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EFFECT OF ACTIVATION TIME ON THE PROPERTIES OF METALLURGICAL SLAGS

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ABSTRACT

The massive accumulation of production and consumption waste at industrial enterprises speaks not only about the imperfection of production technologies and the irrational use of waste as secondary resources but also about the presence of environmental problems. In this regard, research on the possibility of using waste in various industries is becoming increasingly relevant. The purpose of this work is to study the properties of slags of metallurgical production and to assess the possibility of their use as a filler of protective coatings for cast iron casting. The results of the conducted studies have shown that the main mineral of the KKC-1 and KKC-2 slags is cryptocrystalline granite. The average particle size of the initial slags KKC-1 and KKC-2 is 100.4 and 100.9 microns, respectively. The total slag surface was: for KKC-1 - 1393 cm^2/cm^3, for KKC-2 - 1452 cm^2/cm^3.After activation for 20 minutes, the average size of slag particles KKC-1 decreases to 8.1 µm, the total surface increased to 14272 cm^2/cm^3, slag KKC-2 - to 80.5 µm, the total surface increased to 2210 cm^2/cm^3. The activation time significantly affects the morphological characteristics of the particles. There were no significant differences between the samples during machining in the interval of 5-20 minutes. However, treatment for 20 minutes leads to a significant reduction in the size of the plate-shaped particles, while the surface of the particles after activation for 20 minutes is characterized by a much more developed surface. SEM studies of the KKC-2 sample before and after activation showed that there were no significant differences in the size and morphological characteristics of the particles after activation of the sample in the interval of 5-10 minutes. Thus, according to the research results, it can be concluded that it is possible to recommend the use of KKC-1 slag for coatings after its activation for 20 minutes in a planar centrifugal mill. KKC-2 slag can be used in formulations only after its activation in another way.

Keywords: graphite-containing waste, cast iron, non-stick coatings, activation, average particle size, chemical composition.

INTRODUCTION

In the last decade, changed criteria of product quality, because modern technology must meet the criterion of sustainable development, which include in addition to economic indicators, environmental and social [1, 2].

The importance of integrated waste recycling can be considered in several aspects:

- firstly, waste disposal allows solving environmental protection tasks, freeing up land alienated for dumps and sludge storage;
- secondly, industrial waste largely covers the need of a number of processing industries for raw materials;
- thirdly, with the integrated use of raw materials, the specific capital costs per unit of production are reduced and their payback period is reduced, non-production costs of the main production associated with the storage of waste, construction and operation of storage facilities for them, etc. are reduced [3].

The choice of technological solutions in the use of technogenic resources is determined by such factors as the presence of large-scale technogenic formations in the region, which makes them promising raw materials for the development of high-tech industries.

Currently, waste from various industries is used as a refractory filler or additives in the compositions of molding and core mixtures, coatings used in foundry production [4-8].

The experience of using technogenic waste from various industries in the compositions of non-stick coatings is described in [9-13]: spent alumochrome catalyst [9]; waste from galvanic production [12], waste from abrasive and metallurgical production [13], scrap of high-magnesia periclase refractories [14], etc.

All works show that the replacement of traditional fillers with waste leads to an increase in the technological properties of the coatings and a decrease in the amount of burn on the surface of the castings.

One of the most valuable components of products used in many industries is graphite, which is either extracted from graphite ore or obtained by pyrolysis of black coal [15].

Graphite is used to make non-stick coatings for foundry production [16-25], additives for molding and core mixtures [26-33], nonstick dusting [26], modifiers [34, 35], waste water treatment compounds [36], antifriction materials [37] and other products.

In order to improve the quality of natural graphite, it is subjected to mechanical activation and enrichment by separate and complex activation methods [38-49].

Graphite-containing waste can partially meet the needs of metallurgical production in this valuable material [15].

Therefore, the purpose of this work is to study the properties of slags of metallurgical production and to evaluate the possibility of using slags as a filler for non-stick coatings for cast iron casting.

