

Possibilities of utilizing used moulding and core sands by microwave treatment

K. Granat*, D. Nowak, M. Stachowicz, M. Pigiel

Foundry and Automation Group, Wrocław University of Technology,
ul. Łukasiewicza 5, 50-371 Wrocław, Poland

*Corresponding author. E-mail address: kazimierz.granat@pwr.wroc.pl

Received 23.02.2011; accepted in revised form 02.03.2011

Abstract

The paper presents a semi-industrial reactor designed for microwave utilization of waste moulds and cores made of moulding sands prepared in furane resin technology. It was found that a possibility exists of effective incinerating this way prepared residues of cores separated from moulding sands or waste moulds left after casting. The preliminary tests evidenced that microwave heating is an effective way of disposing waste moulding sands and the applied apparatus permits effective control of the microwave heating process. The special structure permitting rotations of charge material and proper selection of the generators working cycles guarantee significant speeding-up the process and its full stabilisation. Application of microwave heating for utilization of waste moulds and cores containing synthetic resins as binders ensures significant and measurable economical benefits resulting from shorter process time.

Keywords: Innovative foundry technologies; Microwaves; Moulding sand; Utilization

1. Introduction

Problems related to utilization of foundry wastes, consisting mostly of various grades of used moulding and core sands, combine numerous fields of science and advanced technology. Neutralization of used moulding sand presents the main economical problem of each commercial foundry plant. Due to restrictive environment protection law, implemented are various technologies consisting in cleaning used moulding sands from residues of binding materials.

The experiences gained from the tests of utilizing noxious industrial wastes containing, among others, asbestos [1] contributed to the attempt of applying the electrothermal process [2], i.e. transforming electrical energy into thermal energy of the heated materials by means of microwave-frequency

electromagnetic fields. In [3], presented are results of microwave utilization of used moulds and cores made of sandmixes containing thermohardening resins. Residues of shell cores separated from moulding sand after casting were neutralised in a short time. In the examinations applied were additives intensifying the heating process and thus shortening the time to reach the required incineration temperature. Moreover, it was found that in the microwave utilization process important is proper preparation of the used moulding sand by its mechanical disintegration. The materials suggested for microwave utilization are these with suitable dielectric properties guaranteeing efficient and sufficiently deep penetration of microwave radiation to transfer the energy emitted by the microwave generator to the substrate [1,2].

It should be emphasised that microwave radiation has found wide application also in other foundry processes, e.g. for drying

traditional moulding sands or hardening sandmixes containing water-glass or thermohardening resins [4,5,6].

2. Measuring stand

The microwave reactor used in the preliminary research to determine possibilities of microwave utilization of noxious substances [1,7,8] was adapted to the needs of testing loose materials with low bulk density. In the previous design of the combustion chamber, an obstacle limiting application of the reactor to microwave utilization of moulding sands was granulation of the used materials. In order to restrict influence of refinement degree and to ensure uniform absorption of microwave energy in the whole volume of charge material in the chamber, design of the reactor was complemented with additional components permitting its rotations.

The reactor shown in Fig. 1 is equipped with four microwave generators with total power output of 6.5 kW. The closures (upper and lower covers) are equipped with reactance chokes preventing microwaves from "leaking" outside. Moreover, the reactor was furnished with safety systems preventing the generators from being turned-on with the combustion chamber opened.

