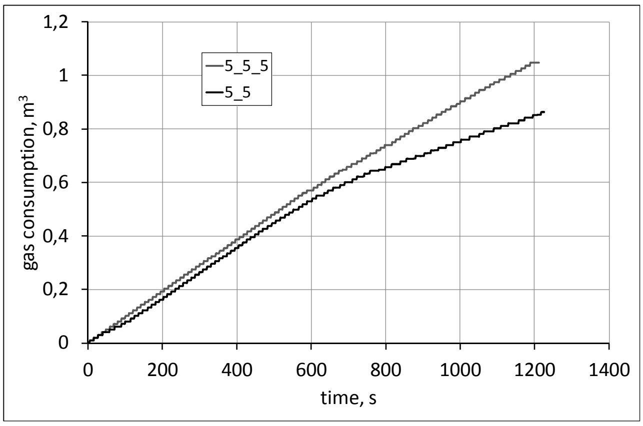


Fig. 14. Gas consumption in the thermal reclaimer in dependence on the set sequence of the bed mixing

The first way of the air distribution, 5_5_5 was more intensive, supplying within the tested time interval, significantly larger air amounts into the reclaimer chamber. It corresponds with, visible in Figure 13, the temperature decrease of the material bed in the first stage of investigations. After the heating time being approximately 10 minutes, the temperature values are equalising. Sequential air supplying into individual zones influences fluctuations of the bed temperature (charge), which results from the data analysis in Figure 13.

The mixing intensity of the bed influences equalising its temperature field, which is diversified in the middle and side zones. This, in turn, at a higher intensity leads to a higher frequency of burners switching on, since they are controlled by the bed temperature. The system of the total mixing sequence, in all reclaimer zones, influences an increased gas demand, which is presented in Figure 14.

## 5. Conclusions

The analysis of the selected options of operations of the experimental thermal reclaimer presented in the paper, allows to indicate which parameters (out of the tested ones) have an essential influence to create favourable, efficient conditions for the planned reclamation of spent moulding or core sands. The basic criterion of the efficient thermal reclamation constitutes the determined temperature of the process. This implies the statement that the operational parameters, which warrant to achieve the required temperature in a shorter time should be considered as more favourable for the reclamation. Taking into account the economic aspect requires finding the equilibrium between the requirements concerning the reclamation treatment temperature, the quality of the obtained reclaim and process costs directly related to the energy consumption. The analyses presented in this paper constitute the domain for looking for the optimal version of the device operations, within which the economical conditions of the grain matrix regeneration from spent moulding sands will be created and which simultaneously could be the solution suitable for the implementation by the foundry industry.

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