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Influence of the Thermal Reclamation of the Spent Core Sand Matrix on Its Reuse

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Abstract

The investigation results of the thermal reclamation of spent core sands made in the hot-box technology are presented in the paper. Energy-consumption of the process was tested by recording the media consumption during the thermal treatment of the determined intensity. Gas demands in dependence of the reclamation process temperatures were compared. During the reclamation process the reclaimed material samples were taken to test ignition losses in order to determine the efficiency of the realised procedures. The influence of the reclamation temperature on the quality of the obtained reclaimed material was checked. The effects of the realised reclamation procedures of the same moulding sand at various temperatures were also assessed on the grounds of strength of moulding sands prepared on the bases of the obtained reclaims. It was found that the process energy-consumption can depend on the expected core sand parameters. The attention was drawn to the fact, that bearing of costs for the thermal reclamation - very often - does not correspond directly with the obtained effects. The thermal reclamation performed very intensively, which corresponds with the costs increase, is not always needed for obtaining the core sand of parameters comparable with the sand made of fresh components.

Key words: Thermal Reclamation, Spent Sands, Thermal Reclaimer, Hot-box Technology**.**

1. Introduction

The thermal reclamation of moulding sands with organic binders is considered - from economic and ecological reasons - the costly process [1]. However, this is the only one treatment method warranting a complete removal of binding materials from grains surfaces. The mechanical reclamation application, cheaper in respect of investments and maintenance, does not create efficient conditions for the grain matrix purification from spent binders. In the majority of cases the application of the mechanical reclamation of spent sands with organic binders is reduced to effective moulding sands fragmentation. Multiple use of matrices reclaimed in such way indicates an accumulation of organic resins on grain surfaces [2]. The reclaim obtained by mechanical way is the most often used for preparations of backing sands. In case of core sands the grain matrix must warrant high-quality cores, which will meet the casting quality requirements. Therefore looking for efficient solutions of thermal reclaimers structure, in which investment and maintenance expenditures can be limited, while the obtained reclaimed material will be fully suitable for making cores e.g. in the hot-box technology, seems essential. One of the ways leading to limiting costs are operations optimising the thermal reclamation process parameters. The thermal treatment realisation is related to obtaining the determined reclamation temperature. The application of the unjustified too high temperature range or too long time, increases process costs and makes the thermal reclamation treatment uneconomic. Undertaking investigations concerning various resins used for core productions aimed at finding satisfying conditions of the thermal reclamation is one of the ways, which can allow to reduce costs of this process.

2. Research methodology

The moulding sand for tests was prepared in the hot-box technology. Its composition was:

- high-silica sand Jaworzno Szczakowa - 100 parts by mass
- resin: FURESAN 8885 - 1.5 parts by mass
- hardener: FUREDUR 8099 - 0.3 parts by mass

This moulding sand, after mixing acc. to the producer recommendations, was shot into the core box of a shape of bending strength samples. Cores were made with using the experimental shooting machine LUT-c of the Multiserw Morek Company. The shooting pressure was 5.2 MPa, shooting time 1 s and run-purge time 2 s. Cores were made at various hardening times 15, 30, 60 and 120 s at a temperature of 220 °C. The shaped samples directly after their removal from the core box (hot) and after 4 hours of cooling (cold) were fractured in the universal apparatus for flexural strength testing LRu-2e. Core scraps were crushed in a jaw crusher and sieved through 0.8 mm sieve. The material obtained in such way was subjected to the thermal reclamation. The thermal treatment of spent core sands was performed in the experimental thermal reclaimer, shown in Figure 1. Operation principles of this device were presented in other publications of the author [4 -6].

Fig. 1. Thermal reclaimer on the experimental stand in the Faculty of Foundry Engineering, AGH.

