

ТҮЙІНДЕМЕ

Жұмыс Қазақстанның Николаевское кенорнының төменсортты сульфидты мырыш концентраттарын өңдеу мен мыс-кадмийлі қалдықты аралық өнімін алу технологиясын құру бойынша өзекті мәселені шешуге бағытталған. Мақалада автоклавы шаймалау үрдісінен кейінгі, темір, мышьяк, сурьма, қорғасын, күкірт және марганецтен гидролитикалық тазарту арқылы алынған сульфатты мырыш ерітінділерін мыс пен кадмийден тазарту үрдісін эксперименталды зерттеу нәтижелері келтірілген. Мыс пен кадмийді цементациялық тазарту үрдісінің технологиялық тәртіптері зерттелуші өнімді ерітіндінің мыс пен кадмий қоспаларынан жоғары дәрежеде тазартылуын қамтитындығы анықталды (ерітіндідегі мыс пен кадмийдің құрамы – 2,98 г/дм³-ден төмен, ал мырыш мөлшері – 221,64 г/дм³). Алынған мыс-кадмийлі қалдық аралық өнімі мыс пен кадмий өнірісінде қолдану үшін жарамды болып табылады.

Түйінді сөздер: рентгенфазалық талдау, атомды-абсорбциялық талдау, температура, мырыш шаңы, бірсатылы тазарту, цементация, мыс-кадмийлі кек, концентрат.

РЕЗЮМЕ

Данная работа направлена на решение актуальной задачи по вовлечению в переработку низкосортного сульфидного цинкового концентрата Николаевского месторождения Казахстана и разработке технологии его переработки с получением промежуточного продукта – медно-кадмиевого кек. В статье представлены результаты экспериментальных исследований процесса очистки от меди и кадмия цинкового сульфатного раствора, полученного после гидролитической очистки от железа, мышьяка, сурьмы, свинца и кремния раствора от автоклавного выщелачивания низкосортного сульфидного цинкового концентрата Николаевского месторождения Казахстана. Было определено, что установленные технологические режимы процесса цементации меди и кадмия обеспечивают высокую степень очистки исследуемого продуктивного раствора от меди и кадмия. В очищенном растворе содержание меди и кадмия составляло менее 2,98 г/дм³, цинка – 221,64 г/дм³. Полученный промежуточный продукт – медно-кадмиевый кек - пригоден для использования в производстве меди и кадмия.

Ключевые слова: рентгенофазовый анализ, атомно-абсорбционный анализ, цинковая пыль, одностадийная очистка, цементация, медно-кадмиевый кек, сульфидный концентрат.

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DEVELOPMENT of TECHNOLOGY and EQUIPMENT for DIRECT SMELTING of REFRACTORY LEDGE GOLD ORES of TERISKEY Ltd ORE MINING COMPANY

Abstract: This article presents the results of the works on improvement of the process parameters and development of the basic design elements of an electric furnace for processing of ledge gold ores from a number of deposits of Teriskey Ltd Ore Mining Company in order to create a pilot project for testing and implementation of a contractile pyrometallurgical selection process (CPS-process) for refractory gold-bearing materials in this enterprise. The design compositions were prepared based on previously completed studies on direct melt processes of the ledge gold ores from Teriskey Ltd deposits, i.e. three-, four- and five-component charges for the CPS-process. The ratio of individual components and their calculated compositions were determined. Constructional calculations of basic dimensions, design and technological parameters of individual components and systems of the pilot project were carried out. Thus, the basic parameters of a two-electrode electric furnace with the capacity of 200 – 300 kVA, the main equipment for the gas cleaning system, systems of feeding and preparation of the raw charge materials with the determination of the structure of load devices were found. Based on the initial data and production schedules of Institute of Metallurgy and Ore Beneficiation JSC, the project of above-mentioned pilot plant of CPS-process approved by the management of OMC Teriskey Ltd has been performed.

