K. MAJOR - GABRYŚ

ISSN 0543-5846
METABK 54(3) 591-593 (2015)
UDC – UDK 621.746:621.74.04:678.7=111

BIODEGRADABLE MATERIALS AS FOUNDRY MOULDING SANDS BINDERS

Received – Prispjelo: 2014-09-17
Accepted – Prihvaćeno: 2015-01-10
Review Paper – Pregledni rad

The aim of this article is to show the possibility of using biodegradable materials as part of the composition of foundry moulding and core sand binders. Research shows that moulding sands with biodegradable materials selected as binders are not only less toxic but are also better suited to mechanical reclamation than moulding sands with phenol-furfuryl resin. The use of biodegradable materials as additives to typical synthetic resins can result in their decreased toxicity and improved ability to reclamation as well as in accelerated biodegradation of binding material leftovers of mechanical reclamation.

Key Words: foundry practice, moulding sand, biodegradable polymer, toxicity, reclamation

INTRODUCTION

Foundry is an area of science which will never have just one technology of preparing moulding sands and only one technology of preparing core sands. The variety of materials of which castings are made (types of alloys and their casting temperature) will always make foundrymen face the requirements for obtaining moulds and cores with high technological properties. Moreover, according to tendencies observed in recent years, foundry mould and core manufacturing technologies must also meet high environmental protection requirements. The group of binders which are predominant in the production of foundry moulds and cores comprises synthetic (petrochemical) resins used in processes such as loose self-hardening moulding sands (no-bake technology), cold-box technologies and hot-box technologies. Phenol, urea and furfuryl resins are especially used. Increased environmental protection requirements necessitate changes in foundry practices. Many domestic and foreign scientific centers have been trying to develop new non-toxic foundry moulding sand binding systems [1 - 3]. The current direction in modern scientific research is to gradually replace binding materials produced from petrochemical stocks with biomaterials originating from renewable resources. This direction is consistent with the concept of sustainable development which is one of the priorities of the European Community policy [4].

BIODEGRADABLE POLYMERS IN FOUNDRY MOULDING SANDS

According to ASTM standard D-5488-94d, "biodegradable" means "capable of undergoing decomposition into carbon dioxide, methane, water, inorganic compounds or biomass", where the predominant mechanism is the enzymatic action of microorganisms. The mechanism can be measured by standard tests, over a specific period of time, with available disposal conditions. There are different media (liquid, inert or compost medium) to analyze biodegradability [4].

During the '90s, General Motors Corporation developed a new binding system based on the protein composition called GMBOND [5]. K. Rusin's scientific group [6] tested the possibility of using biogenic binders based on proteins derived as by-products of pharmaceutical industry. B. Grabowska [7 - 8] proposed the use of aqueous biodegradable polymeric compositions consisting of acrylic derivatives and modified natural polymers (BioCo binders) as moulding sand binders in foundry.

RESEARCH AND DISCUSSION

Based on literature [9], the author assumes that a possibility exists to replace part of organic petrochemical binder commonly used in foundry practice with organic biodegradable material. The replacement can improve the binder quality. The first step of the author's research was to conduct tests using biodegradable materials as moulding sand binders. The search for producers of biodegradable polymers resulted in selecting the following materials as binders: poly(lactic acid), poly(lactic-*co*-glycolic acid), polycaprolactone, polyhydroxybutyrate and cellulose acetate.

According to literature [9], polycaprolactone is often used as an additive in resins to improve their processing characteristics and their end use properties (such as impact resistance). Since it is compatible with a range of other materials, polycaprolactone can be

K. Major - Gabryś, AGH University of Science and Technology, Faculty of Foundry Engineering, Krakow, Poland

mixed with starch to lower its cost and increase biodegradability or it can be added as a polymeric plasticizer to poly(vinyl chloride) (PVC).

In previous studies, the author [1] used selected biodegradable materials as binders for moulding sands. The research proved that moulding sands combined with biodegradable binders showed satisfactory strength properties [1].

To measure the toxicity, moulding sand was used, composed of 100 parts by weight of quartz sand and 2 parts by weight of biodegradable poly(lactic acid). In comparison testing, a typical self-hardening moulding sand with furfuryl resin was used, composed of 100 parts by weight of quartz sand and 1,1 part by weight of phenol-furfuryl resin hardened with 0,55 part by weight of aqueous solution of paratoluenosulphonic acid (PTS) [1].

The hardening of moulding sand bound with poly(lactic acid) was followed by solvent evaporation. The research was conducted using a multifunction device designed to examine the surface properties of liquid alloys. The construction of the device allowed for permanent registration of residual gases content using the quadruple mass analyzer Prisma QMS-200 manufactured by Pfeiffer Co. The research was conducted under high vacuum conditions. Toxicity tests of the hardened moulding sands showed that fewer harmful substances developed during pouring of moulding sand bound with poly(lactic acid) (Figures 1 - 2) [1].

The problem is the toxicity of organic solvents used to dissolute biopolyesters and the toxicity of moulding

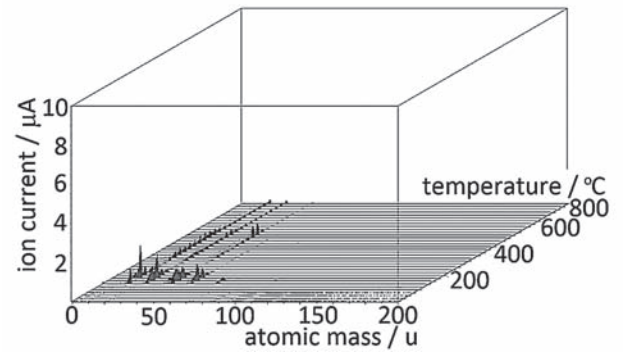

Figure 1 Analysis of gases generated during heating of moulding sand with poly(lactic acid) [1]

