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NEW BICOMPONENT BINDERS FOR FOUNDRY MOULDING SANDS COMPOSED OF PHENOL-FURFURYL RESIN AND POLYCAPROLACTONE

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Preliminary Note – Prethodno priopćenje

The aim of this article is to test the properties of foundry moulding sands with a new bicomponent organic binder. The new binder is the composition of phenol-furfuryl resin, commonly used in foundry practice and biodegradable material – polycaprolactone. The paper presents the research of strength properties, thermal destruction and thermal deformation of moulding sands with a new bicomponent binder. It was proved that inserting polycaprolactone to phenol-furfuryl resin did not lower the strength properties of tested moulding sands. The new additive did not affect the moulding sands thermal degradation but it changed their thermal deformation course.

Key words: foundry practice, moulding sand, biodegradable material, environmental protection, organic binder

INTRODUCTION

The group of binders which are predominant in the production of foundry moulds and cores includes synthetic resins.

All kinds of synthetic resins can be fragmentized and biologically assimilated, however, these processes can mostly take tens or even hundreds of years. Literature data [1 - 3] shows that there is possibility of using biodegradable materials as additives for petrochemical materials to cause their biodegradability. Such material could be biodegradable polycaprolactone (PCL).

Poly(e-caprolactone) is a simple, linear, aliphatic polyester formed by the ringopening addition polymerisation of e-caprolactone, normally initiated by an alcohol or diol in the presence or absence of a catalyst. The polymer has a regular structure and is crystallisable. Polycaprolactone (PCL) crystallises to approximately 50 % in the form of spherulites [4].

Polycaprolactone is compatible with various other polymers, which enables the formation of various biodisintegrable blends and is used as a biodegradable component [2]. Iwamoto and Tokiwa [5] performed detailed studies on the biodegradability of polycaprolactone (PCL) / polyolefin mixture, including the relationship between the biodegradability and the phase structure.

Biodegradability is not the only advantage of polycaprolactone. The polymer, having a very low glass-transition temperature, is usually blended with polymers of higher glass-transition temperature and, in miscible systems, it therefore plasticizes the other component. Substances with low glass-transition temperatures are often added to polymers with high glass-transition temperature in order to render them more flexible and to reduce their brittleness [6].

The problem faced by the foundry practise is that the cores made of core sands with polymeric binders are not flexible enough. It was found that cores are often damaged when automatically placed in moulding boxes [7]. It seems that adding a plasticizer such as polycaprolactone into moulding sand's binding system may improve the flexibility of cores.

The use of polycaprolactone as polymeric plasticizer for vinyl polymers was patented in 1966 [6]. The polyvinyl chloride – polycaprolactone (PVC – PCL) blends are tougher and more extensible than those prepared with conventional plasticizers, display a better softness and a higher resistance to extraction in oil and water [8]. Polycaprolactone is semi-compatible or mechanically compatible with many polymers such as polyvinyl acetate, polystyrene, polycarbonate, etc. Blends of polycaprolactone with epoxidized natural rubber, unsaturated polyester resin and Novolac resin were also prepared, which proved the miscibility of this polymer with variety of materials [6].

In previous paper [9] the author proposed usage of biodegradable materials as components of foundry moulding sand binders.

Measuring stands

In the paper, the biodegradable polycaprolactone and phenol-furfuryl resin (commonly used in foundry practice) were chosen as the new binder's components.

The composition of tested moulding sands MS 1 - MS 4 are shown in Table 1. The moulding sand no. 5 (MS 5) was composed of 98,039 % of quartz sand and

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1,961 % of biodegradable polycaprolactone (PCL) dissolved in an organic binder. The hardening of the moulding sand was followed by solvent evaporation.

Table 1 **Moulding sands compositions / %**

Moulding sand number	Sand grains / %	Binder / %		Hardener / %
	Quartz sand	Phenol-furfuryl resin	Polycaprolactone (PCL)	Aqueous solution of paratoluenosulphonic acid (PTS)
MS 1	98,377	1,082	0	0,541
MS 2	98,377	1,028	0,054	0,541
MS 3	98,377	0,974	0,108	0,541
MS 4	98,377	0,920	0,162	0,541

The first research stage was to analyze the influence of polycaprolactone on bending strength and wear resistance of tested moulding sands.

The next stage involved analyzing the influence of polycaprolactone on thermal properties of tested moulding sands. Derivatographic research and research of moulding sands' tendency to thermal deformation were conducted. The moulding sands' tendency to thermal deformation was studied by determining the hot distortion parameter. A detailed description of the method was presented in previous publication by the authors [10].

TEST RESULTS

Figure 1 presents the influence of polycaprolactone on bending strength and Figure 2 on wear resistance of moulding sands with phenol-furfuryl resin.

Research proves that polycaprolactone did not decrease strength properties of moulding sand with phenol-furfuryl resin. However, the wear resistance of moulding sands with polycaprolactone exceeding 0,108 % is lower.

Figure 3 shows the TG curves of tested moulding sands with compositions as in Table 1 (MS 1 - MS 4). The results of the hot distortion parameter measurements are shown in Figure 4.

Research proves that polycaprolactone did not significantly impact the thermal destruction process of moulding sand with phenol-furfuryl resin.