MATERIAL AND METHODS

The work investigated:

- samples of metallurgical slag (dust from the cyclone), which were selected in the mixing department from the cyclone - KKC-1;
- samples of metallurgical slag (dust from the cyclone), which were selected in the pig iron overflow department - KKC-2.

The average particle size, total surface and fractional composition of the slags were studied by laser light scattering at the PRO-7000 installation at the Novosibirsk Institute of Solid State Chemistry.

An XRD-7000 X-ray diffractometer was used to study the phase composition.

The study of morphological features, shape and particle size of samples of metallurgical slag KKC-1 and KKC-2 was carried out in the laboratory of electron-structural studies of the Center for Collective Use of Siberian Federal University, Krasnoyarsk, Russia, on electron microscope JEOL JSM 6490LV (Japan).
To increase the activity of slag particles, it was activated in the AGO-2 planetary centrifugal mill. The activation time varied from 1 to 20 minutes.

RESULTS AND DISCUSSIONS

The density of slag of both grades slightly exceeds the density of natural graphite due to the presence of impurities and is 2.1-3.1 g/cm^3. The humidity of the slag usually ranges from 0.25 to 1%.

KKC-1 and KKC-2 slags have the same composition, but in individual samples of KKC-1 slag, the carbon content can reach up to 60% (Table-1).

Table-1. Chemical analysis of dust.

Element	Content of elements, mas %	Element	Content of elements, mas%
C	30,76	TiO_2	0,32
Fe_{gross}	51,00	Al_2O_3	2,43
SiO_2	4,79	MnO	4,71
CaO	3,87	MgO	1,51
K_2O	0,17	Na_2O	0,34
P_2O_5	0,10		

Carbon is concentrated in large classes of slag of both grades. In classes of size 80-200, 200-500, 500-1000, 1000-3000 µm, the carbon content ranges from 73 to 85 %, a content of iron of 11-13 %.

The mineralogical composition of slags of both grades is represented by magnetite (60-65%), wustite (5-8%), graphite (≈15%), small amounts of hematite, quartz, calcite and glass phase. The iron content in the form of a metal is less than 1%. Graphite consists mainly of a cryptocrystalline variety.

The average particle size of KKC-1 slag is 100.4 µm, KKC-2 slag is 100.9 µm. Such graphite parameters cannot guarantee high sedimentation stability to non-stick coatings, therefore it is necessary to mechanically activate the slags before use (Table-2).

Table-2. Particle parameters.

Slag	Activation time, min	Granulometric composition, %			Average particle size, µm	Total surface, cm^2/cm^3
		1-10	10-50	> 50		
KKC-1	0	2,3	18,2	79,5	100,4	1393
	1	5,0	26,9	68,1	76,8	2023
	5	10,4	43,4	46,2	44,1	3421
	20	49,7	50,3	0,0	8,1	14272
KKC-2	0	2,4	17,4	80,2	100,9	1452
	1	3,0	20,2	76,8	96,1	1648
	5	3,1	19,7	77,2	97,5	1676
	20	5,8	24,8	70,2	80,5	2210

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Figure-1 shows the SEM image of the KKC-1 sample before and after activation.

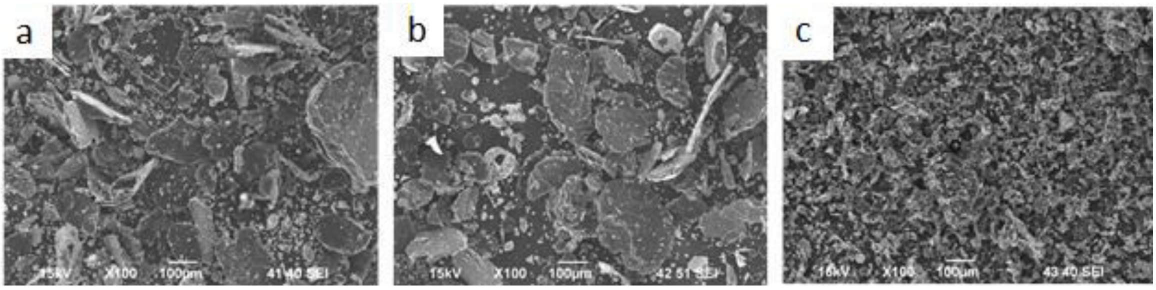

Figure-1. SEM image of the KKC-1 sample: a - initial sample; b - after activation for 5 minutes; c - after activation for 20 minutes

