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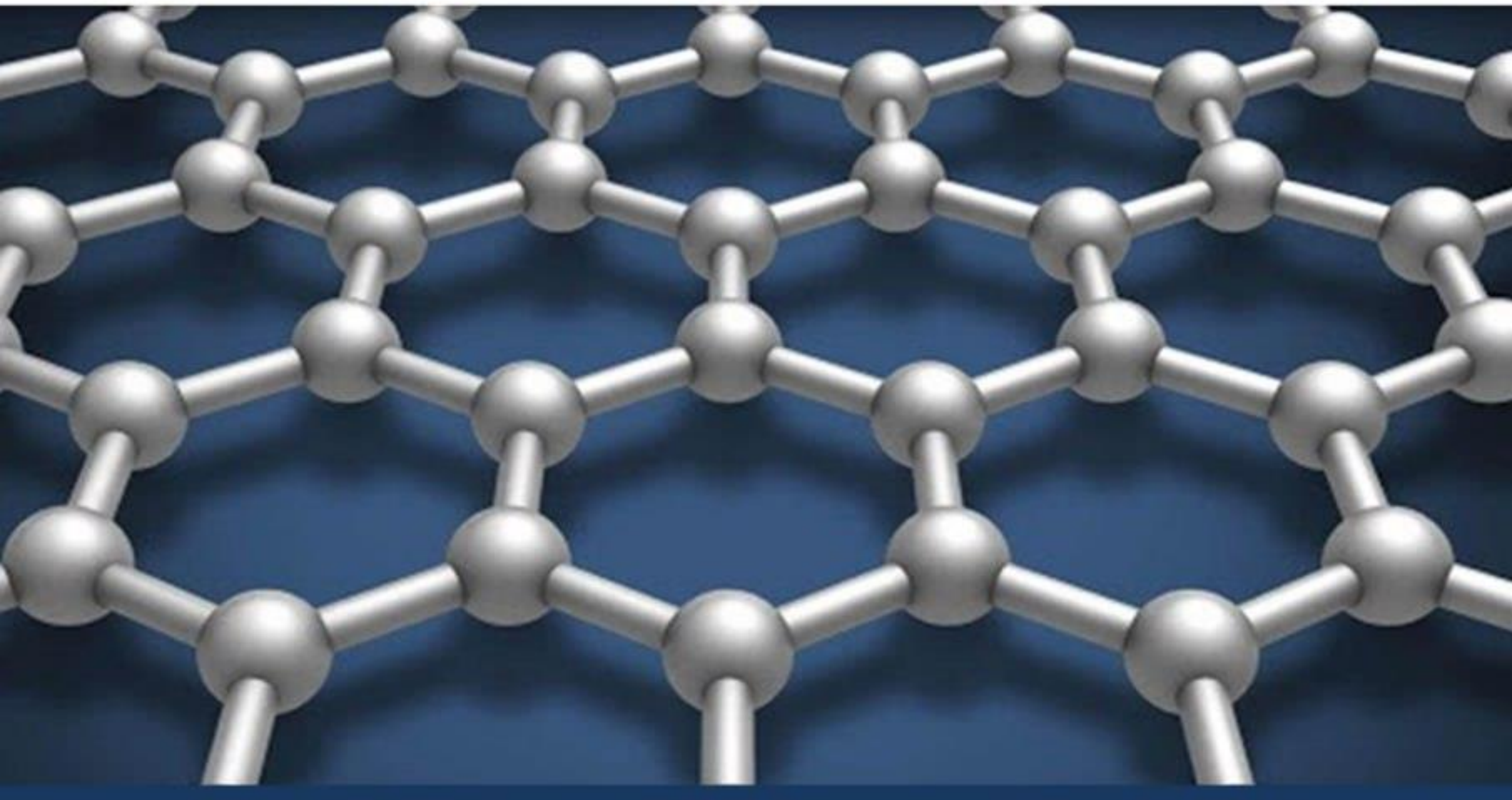
O‘zbekiston

Kompozitsion Materiallar

Ilmiy-texnikaviy va amaliy jurnali



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Композиционные материалы

Key words: fatty acids, oleic acid, cottonseed oil, alkanolamines, surfactants, amidation, hydrophilicity, hydrophobicity, oil in water.

In order to obtain surfactants based on fatty acids and alkanolamines, the reactions of oleic acid and cottonseed oil with mono- and diethanolamine were studied. The composition and structure of the resulting acid amides were analyzed by IR spectroscopy, the amount of formed amides was determined from the amount of free acids in the reaction mixture. It is proved that at an average intensity of 1622.15 cm^{-1}, the region belongs to the bending vibrations of ammonium salts N^+OOC formed by the carbonyl groups of fatty acids C = O and the amine groups of alkanoamines.

