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Surface analysis and chemical composition of dust from dry dedusting system of moulding sand with bentonite using scanning electron microscopy (SEM)

Analiza morfologii powierzchni i składu chemicznego pyłów z suchego odpylania mas formierskich z bentonitem z wykorzystaniem skaningowej mikroskopii elektronowej (SEM)

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Abstract

The article presents the results of surface morphology of dust from dry dedusting of moulding sand with bentonite and mixtures of bentonite with lustrous carbon carrier using scanning electron microscopy. The study identifies the approximate chemical composition of the dust, and compares it with the composition of starting mixtures. The mixtures of bentonite with lustrous carbon carrier from different manufacturers differ in chemical composition. The process of dedusting should be carried out using properly selected operating parameters of the dedusting equipment. If the process of dedusting is carried out incorrectly, it can lead to the loss of valuable components.

Keywords: *bentonite, dust, dedusting, scanning electron microscopy*

Streszczenie

W artykule przedstawiono wyniki badań morfologii powierzchni pyłów z suchego odpylania mas formierskich z bentonitem oraz mieszanek bentonitu z nośnikiem węgla błyszczącego z wykorzystaniem mikroskopii skaningowej. Badania pozwoliły wskazać przybliżony skład chemiczny pyłu i porównać go ze składem mieszanek wyjściowych. Mieszanki bentonitu z nośnikiem węgla błyszczącego oferowane przez ich producentów różnią się pod względem składu chemicznego. Proces odpylania mas formierskich z bentonitem powinien przebiegać przy odpowiednio dobranych parametry pracy urządzeń odpylających. Niewłaściwie prowadzony proces odpylania może doprowadzić do utraty cennych składników.

Słowa kluczowe: *bentonit, pył, odpylanie, skaningowa mikroskopia elektronowa*

1. Introduction

As a result of a impact of heat of the liquid metal into a mould cavity made of moulding sand with bentonite is a loss of binding properties of bentonite. The moulding sand is subjected to a refresh process, which is intended to restore the properties of the moulding sand to enable its reapplied in the process, and removal of the dust. Removing dust is so important that it could negatively affect the technological characteristics (eg. permeability) and mechanical properties of moulding sand with bentonite (eg. compressive strength). Dedusted mould sand also possesses higher demand for water and fresh bentonite in order to achieve the set parameters [1–5].

The composition of dust detained by devices belonging to moulding sand processing line can be different and depends on many factors. On the one hand, the parameters of moulding sand for example. Humidity and temperature of moulding sand thermal loading during casting directly are related to the ratio of the mass of metal/moulding sand in the mould and on the other hand, of the settings and technical parameters of devices [6−8].

The article presents results of research about surface dust from the dry dedusting system of moulding sand with bentonite. The aim of the study was to compare morphology of the surface of dust from the dry dedusting system of moulding sand with the initial mixtures of bentonite with lustrous carbon carrier. These mixtures were introduced into the moulding sand in the period in which the samples collected dust. Chemical analysis of the surface for tested samples was also conducted.

