A R C H I V E S O F M E T A L L U R G Y A N D M A T E R I A L S
Volume 58 2013 Issue 3
DOI: 10.2478/amm-2013-0102

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THE INFLUENCE OF THE CONFIGURATION OF OPERATING PARAMETERS OF A MACHINE FOR THERMAL RECLAMATION ON THE EFFICIENCY OF RECLAMATION PROCESS

WPŁYW KONFIGURACJI WYBRANYCH PARAMETRÓW PRACY REGENERATORA TERMICZNEGO NA EFEKTY REGENERACJI

An experimental machine for thermal reclamation, constructed specifically for the research purposes, enables various ways of regaining sand grains from the used moulding and core sands bound by synthetic resins. The source of heat for the process of burning the used moulding and core sands is provided by three gas burners equipped with automatic ignition devices which control the flame and whose work is individually steered by temperature adjusters. It is extremely important to find an appropriate system of stirring the reclaimed sand in order to create the conditions for fast and even burning of the border of the used synthetic binder. The fluidized floor in the machine for thermal reclamation presented in the paper is divided into three independent sections. Air provided to each section by a blower gets through an electrovalve, whose work is steered by an electronic system which was designed and constructed specifically for the use in machine. The adequately set time adjusters in the controller make the electrovalve open and enable the air to flow to particular sections of the fluidized floor of the reclamation chamber. The process is monitored and the working parameters are recorded electronically. The diverse methods of stirring the reclaimed sand used in the process were analyzed in relation to their influence on temperature fluctuation in the reclamation chamber, the length of reclamation process, the amount of the media needed to obtain the purity of the reclaimed (gas, energy), in order to obtain the reclaimed sand of purity defined in terms of ignition losses.

Keywords: reclamation, moulding sand, thermal reclamations, spent sand

Doświadczalny regenerator termiczny o specjalnie stworzonej konstrukcji umożliwia realizację odzysku osnowy kwarcowej z zużytych mas formierskich wiązanych żywicami syntetycznymi w różny sposób. Źródłem ciepła wypalania zużytej masy w urządzeniu są trzy palniki gazowe wyposażone w automaty zapłonowe z kontrolą powstania płomienia, których praca sterowana jest indywidualnie przez regulatory temperatury. Ważną kwestią pracy regeneratora termicznego jest stworzenie odpowiedniego systemu mieszania złoża regenerowanej masy, w celu szybkiego i równomiernego spalania otoczki zużytego spoiwa syntetycznego. Dno fluidalne w prezentowanym doświadczalnym regeneratorze termicznym podzielone jest na trzy niezależne sekcje. Do każdej strefy doprowadzone jest powietrze z dmuchawy przez elektrozawór, którego pracą steruje specjalnie zaprojektowany i wykonany układ elektroniczny. Odpowiednio zadeklarowane nastawy czasowe w sterowniku decydują o otwarciu elektrozaworu i przepływie powietrza do określonej strefy dna fluidalnego komory regeneracyjnej. Proces jest w pełni monitorowany, a parametry pracy są zapisywane w pamięci rejestratorów. Zastosowane zróżnicowane sposoby mieszania złoża regenerowanej masy analizowano pod względem wpływu: na wahania temperatury w komorze regeneracyjnej, czasu regeneracji, ilości zużytych mediów (gazu, energii) dla uzyskania regeneratu o określonej czystości określonej stratami prażenia.

1. Introduction

The temperature of reclamation is a decisive factor in efficient removing a binder by applying thermal reclamation of the used moulding sands. The process of burning can be performed at three temperature ranges, depending on the kind of resin: low temperature – 350°C, medium temperature – 550°C and high temperature – 850°C. Reaching a particular temperature value involves adequate energy supplies. Thus, the search for optimal conditions of thermal reclamation with the use of different groups of synthetic resins seems to be justifiable. The process of thermal reclamation is extremely expensive because of the investment and exploitation costs [1, 2, 3, 4, 5, 6]. However, it seems to be most effective for a limited group of binders [7]. The method of the distribution of heat inside the chamber, the way the reclaimed sand is stirred, resulting in even burnout, are the subject of research carried out in order to find the most energy – efficient way of performing thermal reclamation process. Because of that the machine presented in the paper, enables different ways of conducting the process of thermal reclamation. The chamber can be equipped with a few sources of heat, located in different places. It is possible to use air of ambient temperature as well as air heated with the heat of the fumes obtained from

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the recuperator. The machine was constructed in such a way that it is possible to stir the reclaimed sand in various ways. The process is monitored, the temperature is controlled and performance parameters are registered, creating the database which is crucial for the comparison of the construction solutions discussed above [8, 9]. The data, being useful source of information, is a guideline which can help find the optimal method of applying thermal reclamation. Most important issues concerning thermal reclamation are the subject of the present paper.