The spent core sand from the hot-box process was charged into the reclamation chamber, when this chamber was heated to the required temperature and the fluidizating air (mixing the deposit) achieved a temperature of 100 °C. Spent core sands (charge of 10 kg) were reclaimed at temperatures: 400, 500, 600 and 700 °C, with the deposit mixing acc. to the sequence: (5s_5s_5s). During the reclamation process (after 1, 2, 4, 8, 16 and 32 minutes) small portions of the reclaim were taken in order to determine ignition losses. Samples of grain matrix, after the determined reclamation times, were roasted in the silite furnace. The results presented in this paper are average from two reclaim samples, heated in the furnace for 1 hour at a temperature of 950 °C. On the bases of the obtained grain matrices, at the determined reclamation temperatures, after cooling, the core sand was again prepared and cores for strength tests were made out of it.

In order to determine the reclamation temperature influence on the quality of the reclaimed material for the given resin, its heat treatment was performed at various temperatures. Effects of the realised operations were estimated by two most important criteria [1, 3]: strength of moulding sand prepared from the reclaim and ignition loss of the spent sand obtained in the grain matrix recycling.

3. Analysis of the results

Temperature pathways in the selected points of the thermal reclaimer, for the reclamation temperature being 400 °C, are presented in Figure 2.

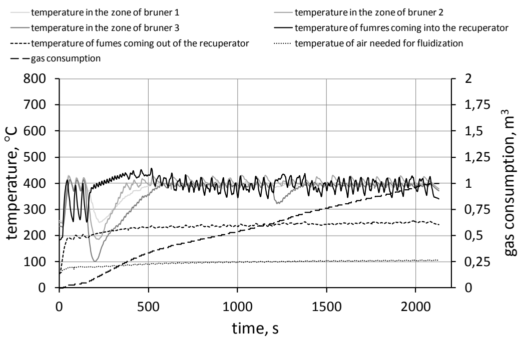

Fig. 2. Recorded temperatures and gas consumption during the reclamation performed at a temperature of 400 °C, the deposit mixed by air from the recuperator.

Simultaneously, during the whole process the gas consumption was recorded. For 32 minutes of the reclaimer operation it was app. 1 m^3.

The recorded parameters of the process realisation at a temperature of 500 °C are presented in Figure 3. During the same time length the gas consumption was increased by 25% as compared with the lower temperature.

Work parameters of the reclaimer were also recorded at its operations at 600 °C (Fig. 4) and at 700 °C (Fig. 5). It was noticed that for the device applied in investigations, working with the determined intensity and functionality, increasing the reclamation temperature by successive 100 °C increases the gas consumption by next 25%. Thus, it means that the amount of combusted gases is proportional to the process temperature. The process energy consumption is essential in relation to the expected results. In order to determine the relation between technological energy costs and obtained effects, at the selected times during the reclamation process the samples for testing ignition losses were taken.

Ignition losses at various temperatures of the reclamation of spent core sands are presented in Figure 6. The process realised at a temperature of 400 °C, in the longest tested reclamation time, did not warrant a good matrix purification leaving more than 0.20% of not burned resin. The spent core sand reclaimed at a temperature of 500 °C contained, in the final moment, still 0.10%

left overs of organic substances. The temperature increase by next 100 °C, caused the costs increase by 25%, but the matrix purification was more efficient since the amount of binder decreased by half. Increasing the reclamation temperature by successive 100°C, also caused the better effect than it would result from the gas consumption used for the thermal resin destruction.

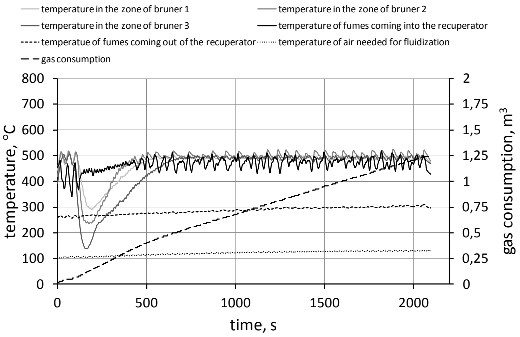

Fig. 3. Recorded temperatures and gas consumption during the reclamation performed at a temperature of 500 °C, the deposit mixed by air from the recuperator.