Keywords: matte, slag, gold, contractile pyrometallurgical selection, CPS - process, blending.

Introduction. It is known that more than 50 % of the available active gold reserves are characterized as hard for benefaction and containing contaminants, i.e. arsenic, antimony and carbon. According to experts, about 60 % of the current reserves can be included into the share of such ores. The gold metallurgy describes

these ores as refractory ores. Kazakhstan deposits of sulphide gold ores are also characterized with a large number of the above mentioned harmful impurities in the ore. In this regard, some of reserves should be described as refractory raw material. At the moment, for many fields there is no effective technology of enrichment and metallurgical processing. For this reason, the gold deposits are currently insufficiently used on an industrial scale. Therefore, the main problem of modern gold mining companies in the world industrial practice is associated with changes of quality of ores and concentrates in the raw material base for the worse. Use of many traditional technologies does not provide the necessary level of environmental protection and requires increase of scientific and technological indicators of production, especially in case of processing refractory ledge gold ores. All this requires the development of a number of innovative treatment processes for ledge gold ores, providing a significant reduction in metal losses and necessary intensification of metallurgical treatment. One of such ways is the direct pyrometallurgical melt of gold ores with concentration of the main amount of gold and silver in sulfide matte melt. In the semi-industrial and industrial scale, electrofusion of gold-concentrates was tested, and the basic technological parameters of the process were determined [1-3]. However, the general total gold and silver recovery is low because of the already afforded significant losses of these metals during enrichment of refractory ores.

In this regard, a pilot testing of a new technology of contractile pyrometallurgical selection of refractory ledge gold ores bypassing their enrichment, is currently planned. At the same time, refractory ledge gold ore deposits of Shovan, Zholbarysty, Kelinshektau, Nizhne-Kumystinskoye and tailings of thiosulfate leaching of gold ore deposits of Kumysty of Teriskey Ltd, located in the Suzak region of South Kazakhstan are identified as the objects of direct melt of ores. For this purpose, together with Teriskey Ltd a complete pilot plant of CPS process is planned to be created in this enterprise.

Experimentally - Calculation and Results Discussion Part. Calculated composition of initial charging materials and outputs of collector gold mattes and melted slags. The compositions of charges on the basis of these ores and output of melt products for pilot tests of the developed technology were calculated [4-6] on the basis of laboratory and pilot tests of CPS-process of gold ore melt of OMC Teriskey Ltd carried out in 2012-2015.

The material loaded into an electric furnace is a charge made up of Shovan, Zholbarysty,

Kelinshektau, Verkhniye Kumysty ore deposits, tailings of thiosulfate leaching, limestone and coal. These ores and tailings of thiosulfate leaching are stored in separate compartments in the closed storage. Preparation of ore, limestone and coal is a two-stage crushing on a cone and jaw crusher to a particle size -20 mm. If required, the individual components of the charge are dried to a moisture content of not more than 6 %. It is necessary to additionally install an oven for drying the charge components with a moisture content of more than 6 %.

Calculations of three options for charge loading in an electric furnace were held. The first option is designed for processing of kinds of ores mined in the company and kept in the ore yard. The second option is designed for processing of four kinds of ores which are scheduled to produce parallel in future. The third option is designed to melt all gold ores together with is tailings of thiosulfate leaching accumulated earlier. The advantage of the above calculation of charges is that they can be used without charge-forming additives by varying the content of sulfide ore deposits of gold in Kelinshektau. To obtain a satisfactory slag composition it is enough to use only one of the calcium flux that provides the minimum possible amount of slags and thus minimizes the loss of useful components from them.

So, to prepare charge for melting in an electric furnace, we take gold ores of OMC Teriskey Ltd and limestone flux containing CaO of not less than 57 %, and coal with an ash content of not more than 40 %, that we tested as raw materials. The chemical composition of the ore is shown in Table 1.