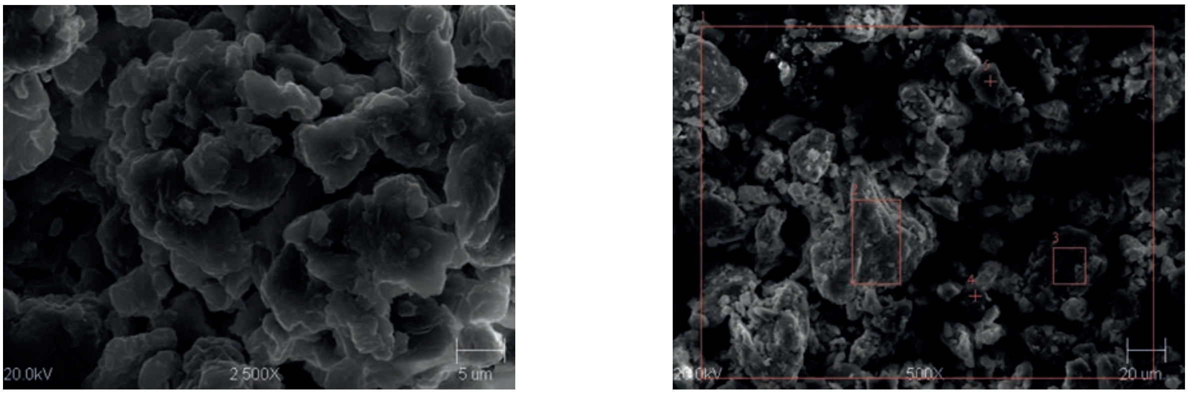
2. Materials and research methods

The study involved a mixture of bentonite-Kormix 75 production by Zębiec Company and three samples of dust from the dry dedusting system of moulding sand with bentonite with different exhaust power fans: D1 (70% power of extractors), D2 (80% power of extractors) and D3 (100% power of extractors). During the sampling of dusts, the refresh process of green sand and a mixture of bentonite-Kormix 75 added in an amount of 1%, was carried out. The study was carried out using a scanning electron microscope JEOL JSM5500 LM. Sample preparation consisted in vacuum vapor deposition of carbon in order to dissipate static electricity. A series point and surface analysis was carried out.

3. Results and discussion

A microscope image of a mixture of bentonite-lustrous carbon carrier Kormix 75 is shown in Figure 1. In Table 1, the chemical composition of the marked areas are shown.

In the mixture of bentonite with lustrous carbon carrier Kormix 75 local and surface analysis showed that the composition is dominated by the carbon carrier and the usual ingredients of bentonite. During the analysis of a large area (area 1) also detected were small amounts of heavy metals (cadmium and antimony). In other areas, these elements are not found.



A) B)

Fig. 1. The mixture of bentonite-lustrous carbon carrier Kormix 75 zoom ×2500 (A) and ×500 with selected areas of chemical analysis (B) [1,6]

Rys. 1. Mieszanka bentonit-nośnik węgla błyszczącego Kormix 75, powiększenie ×2500 (A) i ×500 z oznaczonymi obszarami analizy składu chemicznego (B) [1,6]

Table 1. Chemical composition of a mixture of bentonite-lustrous carbon carrier Kormix 75 [1,6]

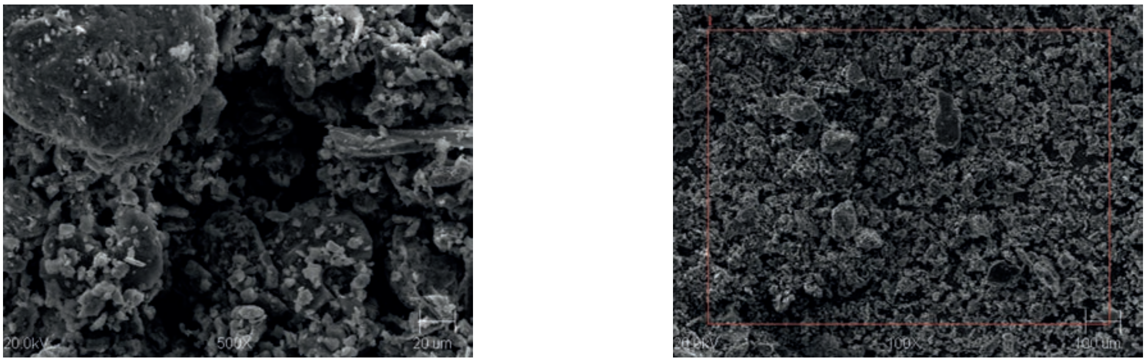
Tabela 1. Skład chemiczny mieszanki bentonit-nośnik węgla błyszczącego Kormix 75 [1,6]