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DETERMINATION OF THE THEORETICAL VISCOSITY OF THE CONVERTER SLAG AND THE FACTORS AFFECTING IT

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Introduction. The understanding of many pyrometallurgical processes depends on the knowledge of the viscosity of solutions, on which little information is available [1].It is known that the viscosity of a liquid is defined as the ability to resist the mutual movement of its parts [2]. The force required to maintain a constant difference in velocities for two layers of fluid with a contact area S and moving with a force F with speeds v_1 and v_2 can be expressed as [3]:

$$F = \eta S \frac{v_1 - v_2}{x} \qquad (1)$$

Where: x is the distance between the layers measured perpendicular to the direction of movement, and η is the viscosity. Viscosity in solutions of salts (oxides) with more than two cations is determined by the ability of one part of the ionic group to move in relation to another part [4]. A part of the anion group is determined by one cation and salt (oxide) anions connected to this ion. In deriving the equation, to simplify the discussion, it is assumed that the ionic group consists of a single cation with a number of anions equal to the valence of that cation.It is explained by additional factors that accelerate or delay this movement of ions depending on the strength of interaction between ions of opposite sign [5]. The resistance to movement between two groups of ions and, as a result, the viscosity of the dissolved salt (oxide) increases with the strength of this interaction. The force of attraction F between two ions of opposite sign is defined by Coulomb's law [6]:

$$F = \frac{z_1 z_2 e^2}{d^2} \qquad (2)$$

Where z_1 and z_2 are ion valences, e is the charge of an electron, and d is the distance between the centers of ions. To use this equation to determine the absolute viscosities (in Poise) of dissolved salts (oxides) near their melting points, the coefficient k must be introduced, and the equation takes the final form [7]:

$$\eta = \frac{z_k e^2}{d^2}(3r - d)(n + 1)k \qquad (3)$$

The coefficient k is expressed in sec/cm^3 and it depends on the type of anion. When k was calculated from experimental data, its value was found to be equal to 10 for chlorides and fluorides, and 104 for sulfides and oxides. If there are empirical data on the viscosity of a single salt with a given anion, it will be possible to calculate the k coefficient for salts with any anion.

Materials and methods. Empirical data on the viscosity of several materials are presented in Table 1 along with theoretical values calculated from the equation proposed in this study. This shows that the proposed equation can be used to calculate the viscosity of dissolved salts (oxides) with two or fewer anions per cation. This is due to the assumption that the proposed equation does not take into account the interaction force for salts (oxides) with more than two anions per cation and the effective path of this force (between groups of ions) depends. The viscosities of the main components in the converter slag calculated on the basis of the proposed equation for several sulfides and oxides for which experimental data are not available are presented in Tables 1.

Table 1

The amount, viscosity, and fluidization temperature values of the components that make up the converter slag obtained in this study

Formulation of components in slag	Amount of components in slag, %	Viscosity, Poise	Melting point, °C
Cu_2O	2,045	21,6	1242
Na_2O	2,438	9,35	1132
K_2O	1,367	5,20	740
MgO	1,227	38,85	2825
CaO	1,450	25,10	2570
PbO	0,449	33,60	886
FeO	24,035	36,75	1377
ZnO	0,782	50,25	1975
Al_2O_3	5,973	94,30	2044
SiO_2	28,918	247,0	1600
BaO	0,125	14,35	1920
Fe_3O_4	19,773	65,14	1538
TiO_2	0,247	142,0	1843
FeS	7,548	42,1	1194
Cu_2S	3,617	20,5	1129

Using the specific viscosity values of the main components of the slag given in Tables 1, the average viscosity of the Almalyk Mining-Metallurgical Combine (AMMC) converter slag obtained for the study was determined by the following expression:

$$\eta_{slag} = \frac{\omega_1 \cdot \eta_1 + \omega_2 \cdot \eta_2 + \ldots + \omega_n \cdot \eta_n}{100} \qquad (4)$$

Where: ω_1, ω_2, and ω_n are the respective mass fractions of each component that makes up the slag, %; and η_1, η_2, and η_n are their respectiveindividual viscosities, Poise.

Results and discussion. Using the formula (4), the partial viscosity values of each component were initially determined, and these values are presented in Table 2.

