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ECOLOGICAL WATER-BASED PROTECTIVE COATINGS FOR MOULDS AND CORES OF IRON CASTINGS

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The aim of the investigations was the development of the protective coating and the method of its preparation intended for foundry moulds and cores. The selection of the proper surface-active agent, allowing graphite wetting by water in order to form homogenous water composition with the remaining components of the coating, was especially important.

Key words: castings, iron, water-based protective coatings, moulds and cores, quality of surface

INTRODUCTION

According to the sustainable development policy and the need of limiting the CO_2 emission to the environment, the application of environment friendly materials is necessary [1]. This concerns – in practice – every industrial branch, including the foundry industry, where materials applied in several processes constitute environmental hazards. One of them is protective coatings for moulds and cores.

Protective coatings are deposited on surfaces of moulds or core cavities in order to protect against moulding sand burning-on to the casting, to improve the casting surface quality and to prevent the liquid metal penetration deep into the mould [2 - 7]. Coatings can be in a form of solids (powdered), liquids or pastes. At the iron castings production liquid coatings, in which alcohol (the most often isopropyl alcohol) is a diluent, are usually applied. These coatings are dried by evaporation or burning of a diluent, and these operations contribute to the emission of harmful substances, including volatile organic compounds (VOC). The alternative, recommended by the European Union, constitute water-based coatings [1, 2, 8 - 10]. Apart from the fact that they are environmentally friendly, they also warrant an increased work safety (none direct fire hazards as during burning of alcohol-based coatings), a significant reduction of substances from the VOC group and they are more economically profitable since water costs are much lower than costs of alcohols.

On the other side, water-based coatings require longer drying time, which influences the process yield and which cannot be applied for every kind of moulding sands. Therefore, regardless of the water-based protective coatings of the company names available in the market, investigations on the optimisation of their composition and properties are still carried on in an aspect of these coatings universality and cost decreasing. According to the EU requirements alcohol-based coatings should be gradually eliminated and substituted with water-based coatings [1, 11 - 13].

MATERIALS FOR INVESTIGATIONS AND METHODOLOGY

The investigation subject constituted of two protective coatings, developed by the Authors [9], and one commercial coating, from a known supplier of foundry materials. This commercial water-based coating is intended for moulds and cores in the production of all kinds of foundry alloys. In order to verify the efficiency of these protective coatings the test mould of the moulding sand of the following composition was made: 98, 5 wt. % of a high-silica sand, 1,0 wt. % of a furan resin, 0,5 wt. % of a hardener. On the specially prepared pattern plate four kinds of standard samples of Ø 50 x 50 mm were formed (moulding sand composition for samples: 89,5 wt. % of a reclaimed sand, 9 wt. % of a new quartz sand, 1 wt. % of a furan resin and 0,5 wt. % of a hardener).

Samples with protective coatings were marked as: 0, 1, 2, 3 - on mould (Figure 1).

Protective coatings were deposited on samples with the immersing method, performed for 15 seconds. The drying time, at an ambient temperature of 23 ^{o}C, was 24 hours. The thickness of coatings was 270 - 350 μm, while their viscosity (measured by the Ford's cup, DIN = 4 mm) was 15 - 20 seconds. The view of the half of the mould with samples is shown in Figure 1. The mould was poured vertically with cast iron, of a temperature of 1 430 ^{o}C, which allowed obtaining the metallostatic pressure of the order of 700 mm of a metal column.

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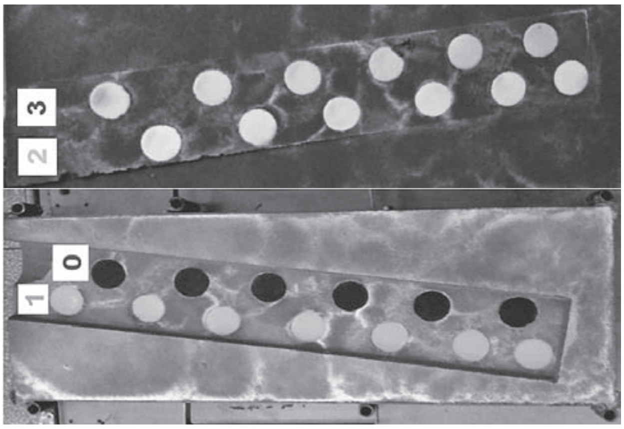

Figure 1 View of the mould from the side of shaped samples marking: 0 – without coating, 1 – with the commercial coating, 2 – with the experimental coating; 3 – with the experimental coating