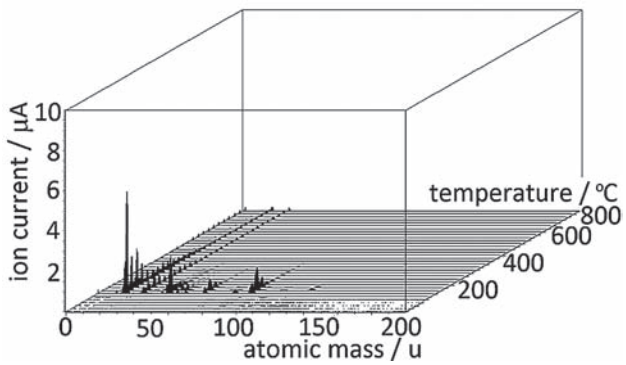

Figure 2 Analysis of gases generated during heating of moulding sand bound with phenol-furfuryl resin [1]

sand production process. It seems reasonable to investigate whether there is a possibility of inserting biodegradable materials into the sand after their earlier dissolution in an organic water-soluble solvent and then inserting the water (as a second solvent) into the solution. In that case the moulding sand would be made of sand grains and biodegradable binder particles in an aqueous suspension.

One of the points of the paper is checking the possibility of increasing the biodegradation rate of binding materials used. However, it must be clearly stated that biodegradation of biodegradable materials used in foundry practice will not replace reclamation processes that are necessary to recover sand grains. The author's own research proved that moulding sands with biodegradable materials selected as binders are not only less toxic [1] but are also better suited to mechanical reclamation than moulding sands with phenol-furfuryl resin that were used [10].

The testing involved using moulding sands with biodegradable binders with the quantity of 2 parts by weight and a typical self-hardening moulding sand with phenol-furfuryl resin with the same composition as in toxicity tests. All the tested moulding sand portions consisted of moulding sands heated at temperatures of 200, 600 and 800 °C and of unheated moulding sand [10].

The testing schedule of the ability to reclaim the moulding sands included the following: crushing the material before secondary reclamation; the secondary reclamation treatment within 10 and 20 minutes of reclamation; the final classification (pneumatic) of the material obtained in reclamation process. The moulding sands and their leftovers were analyzed to define the degree of releasing sand grains from binder leftovers in moulding sands. The following were analyzed: ignition loss, determining the degree of releasing sand grains from binder leftovers in moulding sands (W_{SR}), defining the dusts content, value of pH, analyzing the surface morphology and sieve analysis. All the obtained results were showed in the previous paper by the author [10], which proved that moulding sands with biodegradable binders had high capability of reclamation with their parameters much exceeding analogical parameters of typical moulding sand bound using phenol-furfuryl resin.

It can be concluded that the partial replacement of resin with a biodegradable material will increase the ability to reclaim the moulding sands with new binders.

CONCLUSIONS

Analysis of literature data and the author's own research yield the following conclusions:

- It is possible to develop theoretical foundations and procedures for the production of synthetic resins combined with biodegradable materials as binders for foundry moulding and core sands.
- The use of synthetic resins combined with biodegradable materials as binders for foundry moulding and core sands may reduce their toxicity.

- The use of synthetic resins combined with biodegradable materials as binders for foundry moulding and core sands may increase their capability of reclamation.
- The use of synthetic resins combined with biodegradable materials as binders for foundry moulding and core sands may result in partial biodegradation of binder leftovers of mechanical reclamation.

Acknowledgements

Scientific paper financed by AGH Research Project No 11.11.170.318 - 3

REFERENCES

[1] St. M. Dobosz, P. Jelinek, K. Major - Gabryś, Development Tendencies of Moulding and Core Sands, China Foundry, 8 (2011) 4, 438-446.
[2] A. Wolff, T. Steinhaeuser, AWB - an Environment-Friendly Core Production Technology, Giesserei, 91 (2004) 6, 80-84.
[3] M. Stachowicz, K. Granat, Possibilities of Reclamation Microwave-Hardened Molding Sands with Water Glass, Archives of Metallurgy and Materials, 59 (2014) 2, 757-760.
[4] L. Avérous, E. Pollet, Environmental Silicate Nano-Biocomposites, Springer, London, 2012, pp. 13-40.
[5] J. Eastman, Protein-Based Binder Update: Performance Put to the Test, Modern Casting, October (2000), 32-34.
[6] D. Kramářová, J. Brandštetr, K. Rusín, P. Henzlová, Biogenní polymerní materiály jako pojiva slévárenských forem a jader, Slévárenství, 60 (2003) 2-3, 71-73.
[7] B. Grabowska, Nowe spoiwa polimerowe w postaci wodnych kompozycji z udziałem poli(kwasu akrylowego) lub jego soli i modyfikowanego biopolimeru do zastosowania w odlewnictwie, Wydawnictwo Naukowe Akapit, Krakow, 2013, pp. 87-107.
[8] B. Grabowska, M. Holtzer, R. Dańko, M. Górny, A. Bobrowski, E. Olejnik, New BioCo Binders Containing Biopolymers for Foundry Industry, Metalurgija, 52 (2013) 1, 47-50.
[9] E. - J. Choi, J. - K. Park, Study on Biodegradability of PCL/SAN Blend Using Composting Method, Polymer Degradation and Stability, 52 (1996) 3, 321-326.
[10] K. Major - Gabryś, St. M. Dobosz, R. Dańko, J. Jakubski, The Estimation of Ability to Reclamation of Moulding Sands with Biopolymer Binders, Archives of Foundry Engineering, 11 (2011) 2, 79-84.

Note: Translator responsible for the translation into English is professional certified corporation: LingPerfect Translations, Inc., New York, USA