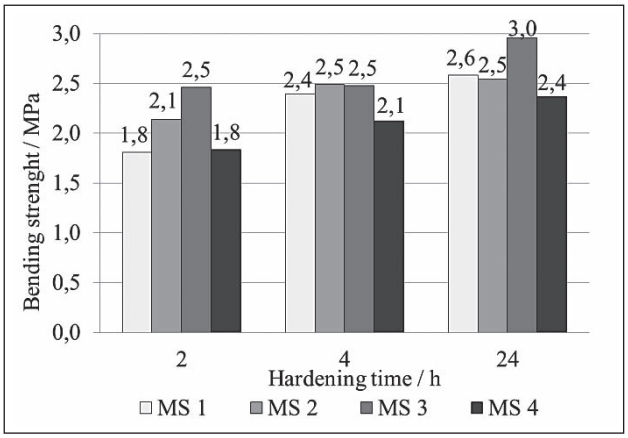

Figure 1 The influence of polycaprolactone (PCL) on bending strength of moulding sand with phenol-furfuryl resin

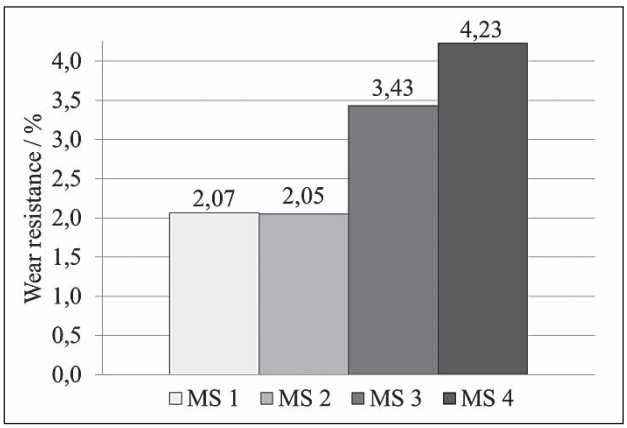

Figure 2 The influence of polycaprolactone (PCL) on wear resistance of moulding sand with phenol-furfuryl resin

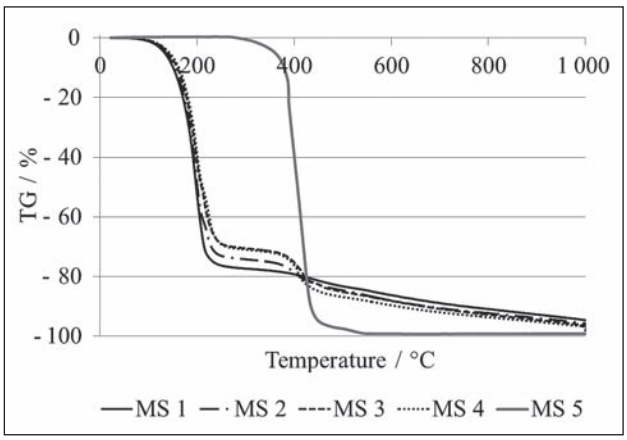

Figure 3 The TG curves of moulding sands: MS 1 - MS 4 (Table 1) and MS 5

Moulding sand with phenol-furfuryl resin undergoes a typical course of thermal deformation (measured by hot distortion parameter) with continuous intensive growth and the rapid sample collapse when the temperature exceeds approximately 480 °C. Inserting polycaprolactone (PCL) in the quantity of 0,054 % (MS 2) decreased the maximum temperature by about 100 °C.

The deformation course of moulding sand with polycaprolactone (PCL) in quantity of 0,108 - 0,162 % (MS 3 - MS 4) and moulding sand with polycaprolac-

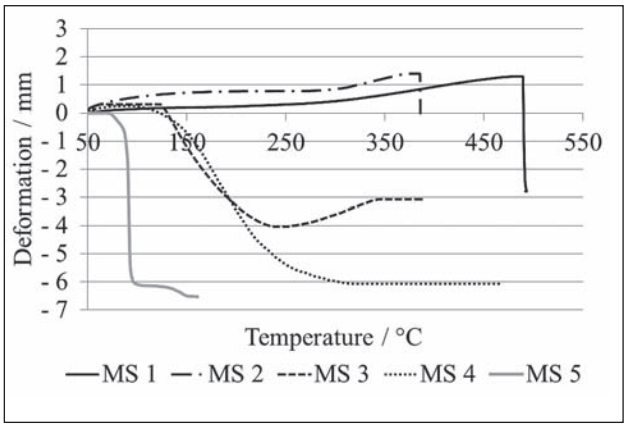

Figure 4 Thermal deformation of moulding sands: MS 1 - MS 4 (Table 1) and MS 5

tone (PCL) as binder (MS 5) is completely different. Moulding sands MS 3 and MS 4 move in plastic state at a temperature of about 110 °C, while moulding sand MS 5 moves in a definitely plastic state at a lower temperature (approximately 70 °C).

CONCLUSIONS

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

- The purpose of using biodegradable materials as components of synthetic resins in moulding sands is to improve their mechanical reclamation properties and decrease the toxicity of reclamation remains.
- The purpose of using polycaprolactone as components of synthetic resins is to improve moulding sands flexibility.
- Research conducted with biodegradable polycaprolactone (PCL) as a moulding sand with phenol-furfuryl resin component has shown that adding 0,054 - 0,162 % of polycaprolactone does not lower the strength properties of the tested moulding sands.
- The additive does not affect the thermal degradation of moulding sands (TG curves).
- Research of moulding sands thermal deformation has shown that the addition of biodegradable material in the quantity of 0,108 - 0,162 % changed the course of deformation, making moulding sands more flexible within the range of tested temperature.

Acknowledgements

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