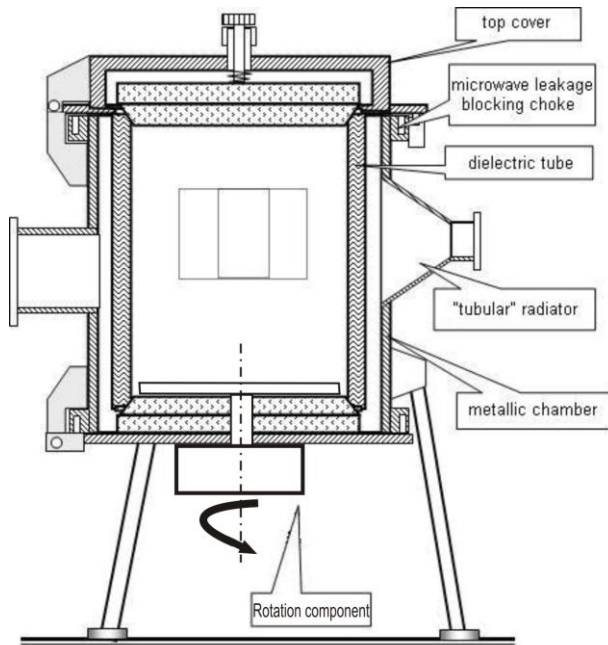


Fig. 1. Design of the microwave reactor

Radiators of the reactor are arranged on its circumference to make possible simultaneous, failure-free operation of all the installed generators, see Fig. 2. A condition of correct operation is also homogeneity of electromagnetic field in the entire reactor chamber.

The four microwave generators with maximum microwave power up to 1.6 kW each are connected with the reactor's chamber by means of wave-guide flanges. The microwave generating lamps (magnetrons) are equipped with a water cooling system, so

each of the generators is connected to the water collecting tube. The generators system is supplied from a specially designed set of microwave power packs (installed in a separate housing) and connected with the generators by means of cables.

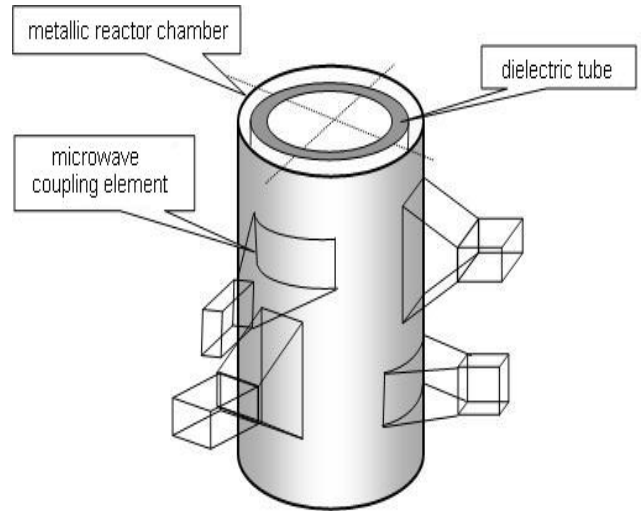


Fig. 2. Layout of microwave generator chamber with arrangement of microwave coupling systems

The charge material is loaded through the upper metal cover. The space between the metal chamber wall and the ceramic tube, visible in Fig. 3, is filled with insulating material, so that thermal energy of combustion can not be conveyed to the metal housing. The applied insulating material is characterised by low microwave attenuation coefficient, thanks to that practically the whole electromagnetic field energy is focused on the charge to be utilised. These requirements are fulfilled by insulating wool named SIBRAL.

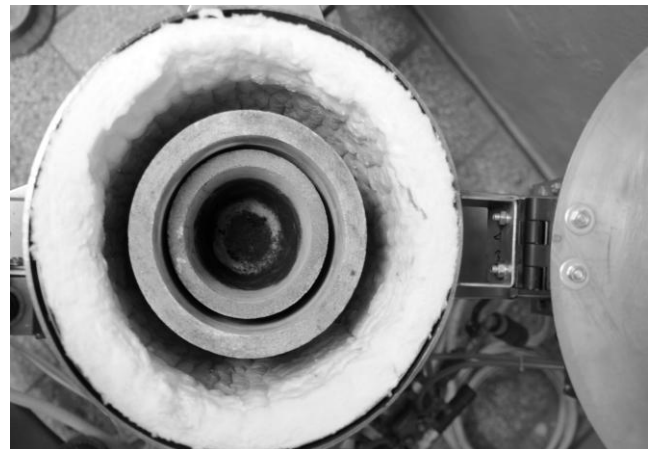


Fig. 3. View of reactor chamber lined with thermo-insulating wool SIBRAL

The chamber is equipped with microwave chokes eliminating risk of leaking microwaves outside the reactor during its operation.

