Abstract to the dissertation of Igor Evgenievich Targanov "Sorption of rhenium and cobalt during complex processing of grinding wastes of nickel superalloys"

The relevance of the theme of the dissertation work is due to the need to provide the Russian Federation with a resource base for a critically important rare metal - rhenium, which is used in the production of special heat-resistant alloys for the aerospace industry, the production of reforming catalysts in the oil refining industry, and electronics. With Russia's forecast demand at 22 t/y by 2032, the absence on its territory of traditional raw material sources of primary rhenium - molybdenum and copper sulfide ores, and dependence on import supplies, the processing of secondary rhenium raw materials is becoming more in demand. Since ~80% of rhenium is used in the form of superalloys, the volume of waste during the manufacture or disposal of products from them is significant.

The most widespread are nickel-based superalloys, in which cobalt is the second element by mass fraction. Historically, an important sector of its consumption was their production. Currently, the main consumption of cobalt (70%, 2022) is related to the production of lithium-ion batteries with cobalt cathode material for the automotive industry.

The circular economy requires the creation and optimization of existing technologies for processing secondary raw materials. Since rhenium and cobalt are in demand on the market and have a high cost, their separation from waste is important.

The degree of development of the theme. Available technological schemes for the extraction of rhenium and other metals from superalloy waste, developed at the IMET named after. A.A. Baikov RAS (Palant A.A., Levin A.M.), Kola Scientific Center RAS (Kasikov A.G., Petrova A.M.), JSC Institute "Gintsvetmet" (Gedgagov E.I.), IOGKh AN RUz (Guro V.P.), IMiO Republic of Kazakhstan (Agapova L.Ya., Abisheva Z.S.), are based on the anodic decomposition of lump waste and hydrometallurgical methods for the extraction and separation of metals from the resulting solutions, mainly liquid extraction.

Along with lump waste, when polishing turbine blade blanks, grinding waste is formed, which is advisable to dissolve without the use of an electrochemical method. Since extraction is a fire and explosion hazardous process, it is important to use sorption instead. There is practically no information on the sorption of rhenium, cobalt and other metals from leaching solutions of nickel-based superalloy grinding waste using ion exchangers, carbon materials, impregnates (SIR's) and TVEX.

The purpose of the work is the sorption of rhenium and cobalt during the complex

processing of rhenium-nickel superalloy grinding wastes.

Job objectives:

1. Establishment of the basic principles of oxidative leaching of rhenium with solutions of mineral acids from grinding waste of rhenium-nickel superalloy.

2. Obtaining sorption characteristics of impregnates and TVEXs when extracting rhenium from solutions of complex processing of rhenium-nickel superalloy waste.

3. Determination of the conditions for the sorption of cobalt from hydrochloric acid solutions by anion exchangers of various compositions and its separation from nickel.

4. Conducting enlarged laboratory tests of the complexing sorbent TVEX-DIDA for the extraction of rhenium and the weakly basic anion exchanger Indion 850 for the extraction of cobalt from hydrochloric acid leaching solutions of rhenium-nickel superalloy grinding waste to produce ammonium perrhenate and cobalt oxide.

Scientific novelty of the dissertation work.

1. For the first time, the sorption-desorption characteristics of the complexing ion exchanger TVEX-DIDA, containing diisododecylamine, and macroporous anion exchanger Indion 850 with functional groups of tertiary and quaternary amines were studied during the extraction of rhenium and cobalt, respectively, from solutions for the complex processing of grinding waste of nickel superalloys.

2. The kinetic characteristics of rhenium sorption by TVEX-DIDA from a rhenium leaching solution during complex processing of nickel superalloy grinding waste were determined: half-sorption time – $9.90 \cdot 10^{2}$ s, rate constant $6.70 \cdot 10^{-3}$ g·mg^{-1}·min^{-1}, effective diffusion coefficient – $7.57 \cdot 10^{-12}$ m^2/s.

3. The kinetic characteristics of cobalt sorption at a temperature of 70 °C from a model solution of leaching of non-ferrous metals from nickel superslaves grinding waste using a macroporous anion exchanger Indion 850 with functional groups of tertiary and quaternary amines were determined: half-sorption time – $2.64 \cdot 10^{3}$ s, rate constant $6.97 \cdot 10^{-5}$ g·mg^{-1}·min^{-1}, effective diffusion coefficient – $2.56 \cdot 10^{-12}$ m^2/s.

Theoretical and practical significance of the work.

1. The optimal conditions for the oxidative leaching of rhenium with hydrochloric acid solutions from grinding waste of rhenium-nickel superalloy have been determined.

2. The possibility of quantitative extraction of rhenium with the complexing sorbent TVEX-DIDA and cobalt with macroporous anion exchanger Indion 850 from hydrochloric acid solutions of complex processing of rhenium-nickel superalloy grinding waste has been demonstrated.

3. A block diagram of the sorption extraction of rhenium and cobalt during the complex

processing of rhenium-nickel superalloy grinding waste has been proposed.

4. Enlarged laboratory tests were carried out on the sorption extraction of rhenium and cobalt from hydrochloric acid leaching solutions of grinding waste of rhenium-nickel superalloy with the production of products: ammonium perrhenate and cobalt oxide, which allows us to recommend the sorbents selected in the work for the complex processing of grinding waste of rhenium-nickel superalloys.

Provisions for defense:

1. Regularities of oxidative leaching of rhenium with solutions of mineral acids from grinding waste of rhenium-nickel superalloy.

2. Sorption characteristics of ion exchangers during the extraction of rhenium and cobalt from solutions of complex processing of rhenium-nickel superalloy waste.

3. Results of mathematical processing of equilibrium, kinetic and dynamic data on the sorption of rhenium and cobalt by selected materials (TVEX-DIDA and macroporous anion exchanger Indion 850, respectively) from hydrochloric acid leaching solutions of rhenium-nickel superalloy grinding waste.

4. Results of enlarged laboratory tests of sorption of rhenium and cobalt from hydrochloric acid leaching solutions of rhenium-nickel superalloy grinding waste to produce ammonium perrhenate and cobalt oxide.