ABSTRACT

to thesis research on

«DEVELOPMENT OF MIXED TECHNOLOGY FOR DESORPTION OF GOLD FROM IMPREGNATED RESIN WITH PRESENCE OF METAL IMPURITIES»,

Submitted for the Degree of Doctor of Philosophy PhD Majoring in Metallurgy

6D070900

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Assessment of current state of scientific or academic and technological challenge. Currently the status of gold-ore mining industry of Kazakhstan is complicated by deterioration of qualitative composition of gold-bearing rocks, which puts more than 50 % of gold reserves to the category of non-active. Limited gold resource base reduces the opportunities for keeping gold extraction indices at the appropriate level. Proportion of gold and forex reserves of Kazakhstan is 26,3 %. The quantity of mined gold from alluvial deposits is being reduced due to reserves depletion, reduced content, as well as economic change. Development of gold-ore deposits is predominantly characterized by two-stage extraction of reserves: rich at the first stage, poor at the second stage. Competitive and profitable gold production increase is based on the combination of traditional mining technology with new technologies: heap and electrosorption leaching, electrochemical extraction, hydrometallurgical process of solutions.

Operational experience analysis of gold miners all over the world attests to the fact that the principal source of obtaining gold is processing of rock mass, herewith more than 70 % of gold is obtained from ledge gold ores. At the moment main process of gold recovery from easy ledge ores is cyanation with the following sorption to coal or ion exchange resins from fine pulps. «During 110 years of its existence, this process has been improved, it has been used for extraction of 75 %, and during the past 30 years – 92 % of gold from ores», - stated the Mining Engineering American magazine. Thus, where previously gold extraction was a prerogative of «artisans», now it has become more a business of chemists, rather than ore dressers.

It has been established that one of the effective methods for extracting gold from gold ores is heap leaching with further sorption. However, in addition to gold, impurity metals are transferred to the resulting productive solutions.

The use of activated carbons of such polycomponent solutions leads to the accumulation of impurities in circulating solutions, which is associated with a higher selectivity of coal to gold ions. For such solutions, it is advisable to use ion exchange resins, which can collectively adsorb metal ions and can be separated at the desorption stage.

One of the limiting factors of the widespread use of activated carbons instead of ion exchange resins is their complex regeneration technology. In this regard, the assessment of the current state of the scientific problem being solved is timely and relevant.

The basis and initial data for the development of the topic.

The basis for the development of the theme of the thesis work is the search for ways of sequential separation of gold and impurities in the stage of elution of metal ions from the phase of the saturated sorbent AM-2B widely used in the gold-bearing industry. As initial data, the following conditions were chosen: sorption gold extraction from productive solutions of cyanide leaching of the Zhaltyrbulak ore, macroporous anionite AM-2B, saturated with metals under production conditions.

Justification of the need for this research work.

Constant reduction of gold content in processed ores and involvement of poor and off-balance gold-bearing raw materials in the production led to the use of an effective and economically expedient method of heap cyanide leaching. However, it is known that with this method of processing, metal-impurities, in addition to the base metal, also pass into the resulting gold-containing solutions, which generally negatively affect all further redistribution. Existing technologies in the direction of gold desorption and ion-exchange regeneration do not allow obtaining solutions of the required purity for the further production of a high-quality product. In this connection, the reason for the necessity of carrying out this research work was the requirement to ensure an almost complete desorption of both noble metals and impurities, which allows long-term use of sorbents in the sorption-desorption cycle, since the metals remaining in the resin, according to the existing schemes, reduce the resin capacity when you reuse it.

Information on the planned scientific and technical level of development, on patent research and conclusions from them.

The analysis of literature data and patent studies in the field of methods for extracting gold from synthetic ion exchangers, regeneration of ion exchange resin, gold desorption is carried out.

Patent-licensing and metrological support of scientific research on the topic of dissertational work were provided with the support of specialists of the relevant services of the Kazakh National Research Technical University K.I. Satpayev and the National Center for Complex Processing of Mineral Raw Materials of the Republic of Kazakhstan.

The analysis of patent studies has shown that in this direction there are a number of patented works in Kazakhstan and abroad (Appendix Б). A patent was received for the utility model of the Republic of Kazakhstan No. 3229 on the topic “Method of regeneration of ion exchange resins in the presence of impurity metals” (Appendix B).

Relevance of the research. Kazakhstan has significant gold reserves, which are approximately estimated at 6 thous. t. There are more than 130 primary actual deposits in the country, including ~ 60 % of all natural reserves of this metal in Kazakhstan, 38 % of gold reserves are concentrated in polymetallic ore deposits.

At the moment, low quality gold-containing raw material is being more widely involved in production, it is being processed by advanced method of heap leaching by cyanide solutions with following sorptive extraction and gold concentration. While developing an effective sorption method for processing PR gold-containing solutions, it is important not only to choose a selective anion-exchange resin, having

high processing behavior, but as well study the influence of solutions composition to sorption indices of precious metals.

In light of the above, research and development of technology for sorption gold recovery from PR solutions of the process for heap cyanide leaching of crude ore though effective macroporous anion-exchange resin of АМ-2Б engineering grade, study of related compounds behavior with their concentration in middlings and conditions of selective elution of precious metal with following regenerative sorption are pertinent and timely.

The novelty of the topic lies in the development of a combined technology for desorption of gold from saturated resins in the presence of impurity metals. The analysis of the literature in the field of elution of gold and regeneration of saturated ion exchangers allows us to conclude that the existing technologies do not reach the conditions for obtaining solutions of the required purity, which reduces the quality of the finished product. In this regard, for the first time, the combined technology of sequential elution of gold and associated impurities from a saturated resin will be proposed.