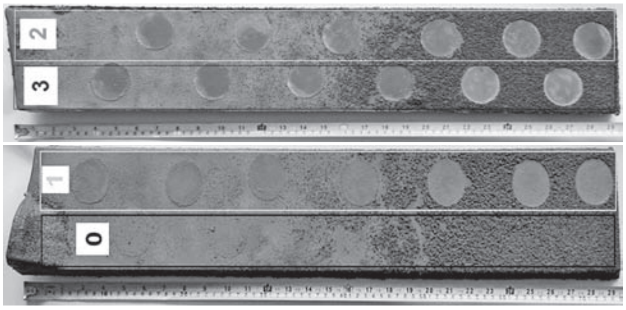

Figure 2 Casting of the pattern plate after being knocked-out – from the side of shaped samples

The rough casting, after knocking-out, was subjected to the surface quality checking by means of the profilometer Surftest 201 of the Mitutoyo Company (Figure 2). The assessment of the casting surface smoothness was based on the R_a indicator – i.e. the mean arithmetic deviation of the profile from the average line, measured with an accuracy of up to 1 µm. The casting of the pattern plate after being knocked-out – is presented in Figure 2 from the side of shaped samples.

RESULTS AND DISCUSSION

The casting surfaces with the protective coatings 1, 2 and 3 are presented as a function of the liquid metal height (metallostatic pressure) in Figure 3.

As can be seen, the increasing metallostatic pressure is not significantly worsening the surface quality. However, it is well known that there is a certain boundary value of this pressure at which a sudden surface worsening occurs. It can be assumed that the protective coating stops fullfilling its function at such high pressure. The system behaves nearly as being completely without a protective coating (sample 0, Figure 4). The quality of the obtained surfaces of the test casting covered by the developed water-based protective coatings (2 and 3) was very good (Figures: 3 and 4). The measured roughness of the casting (R_a) was practically at the same level from 5 - 10 µm (Figure 3, Table 1) within the whole

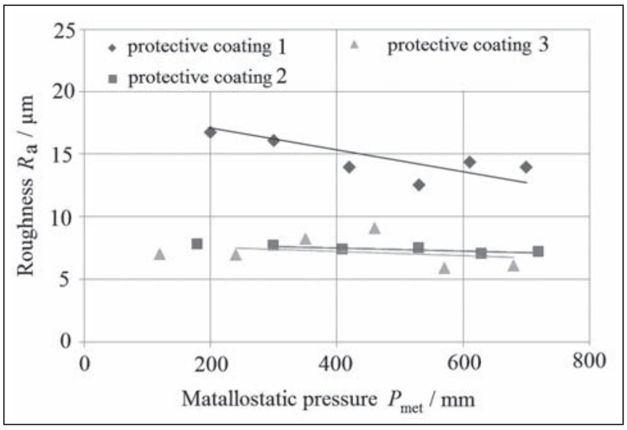

Figure 3 Influence of the metallostatic pressure on the surface roughness of iron castings in dependence of the applied protective coating

tested range of the metallostatic pressure. When these coatings were applied an increasing metallostatic pressure was not influencing the surface quality (within the tested range). However, in case of the commercial coating (1) the surface roughness was higher: 15 - 20 µm. In this case, the surface quality worsening is seen (in photos) when the metallostatic pressure exceeds 350 - 500 mm of a metal column height (Figure 4). At the lack of the protective coating, the obtained surface quality was very bad (Figure 4). It confirms the necessity of applying the protective coatings.

The worse surface quality of the casting – in case when the commercial coating was applied – was most probably caused by materials of larger grains used for this coating preparation. The coating quality could be also not sufficient.

Table 1 **Overall list of the roughness measurements results of casting surfaces when various protective coatings were applied**

Type of sample	Metallostatic pressure P_{met} / mm	Roughness R_a / µm
1	200	16,76
	300	16,09
	420	13,95
	530	12,52
	610	14,38
	700	13,96
2	180	7,80
	300	7,71
	410	7,40
	530	7,51
	630	7,05
	720	7,22
3	120	7,04
	240	6,98
	350	8,26
	460	9,15
	570	5,93
	680	6,15