Table 1 - Chemical composition of native gold ore deposits of OMC Teriskey Ltd used to load in an electric furnace

Deposit	Composition									
	g/t		%							
	Au	Ag	As	C	Cu	Fe	S	SiO ₂	CaO	Al ₂ O ₃
Zholbarysty	6.9	71.7	0.25	0.65	0.24	13.7	13.1	58.8	0.54	4.6
Shovan	7.4	330	0.22	5.30	0.29	13.8	1.5	33.9	11.8	4.9
Kelinshektau	4.8	211	0.40	—	3.30	23.8	25.6	24.6	5.47	0.1
Nizhne-Kumysty	1.7	2.5	0.01	1.5	0.01	6.9	0.25	64.5	3.2	14.2
Verkhne-Kumysty	2.1	5.2	0.01	—	0.5	2.4	—	60.4	1.57	20.3
Tailings	6.7	262	0.30	—	5.45	12.9	9.4	19.9	13.1	0.90

During the processing the technological parameters of contractile pyrometallurgical selection of gold ores of OMC "Teriskey" Ltd, calculations of optimal charge options to load in an electric furnace were carried, including triple, four- and five-component charge. The estimated compositions triple, four- and

five-component charges is shown in Table 2. Output of matte and slag varies within the specified limits due to change of melting temperatures, reducing agent flow within 0 to 1 % of the charge weight, frequency of slag discharges and matte and exposure time before release. Thus, we calculated the load in an electric furnace in three options that provide use of all available melting gold ore materials of OMC Teriskey Ltd and describe the preparation and charge load systems in an electric furnace.

Table 2 - Estimated compositions of the charges consisting of ores, coal and flux for an electric furnace with performance of 2.8 charges a day

Name	Weight of charge components,		Matte output		Slag output	
	kg	%	of charge weight, %	matte weight, kg	of charge weight, %	slag weight, kg
Triple components charge						
Shovan	700	25	10-15	84-126	50-70	1400-1960
Zholbarysty	320	11.43				
Kelinshektau	980	35				
CaCO ₃	771.96	27.57				
Coal (60 % C)	28	1				
Total	2800	100				
Four-component charge						
Shovan	336	12	10-15	280-420	50-70	1400-1960
Zholbarysty	320	17.43				
Kelinshektau	980	35				
V. Kumysty	364	13				
CaCO ₃	771.96	27.57				
Coal	28	1				
Total	2800	100				
Five-component charge						
Shovan	196	7	10-15	280-420	50-70	1400-1960
Zholbarysty	320	11.43				
Kelinshektau	980	35				
CaCO ₃	771.96	27.57				
V. Kumysty	364	13				
Tailings	140	5				
Coal	28	1				
Total	2800	100				

Calculation of structural elements of an electric furnace. Technical characteristics of an electric furnace. Developing structural elements of an electric furnace we took an air cooling furnace transformer available in OMC Teriskey Ltd into account, and its specifications were used to calculate the structural elements of an electric furnace. Four-stage transformer. The first stage is 50 V, the second stage is 100 V, the third stage is 150 V, the fourth stage is 200 V. The remote control of the electric furnace is stationary and consists of stage-switching buttons, ammeter and

voltmeter, showing the strength of the current and the voltage applied to the electrodes. Calculations of the electric furnace were made, recommendations for the basement of an electric furnace were given, and a list of materials and non-standard equipment for the installation and operation of the furnace was settled. Based on the calculations the basic parameters of a two-electrode electric furnace and design features of its basic elements were determined (Table 3).