Table 2

The share of each slag component in the total viscosity

№	Formulation of components in slag	Partial viscosity, Poise	№	Formulation of components in slag	Partial viscosity, Poise
1	Cu_2O	0,4418	9	Al_2O_3	5,6326
2	Na_2O	0,2280	10	SiO_2	71,4281
3	K_2O	0,0711	11	BaO	0,0179
4	MgO	0,4769	12	Fe_3O_4	12,8802
5	CaO	0,3639	13	TiO_2	0,3509
6	PbO	0,1508	14	FeS	3,1779
7	FeO	8,8329	15	Cu_2S	0,7416
8	ZnO	0,3933	16	Total	105,1886

The results of the calculations showed that the average viscosity of the converter slag selected for the study was approximately 105.2 Poise.

When the values presented in Table 2 are expressed in a pie chart, the main part of the total viscosity in the slag system was contributed by the quartz (SiO_2) material (Fig.1).

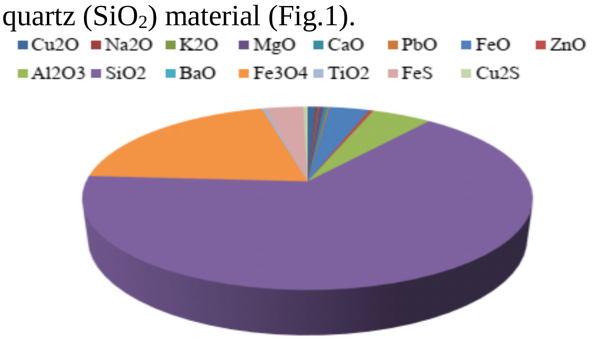

Fig.1. The proportion of each component in forming the viscosity of the converter slag

However, it is impossible to change the amount of quartz while the process is taking place, affecting the viscosity of the slag. Because quartz fluxes are necessarily added in order to bind iron oxides during the conversion process. Most of the aluminum oxide (Al_2O_3) is added to the process through these quartz fluxes. Magnetite mineral is formed during the process itself due to the excess concentration of oxygen.

From the pie chart shown in Figure 1, it can be seen that, after quartz, the substances with the largest share in terms of viscosity are magnetite, wustite, and aluminum oxides. Except for magnetite, all oxides in the slag system chemically bond with each other and form chemical compounds. Physico-chemical properties of these oxides can be changed by adding lime (CaO) or sodium oxide (Na_2O) to the system. However, since the magnetite mineral is formed from the union of two different oxides of iron ($FeO + Fe_2O_3 = Fe_3O_4$), it cannot chemically connect with these auxiliary flux materials and its chemical composition remains unchanged. The amount of magnetite in the slag can be affected only by reducing or sulphiding substances. An increase in the amount of magnetite in the converter slag of copper production increases the viscosity of the slag and reduces its fluidity. The main reason for this is due to the high temperature of liquefaction of magnetite formed in the slag system, magnetite crystals are formed in the silicate solution in the temperature range of 1200-1250 °C, that is, a suspension of solid magnetite particles is formed in the volume of liquid converter slag. The viscosity of the liquid converter slag increases rapidly due to this process of heterogenization in the slag system. This can be understood from the statistical data presented in Table 3 in the form of an increase in the amount of magnetite in the slag solution, as well as an increase in the total viscosity of the system.

Table 3

Values of changes in slag viscosity as the amount of magnetite in the converter slag increases

№	Amount of magnetite in slag, %	Total viscosity of slag, Poise	№	Amount of magnetite in slag, %	Total viscosity of slag, Poise
1	12,3150	103,3501	11	26,2449	106,7836
2	16,2702	104,3253	12	27,0498	106,9819
3	19,7731	105,1886	13	27,8537	107,1801
4	20,3255	105,3248	14	28,6567	107,3780
5	21,3966	105,5887	15	29,4589	107,5757
6	22,2068	105,7884	16	30,2601	107,7731
7	23,0164	105,9879	17	31,0604	107,9704
8	23,8249	106,1872	18	31,8598	108,1674
9	24,6325	106,3862	19	32,6584	108,3642
10	25,4391	106,5850	20	33,4560	108,5608

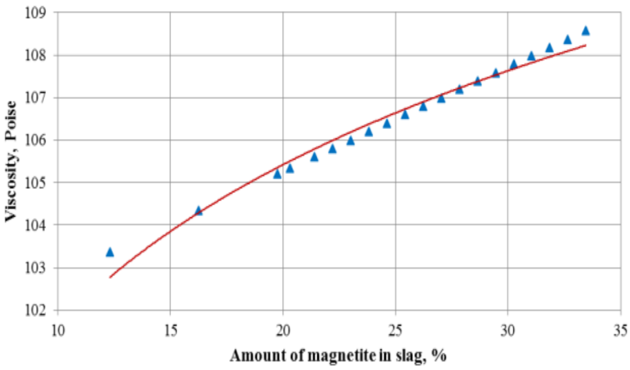

Fig.2. Changes in the total viscosity of the slag as the amount of magnetite in the converter slag increases

From the values presented in Table 3 and the graph depicted in Figure 2, it can be seen that the total viscosity of the system increased linearly with the increase in the mass of magnetite in the oxides in the slag.