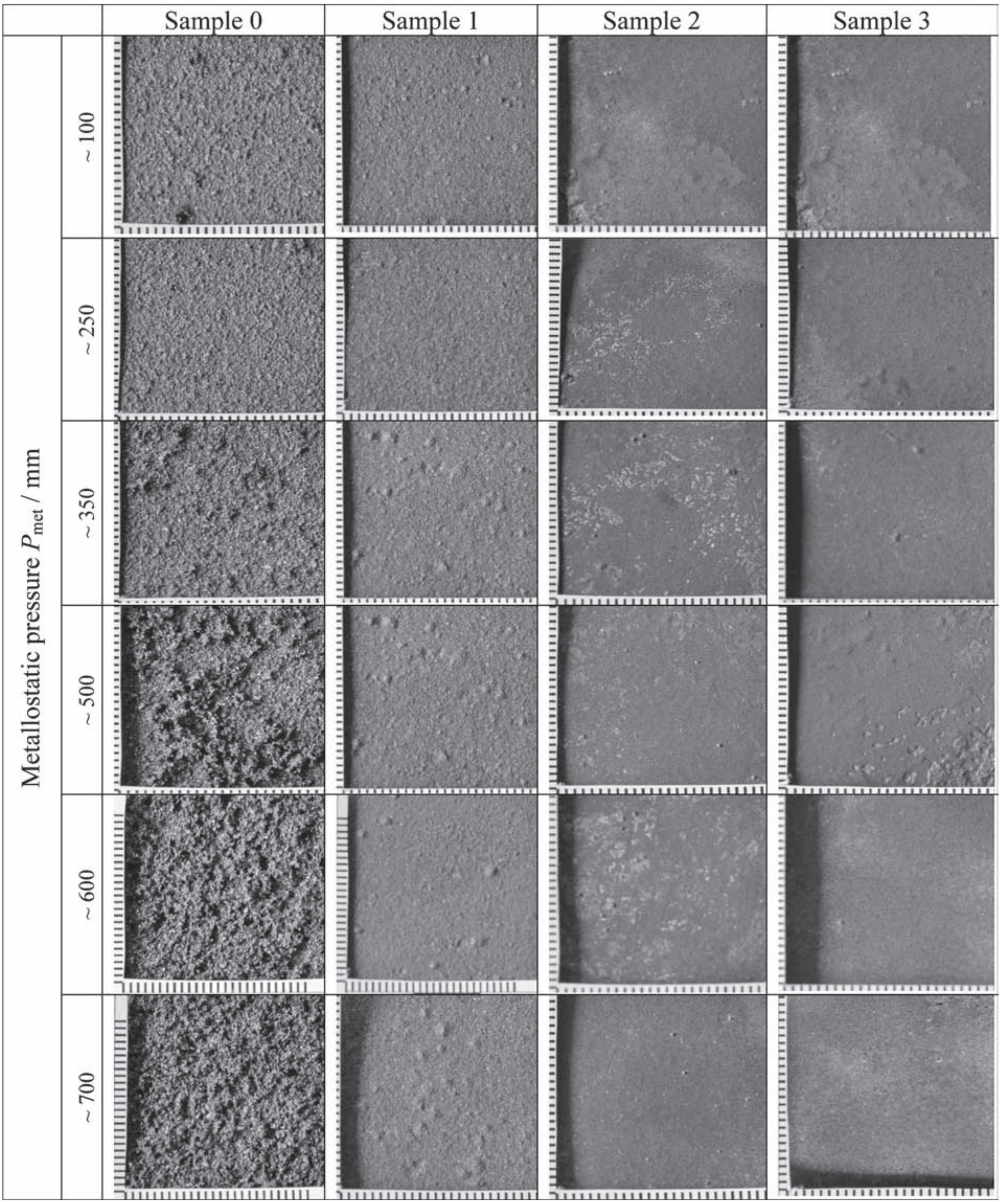

Figure 4 Comparison of the surface quality of castings with the protective coatings and without the protective coating at different metallostatic pressures

SUMMARY AND CONCLUSIONS

It was shown in the experimental tests that the water-based protective coatings efficiently protect mould surfaces against the liquid cast iron penetration.

The surface quality of castings made with the application of the developed water-based protective coatings was better than when the commercial coating was applied. This was confirmed by the surface roughness measurements as well as by visual observations.

The surface roughness (R_a) of castings made with the application of the tested water-based protective coatings was of a value 5 - 10 μm, which means that it was twice smaller than the surface roughness of castings made with the application of the commercial water-based protective coating (10 - 20 μm).

The influence of the increased metallostatic pressure (within the tested range) on worsening the casting surface quality was not significant for the tested protective coatings. The high quality of surfaces of iron castings achieved when the developed water-based protective coatings were applied was possible due to using the special system: graphite-surface active agent.

Acknowledgements

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Note: The responsible translator for English language: “ANGOS” Krakow, Poland