Table 3 - Basic parameters of two-electrode furnace

Parameter	Measuring unit	Parameter value
Set electric power	kVA	200-300
Nominal operation power	kVA	200-250
Maximum voltage	V	180
Maximum current strength	A	2500
Nominal operation voltage	V	50
Nominal operation current strength	A	1300
Number of electrodes	el.	2
Specific resistance of liquid slag	Ohm·m	0.02
Electrode diameter	mm	100
Density of electric current in electrode	A/cm ²	up to 40
Energy flow per 1 ton of slag	kW·h	500
Dimensions of electric furnace outer stack	mm	1300r
Dimensions of electric furnace foxhole	mm	600r
Hearth size	mm	600r
Dimensions of crown outer stack	mm	1400r

The parameters needed to control the operation of the furnace are slag release temperature, matte release temperature periodically measured with an optical pyrometer and temperature along the flue gas path, dust chamber, cyclone scrubber is measured periodically with a portable millivoltmeter with a thermal couple. The electrical capacity of the plant, the voltage across the electrodes, the electrode current is displayed on the stationary control panel with voltmeters and ammeters mounted on it. The furnace parameters are given in Table 4.

Table 4 - Basic accounting parameters of two-electrode furnace

Parameter	Measuring unit	Parameter value
Smelting rate	t/day	2
Energy flow	kW/t of charge	500
Charge moisture content	%	2-3
Slag temperature	°C	up to 1450
Matte temperature	°C	up to 1350

Calculations for gas-cleaning equipment.

Quantity of electrothermics flue gas is typically 10-12 times less than that during smelting sulfide charge in reverberatory furnaces, its amount generally is 100-150 m³ per tonne of charge. Calculated composition of the gaseous phase during processing gold ore of the deposit of OMC Teriskey Ltd with a capacity of 2 tons a day is given in Table 5.

Table 5 - Calculated composition during processing of gold ore from the deposit of OMC Teriskey Ltd with a capacity of 2 tons a day

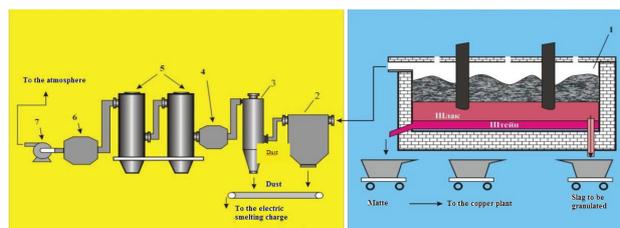
Gaseous phase component	Amount				
	kg	%	l	m ³ /day	%
SO ₂	311.93	55.01	109175.5	109.2	45.65
CO	2.24	0.39	1320.4	1.3	0.55
CO ₂	252.84	44.6	128718.5	128.7	53.8
Total	567.01	100	239214.4	239.2	100

When processing 2 tons a day of gold ore from the deposits of OMC Teriskey Ltd, the output of all process gases after dust chamber will amount to 239.2 m³. Air leaks account for approximately 50 % of the output of process gases. When processing gold ore the output of process gases, taking into account the leak, will be 358.8 m³ per day.

Based on the calculated data shown in Table 5, and the data of the works in pilot plants, taking into account existing technical characteristics, dust and gas cleaning aggregates used in the center of metallurgy, constructive and overall indicators of the system components of gas cleaning were calculated for the pilot plant of CPS-process on Teriskey Ltd. Thus, the structures and the basic dimensions of the following dust and gas cleaning elements are determined, i.e. dust chamber, cyclone, wet scrubber, wet electrostatic filter and smoke exhaust.

The hardware and technological scheme of gas cleaning of the pilot plant composed of the above-mentioned elements is shown in the figure. This diagram shows a five-stage scheme of dust removal and cleaning of process gases released from the furnace. The gas temperature at the outlet from the furnace riser is 800-900 °C, from the cooling chamber is 400-450 °C, at the outlet of the scrubber is 40-60 °C, at the outlet of the second scrubber is 20-40 °C. For more fine cleaning of exhaust gases from the furnace it is offered to install an optional dry electrostatic filter, wet scrubbers and wet electrostatic filter.

Conclusion. On the basis of experimental data obtained during laboratory studies of CPS-process of direct melt of ledge gold ores from the deposits of Teriskey Ltd, the charge compositions and output melt products for the planned pilot tests of this technology were calculated.