The activation time significantly affects the morphological characteristics of the particles. There were no significant differences between the samples in the treatment interval of 5-20 minutes. However, treatment for 20 minutes leads to a significant reduction in the size of the plate-shaped particles, while the surface of the particles after activation for 20 minutes is characterized by a much more developed surface.

Figure-2 shows the SEM image of the KKC-2 sample before and after activation.

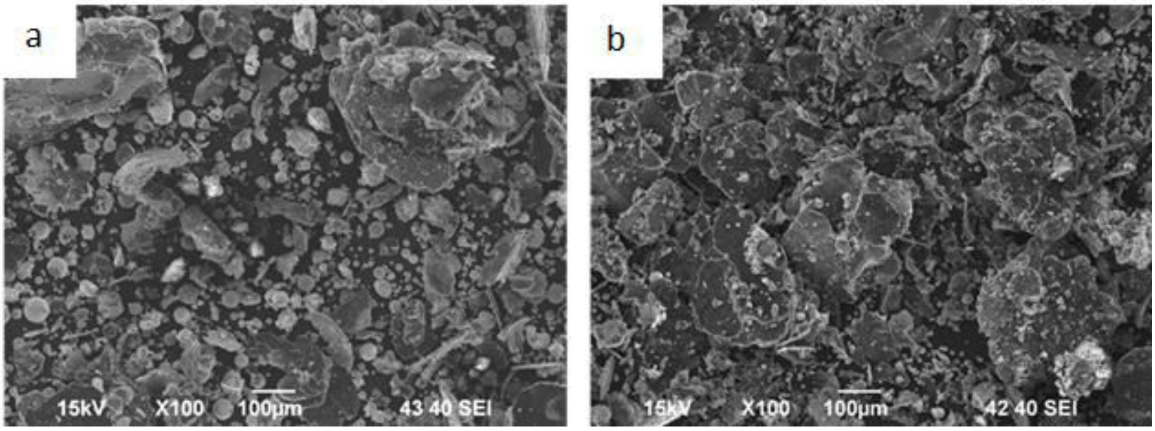

Figure-2. SEM image of the KKC-2 sample: a - initial sample; b - after activation for 5 minutes

SEM studies of the KKC-2 sample before and after activation showed that there were no significant differences in the size and morphological characteristics of the particles after the activation of the sample in the interval of 5-20 minutes.

CONCLUSIONS

The results of the conducted studies have shown that the main mineral of the KKC-1 and KKC-2 slags is cryptocrystalline graphite. Initially, the average particle size of KKC-1 and KKC-2 slags is 100.4 and 100.9 μm, respectively. The total slag surface was: for KKC-1 - 1393 cm^2/cm^3, for KKC-2 - 1452 cm^2/cm^3.After activation for 20 minutes, the average size of slag particles KKC-1 decreases to 8.1 μm, the total surface increased to 14272 cm^2/cm^3, slag KKC-2 - to 80.5 μm, the total surface increased to 2210 cm^2/cm^3.The activation time significantly affects the morphological characteristics of the particles. There were no significant differences between the samples during the treatment interval of 5-20 min. However, treatment for 20 minutes leads to a significant reduction in the size of plate-shaped particles, while the surface of the particles after activation for 20 minutes is characterized by a significantly more developed surface.SEM studies of the KKC-2 sample before and after activation showed that there were no significant differences in the size and morphological characteristics of the samples after activation of the sample in the interval of 5-20 minutes. Thus, according to the research results, it can be concluded that it is better to use KKC-1 slag in coatings after its activation for 20 minutes in a planetary centrifugal mill. KKC-2 slag can be used in formulations only after its activation in another way.

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