The set of microwave generators is placed in a mobile metal control cabinet. In addition, the power packs permit independent switching the generators on and off, as well as reducing power of each generator down to half the maximum power.

3. Preparation of test material

The material used in the preliminary research consisted of non-burnt waste casting moulds and cores made in technologies applied in foundry plants.

Two grades of moulding sands, M1 and M2, were used in the tests. Composition of the sandmix M1 (Fig. 4) was as follows:

- fine-grained quartz matrix
- furane resin binder
- water-glass addition 1.5 to 2 %
- hardener – carbon dioxide.

The sandmix M2 (Fig. 5) was prepared of:

- fine-grained chromite matrix
- furane resin binder 1 to 1.3 %.

In both cases, residues of protective coating were left on the surface, see Figs. 4 and 5. The charge chamber was filled with ca. 700 g of the mentioned sandmixes.

Analysis of the preliminary results and their comparison with those for other materials tested [3] for possibility of using microwave utilization shows that effectiveness of heating the wastes depends on their refinement degree. Therefore, the material to be tested was subject to preliminary mechanical refinement in a laboratory roll mixer.

Microwave heating was performed after closing the chamber and starting the drive ensuring a determined rotational speed. Operation of the generators was controlled in two working stages, see Table 1. In the first stage, all the four generators were successively switched-on to a half of their rated power. In the second stage, the generators' power was increased to the maximum value of ca. 6.6 kW. During that time recorded were changes in the substrate temperature. The incineration process was finished when stabilisation of the charge material temperature was observed.



Fig. 4. View of waste moulds and cores before utilization in the microwave chamber; moulding sand M1



Fig. 5. View of waste moulds and cores before utilization in the microwave chamber; moulding sand M2

4. Utilisation process

Basic process parameters for the moulding sands M1 and M2, measured during the tests, are settled in Table 1. The given heating temperatures are those recorded after the process became stabilised.

Table 1.
Parameters of microwave heating

		Stage 1: 3.2 kW	Stage 2: 65 kW
Mass M1	Temperature	420 °C	670 °C
	Heating time:	10 min + 5 min (stabilization)	5 min + 5 min (stabilization)
Mass M2	Temperature:	470 °C	665 °C
	Heating time:	10 min + 5 min (stabilization)	5 min + 5 min (stabilization)

In the case of the moulding sand M1 in the stage 1, the stabilisation temperature of 420 °C was reached after 10 minutes. Further microwave heating for 5 min did not result in any measurable temperature rise. Switching to the stage 2 permitted heating-up the charge to 670 °C after 5 minutes. Monitoring the temperature changes for further 5 min did not reveal any temperature rise. As a final result, obtained was a very powdery mixture with lumps, with visible residues of protective coating, see Fig. 6.



Fig. 6. View of moulds and cores completely incinerated in microwave chamber; moulding sand M1

Course of incineration process of the moulding sand M2 was similar to that of M1. The highest temperature was reached only when using the working stage 2. Power of 6.5 kW allowed incinerating the moulding sand M2 at the maximum measured temperature of 665 °C. The obtained material was very powdery with its grains very easily separating from each other. The process resulted in practically complete disintegration of the moulding sand (Fig. 7), which could facilitate further transportation of these wastes to a location of further processing, utilizing or storing.



Fig. 7. View of moulds and cores completely incinerated in microwave chamber; moulding sand M2

5. Conclusions

Analysis of the results of the preliminary research on possibilities of thermal utilization of waste moulds and cores containing a furane-resin binder in the process of microwave heating leads to the following conclusions:

- Waste moulding sand moulds and cores can be effectively and efficiently utilized in microwave ovens.

- The incineration process using high-power heating facilities is mostly influenced by homogeneity degree of the used electromagnetic field.
- Time and temperature of microwave thermal utilization of waste moulding sands depend on power of microwave heating.
- Microwave heating of waste moulding sands guarantees measurable economical benefits resulting from significant reduction of thermal utilization time.

Acknowledgements

The scientific work was financed from the budgetary means for science in the years 2010 to 2012 as a research project.

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