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CHEMICAL COMPOSITION OF FeNi ALLOY PRODUCTION SLAG

At present the complex use, the complete utilization of production wastes and the decrease of environmental pollution are very urgent problems. Wastes can be considered as anthropogenic sources of mineral resources. As the cost of raw materials goes up the wastes processing and their utilization have to be introduced wider. Some wastes can be used as a substitute in both materials and products that are applied in various spheres of human activity. One of the perspective kinds of wastes is metallurgical slag. Ferroalloy slag is applied as fertilizers, to neutralize industrial drainage, to produce cement clinker and in road building.

The aim of paper is to clarify possibilities to make use of metallurgical slag in the production of multicomponent building materials. The object of research is slag of Pobuzhskiy ferronickel plant (PFNP) to produce an alloy of iron and nickel.

The use of slag as a building material needs research on its chemical composition, structure, inertness in water, resistance to lixiviation and other factors.

Mineralogical composition of slag of PFNP. The composition of a slag crystalline part is specified by X-ray analysis taken with the powder diffractometer Siemens D500 in copper radiation with a graphitic monochromator. The slag of PFNP contains the main minerals $Ca(Mg,Fe,Al)(Si,Al)_2O_6$ diopside aluminian and $CaMg(SiO_3)_2$ diopside which belong to a group of clinopyroxene that are silicates or aluminum silicates. Crystalline diopside is a chemically inert substance. Diopside hardness on Mohs scale is 6,9-7,2. The diopside structure is on fig. 1. Silicate tetrahedrons are united in the group of three where an edge of a tetrahedron and vertices of two neighboring tetrahedrons are united. The groups of tetrahedrons are located between layers which consist of magnesium octahedrons (darker in colour) and distorted eight-vertex figures (light in colour). The structures of diopside type might contribute to formation of solid solutions which contain other cations. The layer structure of diopside might predispose it to demonstrate sorption properties. The explicit wavy characteristic of the background of both diffraction patterns enables to suppose that the samples have an amorphous phase.

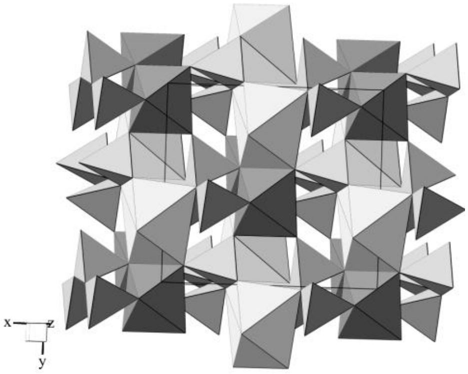

Fig. 1 – Diopside structure: a=9,750; b=8,926; c=5,251Å; β=105,90°

X-ray analysis shows that slag samples, a dry one and a sample that has been soaked in water for one month, are alike and contain one or several phases having the diopside structure $CaMgSi_2O_6$. Analysis by Rietveld method indicates that the soaked slag sample contains insignificant quantities of quartz SiO_2, margarite $Ca_{0,88}Na_{0,12}Al_2(Si_{2,12}Al_{1,88}O_{10})(OH)_2$, albite $NaAlSi_3O_8$ and illite $K(Al_4Si_2O_9(OH)$. Weight content of diopside is 92,4 %, quartz – 3,1 %, margarite – 1,8 %, illite – 0,9 %, albite – 1,9 %. Presence of quartz and albite might be stipulated by the wash-out of surface dispersed constituents into the solution. Unlike this, margarite and illite can be formed when slag minerals and water interact.

Estimation of the mineralogical composition of slag enables to classify it according to acid-base properties using the modules of acidity (Ma) and basicity (Mb) which are accordingly equal to the addition of acid and main oxides and vice versa:

$$Ma = \frac{SiO_2 + P_2O_5 + TiO_2 + B_2O_3}{CaO + MgO + FeO + MnO}; \qquad Mb = \frac{CaO + MgO + FeO + MnO}{SiO_2 + P_2O_5 + TiO_2 + B_2O_3}.$$

Slag oxide composition enables to correctly calculate its acid-base properties (table 1). Amphoteric oxide Al_2O_3 in acid slag reveals itself as basic. It has been taken into account during calculations. Slag is acid.