In metallurgical practice, if the viscosity is up to 10 Poise, such slags are called liquid slags, and they are very fluid. Slags with a viscosity of 10 to 50 Poise are slags with an average viscosity, and their fluidity also meets regulatory requirements. But metallurgical slags with a viscosity of 50-200 Poise are very viscous and are called thick slags in the industry. Such slags are very difficult to flow and pour from metallurgical smelting furnaces to ladles or from ladles to furnaces, and the processing of such slags and the extraction of copper from their composition cause many difficulties. Therefore, in the processing of such slags, it is possible to decrease the amount of magnetite in them and at the same time decrease the viscosity of the slag.

The viscosity of the matte droplets suspended in the slag phase and the corresponding concentrations are presented in Table 4.

Table 4

Viscosities of matte droplets with different compositions

№	Cu_2S	FeS	Cu_{matte}	Fe_{matte}	S_{matte}	The corresponding matte's viscosity, Poise
1	19,167	80,833	15,334	51,438	33,227	24,79923
2	21,66	78,34	17,328	49,852	32,819	24,54021
3	24,083	75,917	19,266	48,310	32,422	24,28849
4	26,394	73,606	21,115	46,840	32,044	24,04833
5	28,689	71,311	22,951	45,379	31,669	23,80983
6	30,922	69,078	24,738	43,958	31,303	23,57781
7	33,095	66,905	26,476	42,575	30,948	23,35199
8	35,242	64,758	28,194	41,209	30,596	23,12891
9	37,304	62,696	29,843	39,897	30,259	22,91465

10	39,399	60,601	31,519	38,564	29,916	22,69698
11	41,356	58,644	33,085	37,318	29,596	22,49365
12	42,689	57,311	34,151	36,470	29,378	22,35513
13	43,953	56,047	35,163	35,666	29,171	22,22376
14	45,207	54,793	36,165	34,868	28,966	22,09353
15	46,475	53,525	37,18	34,061	28,758	21,96169

From the values presented in Table 4, it can be observed that the total viscosity of the matte decreased with the increase of copper content in the matte droplets.

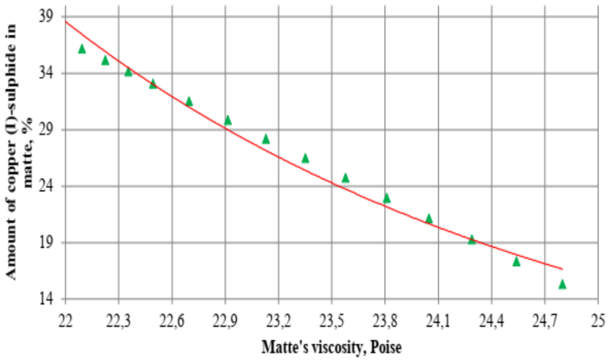

Fig.3. Variation of the viscosity of matte droplets with different compositions in the converter slag phase

The graph in Figure 3 shows the decrease in the viscosity of the matte as the mass fraction of copper sulfide in the matte increases. Increasing the amount of copper in the matte droplets in the slag phase is achieved by reducing magnetite in the slag.

Conclusion. The material composition of the converter slag selected as the research object was analyzed and it was determined that the main binary components of it are FeO, Al_2O_3, SiO_2, Fe_3O_4, FeS, and Cu_2S. It was found that copper and iron sulfides are matte droplets in a dispersed form suspended in the slag phase.

According to the results of research on finding the individual viscosity of binary compounds, it was found that among the main components of the slag system, binary compounds with the highest viscosity are SiO_2 and Fe_3O_4 compounds.

The respective combination of each component in the converter slag was assumed to be binary, and based on the mass fraction of these binary compounds and the respective individual viscosities, a methodology for determining the partial viscosity of the components was developed.

According to the results of the developed methodology, the viscosity of the converter slag selected for the experiment was approximately 105.2 Poise. It was found that converter slag having such a viscosity leads to deterioration of its further processing.

As the amount of magnetite in the converter slag increases, it was found that the total viscosity of the slag and the amount of oxidized copper in it increase.