Component/ Pierwiastek	Concentration, wt. % / Stężenie, % wag.				
	Area 1 / Obszar 1	Area 2 / Obszar 2	Area 3 / Obszar 3	Area 4 / Obszar 4	Area 5 / Obszar5
C	52.50	20.78	88.12	57.19	78.51
O	33.13	48.10	10.36	33.38	15.24
Na	0.61	1.49	0.16	0.61	0.31
Mg	0.48	1.29	0.09	0.29	0.35
Al	4.15	8.18	0.24	2.43	1.48
Si	7.32	18.99	0.30	5.22	3.20
S	0.06	0.05	0.24	0.09	0.16
K	0.04	0.08	0.18	0.05	0.09
Ca	0.43	0.39	0.32	0.30	0.22
Fe	0.87	0.66	–	0.44	0.44
Cd	0.25	–	–	–	–
Sb	0.15	–	–	–	–

Analysis of microscopic images, obtained due to high magnification, also enables describing surface morphology of the tested samples. In the case of the starting mixture bentonite-lustrous carbon carrier Kormix 75 there can be observed a specific layered structure for that group of materials. The packets form agglomerations of bentonite and on their surface there is a layer of the lustrous carbon carrier.

Figures 2–4 show microscopic images of dust D1, D2 and D3 with areas of chemical analysis.

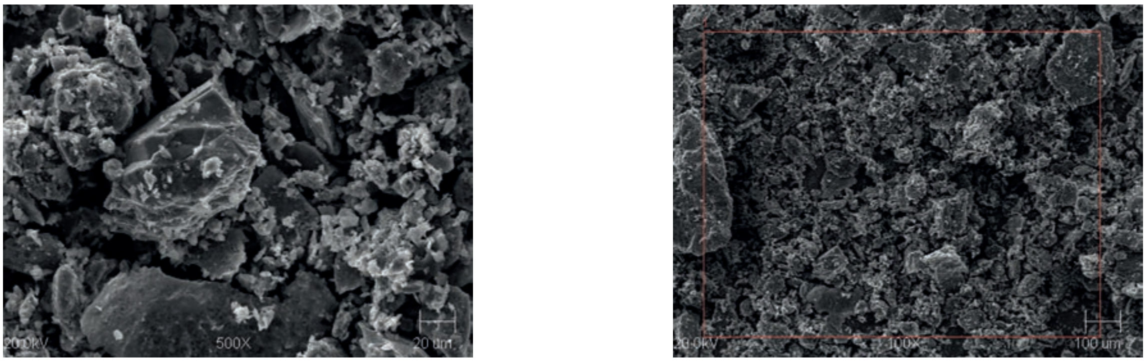
Table 2 shows a local analysis of chemical composition of tested samples of dust.



A) B)

Fig. 2. Microscopic image of dust D1 with zoom ×500 (A) and ×100 with selected areas of chemical analysis (B) [1,6]

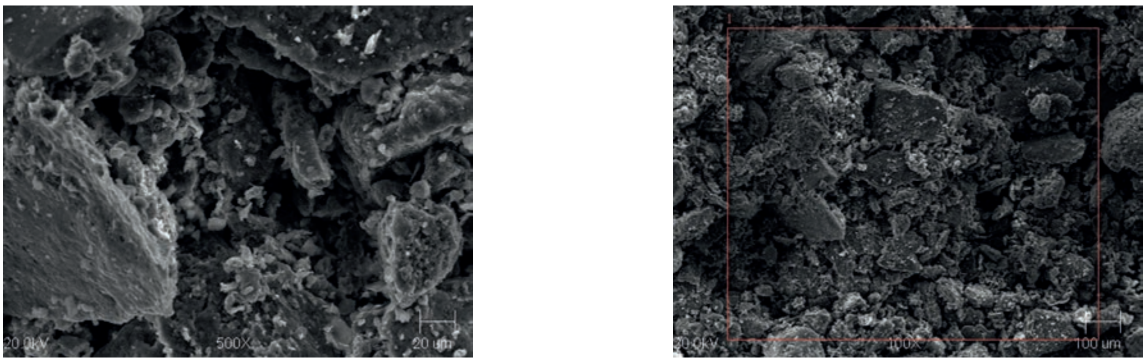
Rys. 2. Obraz mikroskopowy pyłu 1 w powiększeniu ×500 (A) i ×100 z oznaczonymi obszarami analizy składu chemicznego (B) [1,6]



