ABSTRACT

to thesis research on **«DEVELOPMENT THE TECHNOLOGY FOR THE COMPLEX PROCESSING OF MAN-MADE TAILINGS OF THE ENRICHMENT OF DONSKOY GOK»,** Submitted for the Degree of Doctor of Philosophy PhD Majoring in Metallurgy-6D070900

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Assessment of the current state of the solved scientific problem. At present, world practice is characterized by an increase in interest in studies of the processing of poor chrome ores, an increase in the recoverability of useful components from tailings and dumps, as well as the integrated use of ores [1-2].

In recent years, China has taken a leading position in the production of ferrochrome, where the new technology for producing ferrochrome in DC electric arc furnaces is widely used. In it, unlike the classical AC-furnace technology, thin chromite concentrates that do not require preliminary agglomeration are successfully used [3]. Major producers of chromite raw materials are also increasing the production of fine chromium concentrates. In particular, such concentrates in some mines in South Africa are obtained from waste from the extraction of platinoids of the UG-2 formation. In Turkey, one of the leading countries producing chromite, ore reserves are 26.6 million tons with an average grade of 20% Cr_2O_3 and another 400 million tons of poorer chromium ores are considered as a resource potential for use in the near future [4].

Based on the above, deposits and materials - tailings even with a very low chromium content are in demand.

In the Republic of Kazakhstan, during the processing of chrome ore at the mining and processing complex of DMPP «Kazchrome» TNK JSC, man-made tailings are formed. The involvement of tailings in processing will not only solve environmental aspects, but also expand the raw material base for the production of chromite concentrate and other related valuable components.

An analysis of existing methods for processing chromite-containing ores, materials and tailings shows a variety of existing technological methods, including obtaining not only chromite concentrate, but also the possible comprehensive extraction of valuable related components [9-30].

The main disadvantage of existing technologies for processing poor chromite ores is low efficiency, high consumption of reagents, the use of energy-intensive roasting operations, and the formation of toxic ore dressing waste - sludge stored in sludge collectors. The utilization of sludge has not been solved anywhere in the world, which led to the closure of chromium production in a number of developed countries in Europe and Japan. The high content of magnesium oxide in the sludge prevents its use in cement production, and the high content of calcium and silicon in the production of refractory materials.

To solve the existing problem associated with a large number of man-made tailings and a high consumption of reagents during processing by known methods, a new effective technology for complex processing of chrome ore dressing tailings,

including chemical activation, gravity dressing and leaching using a regenerated reagent, is proposed in the dissertation.

The basis and initial data for the research intothe topic. The dissertation uses the results of studies of the integrated processing of the DMPP man-made tailings obtained during research work as part of program-targeted financing of scientific research for 2018-2020 “Development and implementation of innovative technologies that increase the extraction of non-ferrous, noble, rare and rare-earth metals and the solution of production problems of industrial enterprises of the Republic of Kazakhstan (BR05236406) ” on the topic: “Definition of conc centering of rare and rare-earth metals according to the redistribution of JSC TNK Kazchrome and the development of a method for processing industrial products”.

Rationale for the need for research work. The extraction of chromium from man-made tailings of chromium ore dressing, taking into account the existing demand for chromium concentrates, is an important practical task. Integrated utilization of sludge tailings will increase the profitability of production and solve the environmental problems of the region.

Information about the planned scientific and technical level of development, patent research and conclusions from them. In the process of performing the work, an analysis of the literature data and patent research on the problem of the complex processing of tailings for the processing of chromium ores was carried out. On the basis of which it can be concluded that due to the lack of technologies that allow efficiently and comprehensively processing finely dispersed chromite-containing tailings, the results obtained in the thesis are in demand from the point of view of environmental protection and rational use of natural resources. The novelty of the technical solutions adopted is confirmed by 3 patents for the inventions of the Republic of Kazakhstan and corresponds to the modern level of scientific research.

Information about the metrological support of the dissertation. In the process of conducting research work, metrological support was determined by the presence of certified chemical analytical services and a laboratory of physical analysis methods. Metrological measurements were performed on trusted instrumentation.

National Research Laboratory in the priority area “Technologies for the hydrocarbon and mining and metallurgical sectors and related service industries “Institute of Metallurgy and Enrichment” JSC (“IMOB” JSC), “KazNRTU named after K.I. Satbayev” NJSC is accredited for technical competence in the National Accreditation Center of the Committee for Technical Regulation and Metrology - Accreditation certificate No. KZ-I.02.1138 of February 23, 2016 (valid until February 23, 2021, for compliance with GOST ISO / IEC 17025-2009 “General requirements for the competence of testing and calibration laboratories”).

Research work was carried out in the laboratory of alumina and aluminum of “IMOB” JSC.

Relevance of the topic. The topic is relevant and timely in connection with the involvement in the processing of technogenic sludge tailings accumulated at

the Don Mining and Processing Plant, with which up to 25% of chromium is lost. Reducing the volume of primary raw materials and their quality requires expanding the raw material base and finding new additional sources of raw materials. The absence of rational technologies for the processing of this material requires additional scientific research aimed at expanding the fundamental base and developing experimental material to build a highly efficient technology for their processing.

For the first time demonstrated the possibility of efficient recycling of chromium ore tailings by chemical activation, gravity separation and complex processing.