2. Research station and the way of conducting the experiments

Figure 1a shows the outline of the research station and Figure 1b presents the research station with the control system seen from two different perspectives.

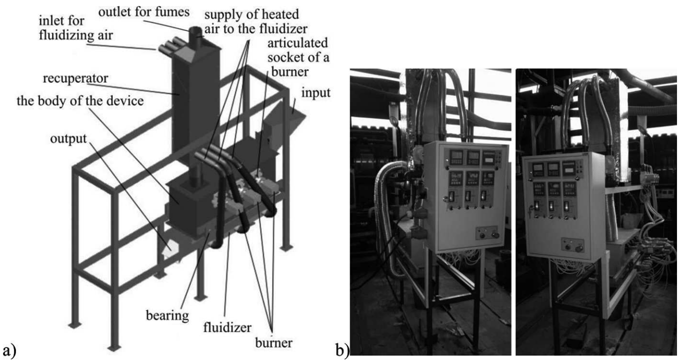

Fig. 1. Research station a) schematic diagram b) station used in the research

Some used furan sand from a foundry in Cracow was applied for initial research. The process was fully monitored. The following data was registered: the changes in temperature inside the machine and at the inlet and outlet of the recuperator, the temperature of air coming into the fluidization chamber and the length of the air blow. When the desired temperature of 650°C was reacheded, the loading process started. After the temperature in the middle section no 2 reached 500°C, samples of the reclaimed sand were taken every 5 minutes in order to determine ignition losses.

3. The monitoring of the examined parameters and the analysis of the registered data

Air temperature is an important factor in the application of the machine for fluidized stirring of the reclaimed used sand. Every blow of cold air lowers the temperature in the chamber, so some part of energy needed for burning must be used to compensate for temperature drops. As a result the process takes long, is less effective and requires higher costs. The research carried out earlier [10] in another machine for thermal reclamation showed a considerable temperature drop in the chamber when the fluidized bed was stirred with cold air. In the case of the machine mentioned in the paper [10], it was found that the heating condition of the device impacted on the effectiveness of thermal reclamation. The process of thermal reclamation conducted in the machine with heat accumulated inside it was much faster in comparison to the one which started in a cold chamber. That is why, at first stage of the research, attempts to determine the exploitation parameters of the machine by heating it with the blow of hot and cold air were made. The results are shown in Figure 2.

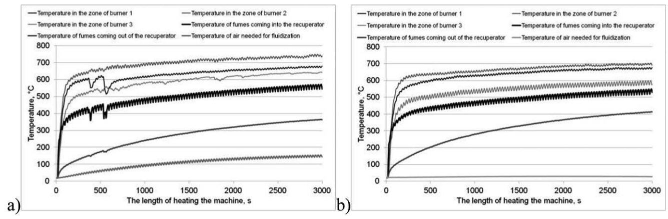

Fig. 2. The influence of the temperature of air used for fluidized stirring on the range of temperatures achieved in a thermal reclamation machine: a) air heated in the recuperator b) air in the surrounding area

The temperature was taken in the surrounding of each burner, at the inlet and outlet of the recuperator, as well as at the air inlet to the chamber under the fluidized floor. The temperature at the adjuster was set at 850°C. The attempt to achieve the temperature in the time period of 50 minutes finished in failure but it was possible to achieve the required higher temperature by recapturing the heat from the fumes. It can be assumed that accelerating the heating process results in reducing performance time and, in consequence, gas consumption, and finally in reducing the total costs of thermal reclamation.