Formation of resistant rhodanate complexes of copper, zinc, nickel and cobalt is determined at the first stage of elution of components from resin phase АМ-2Б by lean solutions of sulphorhodanates under conditions of conserving consistent cyanide complex of gold in ion-exchange material with further elution of gold by thiourea solutions, determined by the formation of cationic complex of gold, unable to be kept by anion-exchange resin, having anionic counter-ions.

The goal of this thesis is research is detecting main correlations, sorption gold concentration and its selective elution with presence of metal impurities (copper, cobalt, nickel, zinc) while processing solutions of gold ore heap leaching.

The object was the gold-bearing ore of the Zhaltyrbulak field site. A representative sample of ASJ-5 oxidized gold-bearing ores from was selected (Aktau, Zhil'nyy i Severo-Vostochnyy) for the study and AM-2B resin, saturated in production conditions, was provided.

The subject of research is a thermodynamic analysis of the stability of cyanide complexes of gold and metal impurities involving theoretical ideas about the nature of complexation, studying the kinetics of gold sorption, determining the mechanism of desorption of gold ions and impurity metals with sodium rhodanide and thiourea solutions, and studying the conditions for implementing the combined technology of sequential desorption of gold and impurities from the AM-2B saturated resin phase.

The purpose determined it necessary to solve the following challenges:

− to choose an effective sorbent from the number of anion exchange resins of engineering grades;

− to study conditions of gold sorption by selected sorbent and distribution of related compounds to equilibrium phases;

− to study kinetics of gold sorption by selected ion-exchange material;

− to lay a foundation for agent selection for selective gradual elution of metal impurities and gold, identify key patterns, dynamics and process kinetics;

− to build a mathematical model and improve gold desorption process;

− to develop a combined flow diagram of gradual elution from the phase of gold resin and related compounds with return to the sorption cycle of regenerative ion-exchange material;

− to develop selection of implementation for the proposed process of desorption of gold and related compounds;

− to conduct technical and economic assessment of the proposed technology.

Main principles submitted for defence:

– research results of sorption characteristics of sorbents widely used in gold industry;

– research results of kinetics of gold sorption based on resin АМ-2Б engineering grade;

− research results by selection of strength of eluting solutions for desorption of gold and metal impurities;

− development results of mixed technology for desorption of gold and its regeneration;

− comparison results of hydrodynamic characteristics of devices for conducting the process of resin regeneration;

− test results of suggested technology in dynamic and static conditions of metal desorption;

− results of mathematical model formulation and process optimization of gold desorption;

− test results of developed mixed technology of gradual elution of gold and metal impurities in heavy use in bell-type device.

Practical relevance of thesis.

− conditions for sorption gold extraction are developed by ion-exchange material of АМ-2Б engineering grade from PR solutions of heap leaching process of gold-containing ores at Zhaltyrbulak field;

− mixed flow diagram for gold desorption from the phase of macroporous anion-exchange resin of АМ-2Б engineering grade is developed, being used at technological scale, and accompanying separate concentration of metal impurities with further sorbent regeneration. Mixed flow diagram for desorption of gold and impurities is tested in enlarged laboratory scale and recommended for conduct of pilot plant tests with the purpose of its use at processing solutions of heap leaching of gold-containing ores of the Republic of Kazakhstan;

− bell-type installation is developed and constructed for gradual desorption of gold and metal impurities, enabling to significantly raise kinetic indicators of the process, reduce metal intensity of used installations and reagent consumption;

− research results are being used in desk studies at courses «Theory and practice of metal purification and separation», «Complexing in metallurgical systems and processes» for postdoctoral students majoring in Metallurgy 6D070900 – at Kazakh National Research Technical University after K. I. Satpayev.

Contributions and work approbation. According to the results of thesis paper there are 14 published works, including:

– 2 in the magazines, included in the database of Scopus (Izvestiya NAS RK, the series of geology and technical science with impact factor 0,06);

– 5 in publications recommended by Committee for Control of Education and Science of Ministry of Education and Science of the Republic of Kazakhstan;

Main principles and research results were reported at international conferences:

– International scientific-practical conference «Prospects for the development of modern science» Jerusalem – Israel, 2016;

– Scientifically-practical conference «Innovations in comprehensive mineral processing of mineral raw materials» (Abish readings) Almaty, 2016;

– «The 49th International October Conference on Mining and Metallurgy» Bor – Serbia, 2017;

– International scientifically-practical conference «Integration of Science, education and production – the base for implementation of National Plan» (Saginov readings № 9), Karaganda, 2017;

– International scientific conference «Contemporary problems of comprehensive mineral processing of complex ores and industrial raw material» (Plaksin readings), Krasnoyarsk, 2017;

– International scientifically-practical conference «Stimulation of hydrometallurgical processes for processing natural and industrial raw material. Technologies and equipment» St. Petersburg, 2018.

A patent was received for the utility model of the Republic of Kazakhstan No. 3229 “Method of regeneration of ion exchange resins in the presence of impurity metals”.

The work was carried out at the department "Metallurgical processes, heat engineering and technology of special materials" of the Kazakh National Research Technical University named after K. I. Satpayev, in the laboratories of precious metals of the State Scientific and Production Association “Kazmekhanobr” of the National Center for Complex Processing of Mineral Raw Materials of the Republic of Kazakhstan.

Connection of research with government programs and scientific-research works. Research was made in accordance with international projects, indicated in the Strategy «Kazakhstan-2050», the concept of innovation development of the Republic of Kazakhstan until 2020.

Structure and volume of thesis. The thesis consists of introduction, 5 chapters, conclusion and 7 annexes. Research is set out at 156 pages of typescript text, contains 28 tables and 59 pictures. The list of cited references includes 119 names.