A) B)

Fig. 3. Microscopic image of dust D2 with zoom ×500 (A) and ×100 with selected areas of chemical analysis (B) [1,6]

Rys. 3. Obraz mikroskopowy pyłu 2 w powiększeniu ×500 (A) i ×100 z oznaczonymi obszarami analizy składu chemicznego (B) [1,6]



A) B)

Fig. 4. Microscopic image of dust D3 with zoom ×500 (A) and ×100 with selected areas of chemical analysis (B) [1,6]

Rys. 4. Obraz mikroskopowy pyłu 3 w powiększeniu ×500 (A) i ×100 z oznaczonymi obszarami analizy składu chemicznego (B) [1,6]

Table 2. Chemical composition of dust D1, D2 and D3 in marked areas from Figures 2–4 [1,6]

Tabela 2. Skład chemiczny pyłów D1, D2 i D3 w obszarach oznaczonych na rysunkach 2–4 [1,6]

Component/ Pierwiastek	Concentration, wt. % / Stężenie, % wag.		
	D1	D2	D3
C	48.75	46.08	44.43
O	26.84	32.32	34.90
Na	0.84	0.66	0.79
Mg	0.37	0.68	0.66
Al	7.33	5.75	4.39
Si	10.18	11.22	12.26
S	0.03	0.00	0.25
K	0.26	0.18	0.22
Ca	0.22	–	0.31
Fe	1.29	–	1.36
Cd	0.18	–	0.23
Sb	0.27	–	0.22
Pb	0.48	–	–
Bi	2.95	–	–

Already at relatively low magnification there can be seen a difference in scanning images of dust compared to the reference sample, that is the starting mixture of bentonite-carbon carrier. As a result of the technological processes, it comes to degradation of the packet structure of bentonite. Individual packages not present in the agglomerations form and are characterized by a significant increase of dispersion degree. On the microscopic images single grains of quartz sand surrounded by a small fraction of bentonite can be observed.

As shown in Table 2, along with an increase in power extractor located in the processing station of moulding sand with bentonite increases the average amount of silica in the dusts. This is due to individual grains of sand entrained by the exhaust fans with lighter weight fractions of moulding sand components. The process of dedusting should therefore be carried out with properly selected operating parameters of the dedusting equipment. Incorrect parameters of the dedusting system may lead to the removal not only of the dust but also the valuable components of moulding sand, i.e. bentonite and lustrous carbon carrier. It is necessary to supplement them which leads to raising the costs of preparation of the moulding sand, which in turn contributes to the cost of castings. These losses may affect the profitability of production or reduction of competitiveness among producers of castings. The generation of large quantities of dust enforces the need for their utilization. This leads to additional costs connected with their recycling or disposal.

4. Conclusions

1. Studies made by scanning electron microscopy allow the surface morphology of tested samples and also the approximate chemical composition to be determined.

2. Samples for testing should be representative, to increase the accuracy of measurements, because the analysis of chemical composition takes place merely on the surface and not in the whole volume of the sample.

3. The starting mixture bentonite-lustrous carbon carrier Kormix 75 is characterized by a specific layered structure for that group of materials. The bentonite packets form agglomerations.

4. As a result of the technological processes, it comes to degradation of the packet structure of bentonite. Individual packages of bentonite not present then in the agglomerations form and are characterized by a significant increase of dispersion degree.

5. The process of dedusting of used moulding sand should be carried out using properly selected operating parameters of dedusting equipment. If the process of dedusting is carried out incorrectly it can lead to the loss of valuable components of moulding sand such as bentonite and lustrous carbon carrier. Producers of castings are forced to incur additional costs associated with the need to supplement lost moulding sand components and the cost of disposal of large quantities of waste.

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