Another important factor which requires configuration in order to choose optimal performance conditions is the method applied to stirring the fluidized bed. In the machine presented in the paper its bottom part is divided into three sections provided with slots through which air can be blown into each zone. A controller, designed for the research purposes, which controls the performance of electrovalves, enables two methods of fluidization. In the first one, a sequential way, the operation is performed in particular zones of the fluidized floor in sequence, whereas in the second one, a simultaneous method, the process of stirring the fluidized bed is performed simultaneously in all zones of the chamber. Both, the length of the cycle and the impulse of air blow can be set in the controller for particular zones. An example of sequential fluidization, in which the length of the cycle and that of the impulse of air blow was 10 seconds, is shown in Figure 3a. Figure 3b, on the other hand, presents an example of simultaneous fluidization, in which the length of the cycle was 30 seconds and the length of the impulse of air blow was 10 seconds. In both methods it is possible to apply either hot air from the recuperator or cold air of low ambient temperature.

The diversity of methods of fluidization provided by the machine enables the search for optimal conditions of reclamation process. The application of the blow of air in machines for thermal reclamation with a fluidized bed is necessary for two reasons. On the one hand it makes the process of stirring and burning the reclaimed sand even and ,on the other hand, it enables efficient burning of the used binder which covers matrix grains. Every single application of the blow of either cold or hot air results in the fall of temperature in the machine and, in consequence, in cooling the fluidized bed. The use of diverse fluidization methods aims at determining optimal conditions of the process and, in consequence, at finding a compromise between the necessity of stirring the fluidized bed with air provided for the process of burning and reducing the temperature.

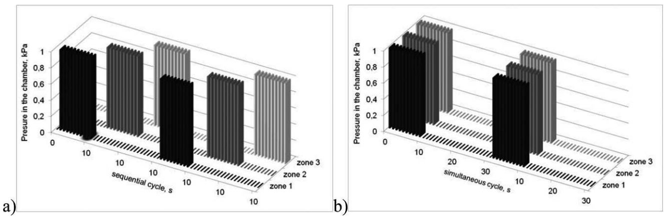

Fig. 3. The controller of fluidization of the reclaimed sand and suggested ways of setting the controller: a) sequential method of fluidized stirring (length of a cycle:10 seconds, length of an air blow impulse: 10 seconds) b) simultaneous method of fluidized stirring (length of a cycle: 30 seconds, length of an air blow impulse: 10 seconds)

In view of the considerations discussed above initial attempts to perform thermal reclamation with the use of diverse settings for fluidization of the reclaimed moulding sand were made. Figure 4 shows temperatures registered for the time function for simultaneous fluidization of the whole fluidized bed, with equal time settings and with application of either hot or cold air. As a result of monitoring it was found that the drops in temperature in the chamber were bigger and of a more equal character in the case of fluidization with cold air (Figure 4a) than the ones observed at fluidization with hot air (Figure 4b.) At the same time it is important to notice that the application of hot air for fluidization causes smaller rise in temperature of the fluidized bed in particular zones as compared to the temperature initially set. However, it was also observed that once the required temperature was reached, the performance was regular and in accordance with adjuster settings. An attempt to perform the process at other time settings for the air blow was also made. Figure 5 presents temperature results of fluidization with the use of hot and cold air, for a cycle lasting 20 seconds and the air blow lasting 10 seconds. Such settings make the temperature in the chamber even and, in consequence, make the burning of the reclaimed sand even.

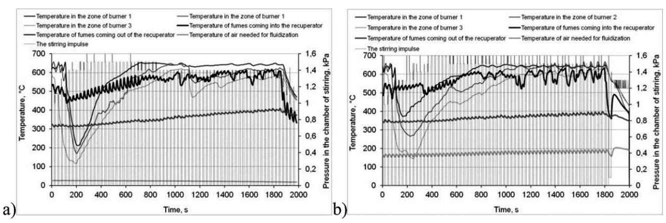

Fig. 4. Temperatures registered in the machine for thermal reclamation with the application of simultaneous fluidization of the whole reclaimed sand, the length of the cycle: 30 seconds, the length of the impulse of air blow: 10 seconds: a) with air from the surrounding environment, b) with air heated in the recuperator

On the basis of comparison of Figure 4 and Figure 5, which show different time periods of fluidization, only a slight fluctuation of temperature in a shorter cycle of reclamation can be observed. Furthermore, the temperature is more or less equal in the whole space of the machine and creates perfect conditions for effective operation.