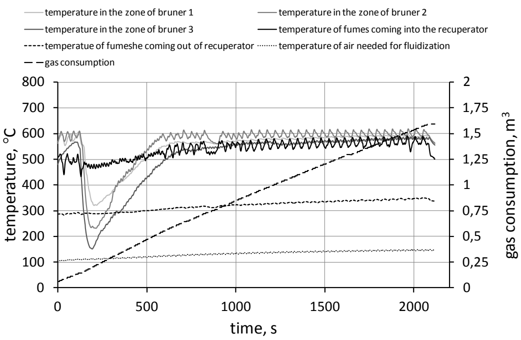

Fig. 4. Recorded temperatures and gas consumption during the reclamation performed at a temperature of 600 °C, the deposit mixed by air from the recuperator.

The reclamation at a temperature of 700 °C for the longest time, did not cause any essential decrease of spent resin on grain surfaces. For the twice shorter time the level of ignition losses was the same. In case of a lower reclamation temperature being 600 °C, the resin was still burning after 16 minutes. Thus, it should be stated that the heat treatment of the tested spent sand realised at a temperature of 700 °C can be finished after 16 minutes. The gas consumption (see Fig. 5) for this time is below 1 m3, i.e. less than in case of twice as long process at a temperature of 400°C. The resin purification from spent binder is several times more efficient at the higher reclamation temperature in shorter time. However, it should be remembered that heating the reclaimer chamber to a higher temperature (heat accumulation) increases media consumptions.

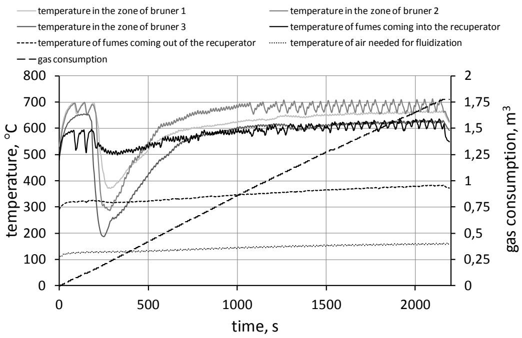

Fig. 5. Recorded temperatures and gas consumption during the reclamation performed at a temperature of 700 °C, the deposit mixed by air from the recuperator.

In the initial phase an abrupt decrease of ignition losses is seen followed by their increase (Fig. 6). This is a result of the device operation, in which a spent sand is transported from the charge to the pouring out opening. Since burners strongly influence the deposit from the top its surface layer is more intensely destructed and is poured through in the direction of the opening. From the moment of the deposit level equalisation in the reclaimer chamber as well as the result of air mixing of the material portion, the process occurs with the successive burning of organic compounds being the resin components.

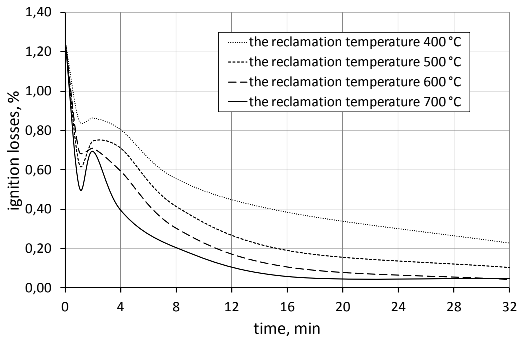

Fig. 6. Ignition losses of the reclaim in dependence of the reclamation temperature and the thermal treatment time.

The most important criterion of the reclaimed material quality is the strength of the core sand prepared on its basis. Bending strength of core sands prepared on the matrix of the obtained reclaims was analysed directly after hardening i.e. when they were hot, and after 4 hours of cooling. The results of bending strength of shaped elements performed directly after taking them from the core box are shown in Figure 7. The highest strength had the core made on the fresh sand matrix. Shaped elements obtained by the blowing method of core sand on the reclaimed matrix had worse results. Up to 60 seconds of hardening time, regardless of the reclamation temperature, the results were by app. 0.5 MPa weaker as compared with the results of cores made of fresh sand. However, the longer was the cores holding process in the core box heated to 220 °C, the more different were ‘hot’ strength values in dependence of the applied reclaimed grain matrix.