The novelty of the topic:

– development of a technology for the integrated processing of man-made tailings for the enrichment of Donskoy GOK;

– establishing a mechanism for the transformation of the phase structure of the tailings of chromium ore beneficiation during chemical activation with a solution of sodium hydrogen carbonate;

– determination of kinetic parameters and leaching mechanism of the combined tailings of the enrichment solution of ammonium hydrosulfate;

– the method of regeneration of the leach reagent of the combined tailings - ammonium hydrosulfate, by autoclaving a mixture of ammonium sulfate and sulfuric acid;

– a method for producing amorphous silicon dioxide from a silicate solution for treating leach cake by carbonization in a solution of sodium bicarbonate.

Communication with other scientific research works. The results obtained in this thesis are closely related to scientific research carried out in the framework of solving problems on the project project “Determining the concentration of rare and rare earth metals in the processing of “Kazchrome” TNK JSC and developing a method for processing industrial products”.

The purpose of the work is development the technology for the complex processing of man-made tailings of the enrichment of Donskoy GOK.

The objects of study are the man-made tailings of the enrichment of the Donskoy GOK “Kazchrome” TNK JSC.

Subject of research - physicochemical composition of tailings; the mechanism of chemical activation of tailings; gravitational enrichment process; acid leaching process; processing the leach solution to obtain marketable products.

The objectives of the study, their place in the implementation of research work in general.

Research objectives include:

– the study of the physicochemical characteristics of the man-made tailings of the enrichment of Donskoy GOK;

– development of a technology for producing chromite concentrate from tailings;

– the study of the mechanism and transformation of the phase structure of the tailings during chemical activation;

– the development of a technological scheme of gravitational enrichment;

– the study of the kinetics and mechanism of leaching of tailings from enrichment with a solution of ammonium hydrosulfate;

– development of the technology for the integrated processing of enrichment tailings to produce chromium concentrate, non-ferrous and rare metal concentrates, REE-containing product, amorphous silicon dioxide and double magnesium sulfate.

Research and analysis methods.

The main research methods and analyzes used in the implementation of the thesis include:

– critical analysis of patent information sources;

– the mechanism of chemical activation of raw materials by chemical, x-ray, thermal analysis and infrared spectroscopy;

– technological studies of gravitational enrichment on a SKO-1 concentration table and a Knelson KS-MD3 centrifugal separator from FLSmidth;

– kinetic studies of the process of sulfuric acid sludge processing technology on the laboratory and enlarged laboratory equipment of the "Pilot installation for testing Bayer-hydrogarnet technology" for processing aluminosilicate raw materials of IMiO JSC;

– performing chemical analysis of samples on an Optima 2000 DV inductively coupled plasma optical emission spectrometer (USA, PerkinElmer);

– X-ray phase analysis of samples using the D8 Advance instrument (Bruker AXS GmbH) using the EVA, Search / match software and the ASTM card database;

– mineralogical analysis of the samples under a MIN-8, OLYMPUS, Leica DM 2500P microscope using the Stream BasicR program;

– thermal analysis of the samples using the STA 449 F3 Jupiter synchronous thermal analysis instrument using the NETZSCHProteus software;

– the phase composition of the samples by infrared spectroscopy (IR) using an Avatar 370CsI IR Fourier spectrometer using the Transmission E.S.P program;

– the specific surface of the particles, the specific volume and the average pore size of the obtained amorphous silica by the method of single-point BET analysis (Brunauer-Emmett-Teiler method) on a Sorbtometer M device (Katakon company, Russia).

Provisions for the defense of a doctoral dissertation.

The following provisions are made to defend the dissertation:

– studies of the transformation of the phase composition as a result of chemical activation of the tailings of chromium ore beneficiation;

– the kinetics and mechanism of leaching of the tailings of the enrichment solution of ammonium hydrosulfate;

– the results of a comprehensive processing of tailings to obtain marketable products.

The practical significance of the work.

The technology for the integrated processing of chrome ore dressing tailings at DMPP has been developed, the difference of which is the conduct of gravity dressing with preliminary chemical activation and the use of a regenerated acid reagent in hydrometallurgical processing. The results of the comprehensive processing of tailings obtained in the studies were adopted to calculate the Technological Regulations (TR) and the Preliminary Feasibility Study (FS) on the project topic: “Determining the concentration of rare and rare-earth metals in the processing of JSC TNK Kazchrome and developing a method for processing industrial products” .

The new method for the chemical activation of chrome ore dressing tailings before gravity dressing, by treatment with a sodium hydrogen carbonate solution, changed the phase structure of the sludge, which made it possible to increase the extraction of Cr_2O_3 into a concentrate and to obtain high-quality chromium concentrate [5].

According to the developed method [6], the synthesis of ammonium hydrosulfate is carried out in an autoclave at a temperature of 230 - 260 °C in a mixture of ammonium sulfate and sulfuric acid and, thereby, the use of expensive ammonium hydrogen sulfate for leaching is excluded.

The method has been developed to produce high-quality amorphous silicon dioxide, the difference of which is the use of sodium bicarbonate solution to neutralize the silicate solution to a pH of 9.0–9.5 [7].

Approbation of the work: the main provisions of the dissertation were reported at 6 International Conferences, including:

- XIII International Mineral Processing and Recycling Conference (Serbia, 2019);
- 19th International Multidisciplinary Scientific GeoConference SGEM 2019 (Bulgaria, 2019).

Publications: 12 publications were published on the topic of the dissertation, including 2 articles in journals peer-reviewed by the Scopus database, 1 article from the list of scientific journals recommended by Committee for Control in the Sphere of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 6 abstracts, 3 patents received.

The structure and scope of the dissertation. The dissertation consists of introduction, 4 chapters, conclusion and 3 applications. The work is presented on 110 pages of typescript, contains 29 tables, 47 figures.