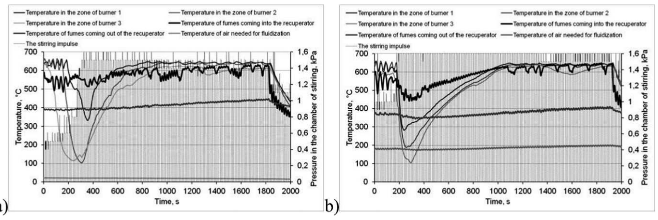

Fig. 5. Temperatures registered in the machine for thermal reclamation with the application of simultaneous fluidization of the whole reclaimed sand, the length of the cycle: 20 seconds, the length of the impulse of air blow: 10 seconds: a) with air from the surrounding environment, b) with air heated in the recuperator

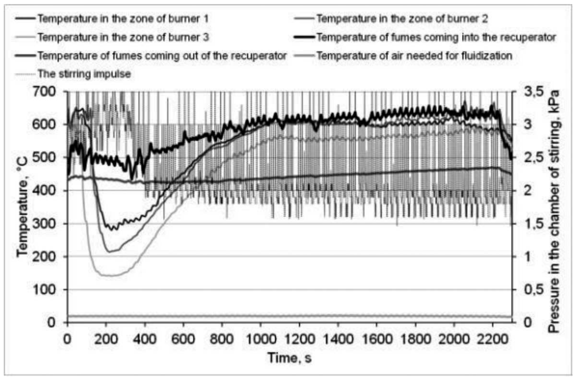

Fig. 6. Temperatures registered in the machine for thermal reclamation with the application of sequential fluidization of the whole reclaimed sand, the length of the cycle: 10 seconds, the length of the impulse of air blow: 10 seconds

Figure 6 presents temperature values registered for sequential fluidization performed according to the diagram shown in Figure 3c. No considerable fluctuation of temperature can be observed in the chamber since in the case of sequential fluidization

Temperature increases at the inlet to the recuperator observed in all diagrams are due to the necessity of opening the inlet for samples to be taken in order to determine the ignition losses. The results of initial attempts to test the machine were measured in terms of ignition losses as shown in Figure 7.

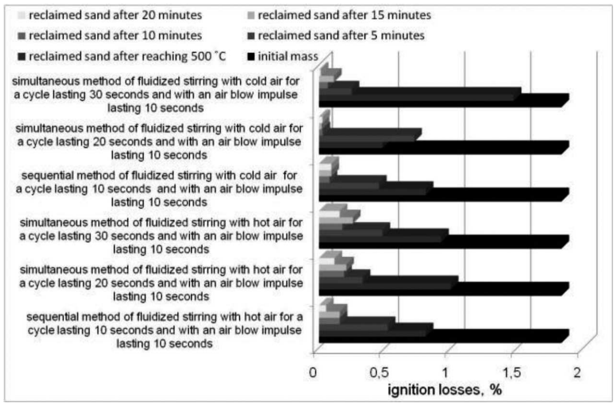

Fig. 7. A comparative specification of ignition losses of the reclaimed sand in the performed tests

On the basis of the results obtained in the tests, it can presumed that the sequential method seems to be more advantageous than the simultaneous one because it makes the burning of the binder even during the whole process, whereas the periodical, simultaneous method makes the process uneven. The diverse values of ignition losses during the process provide the evidence to the observation.

4. Conclusions

The findings presented in the paper lead to a conclusion that the way in which the stirring of the reclaimed sand during the process of thermal reclamation in a fluidal layer is performed might help determine the most advantageous conditions of the process which are crucial for its effectiveness. The application of heat obtained from fumes to heat the air needed for fluidization is a step towards reducing the costs of reclamation. The attempts to find a way of reducing exploitation costs of thermal reclamation will enable putting the method into industrial practice on a larger scale. The undisputed advantages of the method, namely: the possibility of using 100% of the reclaimed sand to produce fresh sand by utilizing original binders, reducing the wear and tear of fresh sands and stability of thermal properties provide incentive to carry out thorough research on the process of thermal reclamation. The research station presented in the paper enabling the diversity of ways of performing the process at the complete monitoring of the operation parameters and with indicators of evaluating the reclaimed sand make guidelines for performing the process in the most effective way.

Acknowledgements

This work was carried out with a financial support of the National Committee for Scientific Research No N N507 513139.

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This article was first presented at the VI International Conference "DEVELOPMENT TRENDS IN MECHANIZATION OF FOUNDRY PROCESSES", Inwałd, 5-7.09.2013

Received: 20 January 2013.