The core sand made on the matrix reclaimed at a temperature of 700 °C had - for the longest hardening time used in tests - the bending strength comparable with the fresh sand matrix hardened for 60 seconds. The holding time in the core box being 1 minute for core sands made on the fresh sand matrix and the reclaims obtained after the reclamation at 400 °C and 500°C was optimal in respect of bending strength, when samples were hot.

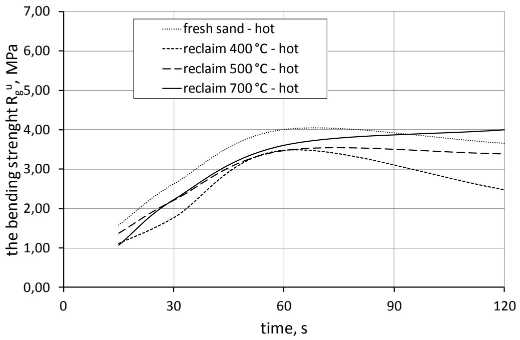

Fig. 7. Comparison of bending strength of samples hardened when being hot, made of fresh sands and of the reclaim obtained at various temperatures.

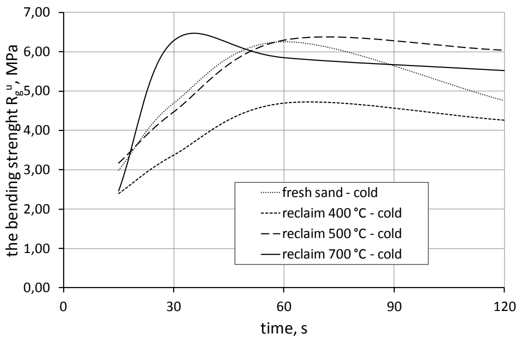

Fig. 8. Comparison of bending strength of samples hardened when being cold (after 4 hour of cooling), made of fresh sands and of the reclaim obtained at various temperatures.

The bending strength results of cores after cooling (4 hours) are shown in Figure 8. The application of the reclaim after the reclamation process performed at a temperature of 700 °C allowed to achieve cores bending strength higher for the shorter hardening time in the core box than for the fresh sand. Similar values as for the initial matrix were obtained in the situation when the reclaim was subjected to the treatment at a temperature of 500 °C. Only the reclamation process realised at 400 °C did not assure comparable values of the bending strength of the obtained cores.

4. Conclusions

The performed investigations indicate that several factors have an influence on the realisation of the thermal reclamation adequate for needs and efficient. The discussed process in dependence on the realisation way can occur not so costly as it results from the common opinion, if ecological reasons do not require a high temperature application (degradation of harmful substances). The analysis of ignition losses from Figure 6 and bending strength values from Figure 8 induces to ponder over the functionality of the complete purification of spent binder grains in the situation of reusing them in the same technology.

The application of a shorter time and a higher reclamation temperature provides conditions for obtaining comparable strength results as the ones obtained at lower temperatures and longer times, if the ignition losses are compared. Simultaneously, the obtained bending strength values, in the discussed range, are similar to the values obtained when fresh components were used. For economic reasons a gas consumption is lower since the reclamation time is shorter.

Analysing ignition losses it is possible to notice that, the binder degradation is the most intensive at the initial stage of the process. This is another factor in favour of shortening the reclamation treatment.

Taking into account the presented above considerations some thought should be given to the new approach to the thermal reclamation, as the rebounding process – partial deactivation of an organic binder. The remaining criteria of the reclaim assessment such as: pH value, sieve analysis, or the surface morphology, at taking into account the temperature influence on the harmful gases neutralisation, can occur important in undertaking such decision. The analysis should be performed for multicyclic usage of the same grain matrix for preparation core sands in the hot-box technology.

Acknowledgements

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