Table 1 – Slag oxide makeup of PFNP ferronickel production, acidity and basicity modules

Oxide mass fraction, %									Ma	Mb
CaO	MgO	SiO_2	FeO	Al_2O_3	Cr_2O_3	MnO	TiO_2	others	1,38	0,72
12,5	9,0	50,0	14,0	7,0	1,5	0,9	0,4	< 0,2		

Crystal phases in acid slag are well crystallized and an amorphous phase is 50 % of volume. It is associated with initial acidity of melt. Acidity growth sharply increases viscosity and decreases the crystalline ability of silicate melt. Viscous and acid melt hardening is usually accompanied by glass formation. In the case under scrutiny it is confirmed by diffraction patterns and micropictures where you can clearly see a glass phase and loose pores on the surface of a non-atomizated sample.

Element composition of slag of PFNP. Chemical elemental composition of slag is determined by means of the electron probe microanalysis (EPMA) method on the scanning electron microscope JSM-6390 LV with the system of micro roentgen analysis INCA.

The elemental compositions of the granulometric factions of PFNP are practically identical (table 2). The content of heavy metals is low.

Atomic absorption analysis on the spectrophotometer Saturn additionally discovered the copper content of $4{,}8 \cdot 10^{-4}$ % and cobalt content of $3{,}0 \cdot 10^{-3}$ %.

Tests on the desorption of the cations into acid solutions and alkalis within 24 hours indicate that the metal ion concentration is lower than sanitary standards, mg/dm^3: Cu^{2+} - 1; Co^{2+} - 0,1 (table 3).

Table 2 – Elemental composition of slag samples of PFNP

Chemical element	Mass concentration of element, %	
	fraction, mm	
	>20	<2,5
O	63,94	52,60
Na	0,57	0,00
Mg	3,50	3,15
Al	4,44	8,95
Si	17,28	18,01
S	0,07	0,10
Cl	0,06	-
K	0,18	0,24
Ca	6,38	8,76
Ti	0,11	0,15
Cr	0,23	0,65
Mn	0,19	0,40
Fe	3,05	7,00

Table 3 – Results of atomic absorption analysis to desorb copper and cobalt ions out of slag of PFNP into solutions of various compositions

Element	Mass concentration of metal ions, mg/dm^3	
	after desorption into solution	
	1 H H_2SO_4	1 H NaOH
Cu^{2+}	0	0,04
Co^{2+}	0,08	0,05

Slag radioactivity. Gamma-ray spectrometry analysis of slag is made by means of a scintillation gamma-ray spectrometer. Slag composition contains radionuclides: ^{226}Ra, ^{232}Th и ^{40}K. The parameter C_{eff} for slag factions does not exceed 370 Bq/kg. It is the first class radiation hazard. According to radiation characteristics, slag can be used as a building material.

Thus, according to the mineralogical, elemental and radionuclide composition as well as the absence of the toxicity and chemical stability of the metallurgical slag of PFNP, it can be used as a filling agent of multicomponent concrete.

Table 4 – Results of gamma-ray spectrometry analysis of slag factions

Slag fractions (mm) to produce FeNi alloy	C_i, Bq/kg			$C_{sum.}$, Bq/kg	$C_{eff.}$, Bq/kg
	^{40}K	^{226}Ra	^{232}Th		
<2,5	112,0	63,0	36,3	211,0	120,0 ± 12,5
10-20	84,3	53,1	44,5	182,0	119,0 ± 13,1
>40	67,3	61,8	37,0	166,0	116,0 ± 13,5

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RESEARCH OF SORPTIVE FEATURES OF SLAG

Reuse of industrial waste in various industries, including construction materials wastes requires prior research of their chemical properties, surface structure and sorption activity.

The aim of the work was to determine the sorption capacity of metallurgical slag of Pobuzhsky Ferronickel Plant (PFNK) with respect to the organic dye methylene blue (MB).

PURPOSE: determination of the change of surface morphology under different conditions, to ascertain the conditions of slag activation with increasing of speed and sorption capacity.

Morphological features of slag surface were studied by means of scanning electron microscope JSM-6390 LV. Using of scanning electron microscopy showed the presence of the amorphous state of substances and the structure-porosity on the sample surface of PFNK slag. According to characteristics of the surface layer, slag is a good sorbent with numerous microscopic protrusions, recesses, and the presence of sorption active centers.

To increase the degree of loosening the surface, increasing the number of compounds in the amorphous state and increase of sorption capacity of slag is necessary to conduct its chemical activation. Microscopic examination of slag