This research allows to theoretically determining the viscosity of converter slags produced in the copper production process, but the obtained results are not the same as the practical results, but they are very close to the abstract value. The reason for this disproportion is explained by the excessive spray coefficient of oxygen supplied to the liquid bath during the converting process and the prolongation of the spray duration. Because each oxygen molecule entering the liquid bath destroys the fayalite structure and disintegrates iron and silicon oxides into individual states. As a result, a special magnetite phase and free quartz phases not bound to basic oxides appear in the system. These factors increase the viscosity of the slag and have a negative effect on the slag processing process. Therefore, it is necessary to optimize the physico-chemical properties of converter slags containing a large amount of iron before processing them. For example, it is proposed to combine the free quartz molecules that have increased due to the breakdown of the fayalite structure by neutralization with oxides of alkaline and alkaline-earth metals, and to reduce the increased magnetite molecules with local reducing agents.

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Kalit so‘zlar: konvertor shlaki, magnetit, kvarts, nisbiy yopishqoqlik, shteyn tomchilari, qayta ishlash, ta’sir etuvchi omillar.

Maqolada konvertor shlakining yopishqoqligini va unga ta’sir qiluvchi omillarni aniqlash masalalari ko‘rib chiqilgan. Tadqiqot obyekti sifatida “Olmaliq kon-metallurgiya kombinati”ning konvertor shlaklari tanlab olinib, ularning moddiy tarkibi rentgen difraktometrik tahlil yordamida aniqlangan. Mis ishlab chiqarishda ishlab chiqarilgan konvertor shlaklarining nazariy yopishqoqligini aniqlash metodologiyasi ishlab chiqilgan bo‘lib, unda shlakning asosiy tarkibiy qismlarining nisbiy yopishqoqligini aniqlash va ulardan shlakning o‘rtacha taxminiy yopishqoqligini topish uchun foydalanish taklif etilgan. Ishlab chiqilgan metodologiya bo‘yicha tajriba uchun tanlangan konvertor shlakining yopishqoqligi taxminan 105,2 Puazga teng. Olingan qiymat abstrakt qiymat bilan taqqoslangan. Bunday yopishqoqlikka ega bo‘lgan konvertor shlaklari uni Yallig‘ qaytaruvchi va Vanyukov pechlari kabi eritish pechlarida missizlantirishni qiyinlashtirishi aniqlangan. Shlakning yopishqoqligini oshiradigan omillar va ularni samarali bartaraf etish yo‘llari taklif qilingan.

Ключевые слова: конвертерный шлак, магнетит, кварц, парциальная вязкость, капли штейна, переработка, влияющие факторы.

В статье рассмотрены вопросы определения вязкости конвертерного шлака и факторов влияющих на нее. В качестве объекта исследования были выбраны конвертерные шлаки Алмалыкского горно-металлургического комбината, вещественный состав которых определен методом рентгенодифрактометрического анализа. Разработана методика определения теоретической вязкости конвертерных шлаков медного производства, в которой предлагается определять парциальные вязкости основных компонентов шлака в бинарном виде и по ним находить среднюю приблизительную вязкость шлака. Вязкость конвертерного шлака, выбранного для эксперимента по разработанной методике, была примерно равна 105,2 Пуаз. Полученное значение сравнивается с абстрактным значением. Установлено, что конвертерный шлак, имеющий такую вязкость, затрудняет его обезмеживание в плавильных печах типа отражательных и печей Ванюкова. Выявлены факторы, повышающие вязкость шлака, и предложены пути их эффективного устранения.

Key words: converter slag, magnetite, quartz, partial viscosity, matte droplets, recycling, influencing factors.

The article deals with the issues of determining the viscosity of converter slag and the factors affecting it. The converter slags of “Almalyk Mining and Metallurgical Combine” were selected as the research object, and their material composition was determined by X-ray diffractometric analysis. A methodology for determining the theoretical viscosity of converter slags produced in copper production has been developed, in which it is proposed to determine the partial viscosities of the main components of slag in a binary form and use them to find the average approximate viscosity of slag. The viscosity of the converter slag selected for the experiment according to the developed methodology was approximately equal to 105.2 Poise. The obtained value is compared with the abstract value. It has been found that converter slag having such viscosity makes it difficult to decopperize it in smelting furnaces such as Reverberatory and Vanyukov furnaces. Factors that increase the viscosity of slag have been identified and ways to effectively eliminate them have been proposed.

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С О Д Е Р Ж А Н И Е

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2. Физико-механика и трибология композиционных материалов

3. Разработка и технология получения композиционных материалов