1 - electric furnace; 2 - dust chamber; 3 - cyclone; 4 - dry electrostatic filter; 5 - wet scrubbers; 6 - wet electrostatic filter; 7 - exhauster.

Figure - Proposed scheme of gas cleaning during smelting of gold charge of OMC Teriskey Ltd using the method of Contractile Electric Melt (CPS-process)

Taking into account these technological parameters, as well as the results of the CPS-process pilot tests, the calculations of the main melting unit, two-electrode electric furnace with a rated capacity of 200-300 kVA, were carried. The design was selected, and the main overall indicators of the elements of the gas cleaning system were calculated, and on that basis a hardware and technological scheme of the CPS-process pilot plant in the Teriskey Ltd was offered [6].

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ТҮЙІНДЕМЕ

Негізгі мақалада ЖШС «Теріскей» өндірісінде тәжірибелі-өндірістік комплексі алтын құрамды берік шикізатын қысқартылған пирометаллургиялық процесс әдісімен өңдеуді тәжірибелеу және енгізу үшін сол ЖШС «Теріскей» тау-кен компаниясының бірқатар түпкі алтын кендерін өңдеу мақсатында құрылатын электр пешінің негізгі конструктивті параметрлерін өңдеу және анықтау жұмыстары келтірілген. Біздің зерттеу жұмыстарын жүргізуіміз барысында ТҚК ЖШС «Теріскей» түпкі алтын кендерін тікелей балқыту барысында есептік құрамдары дайындалды: үш-, төрт- және бес компонентті шикіқұрамдар ҚПС-процесімен бөлек компоненттер және құрамдардың есептеулеріне қатынасы. Негізгі габаритті есептеулері, конструкциясы және бөлек қондырғылармен тәжірибелі-өндірістік комплексінің жүйесінің технологиялық көрсеткіштері есептелген. Сонымен қатар, енгізілген күштілігі 200-300 кВА екі электродты электр пешінің негізгі параметрлері, газтазалау жүйесінің негізгі жабдықтары, жүктеу жүйесінің конструкциясымен қождамалы материалдарды дайындау және беріп тұру жүйелері анықталды. Негізгі берілген мағлұматтар АҚ «Металлургия және кен байыту институты» дайындалған регламент ҚПС-процесінің жоғарыда айтылғандай тәжірибелі-өндірістік қондырғы ТҚК ЖШС «Теріскей» басшылығының бекітуімен жасалды.

Түйінді сөздер: штейн, қож, алтын, қысқартылған пирометаллургиялық селекция (ҚПС-процесс), қождамалау.

РЕЗЮМЕ

В данной статье приведены результаты работ по отработке технологических параметров и разработке основных конструктивных элементов электропечи для переработки коренных руд золота из ряда месторождений горнорудной компании ТОО «Терискей». Исследования проведены с целью создания на этом предприятии опытно-промышленного комплекса для испытания и внедрения процесса сократительной пирометаллургической селекции (СПС-процесс) золотосодержащего упорного сырья. На основании ранее выполненных нами исследований по изучению процессов прямой плавки указанных коренных руд золота, подготовлены расчетные составы трех-, четырех- и пятикомпонентных шихт для СПС-процесса. Определены соотношения отдельных компонентов и их расчетные составы. Выполнены конструктивные расчеты основных габаритов, конструкции и технологических показателей отдельных узлов и систем опытно-промышленного комплекса. Так, найдены основные параметры двухэлектродной электропечи установленной мощности, равной 200 – 300 кВА, основного оборудования для системы пылегазоочистки, систем подачи и подготовки шихтовых материалов с определением конструкции загрузочных устройств. На основании исходных данных и технологического регламента, разработанного АО «Институт металлургии и обогащения», выполнен проект вышеназванной опытно-промышленной установки СПС-процесса, утвержденный руководством ГРК ТОО «Терискей».

Ключевые слова: штейн, шлак, золото, сократительная пирометаллургическая селекция, СПС-процесс, шихтовка, расчеты.

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