ISTC Project No. 3923

Development of ultrasonic equipment and typical complex technology for deep purification of acid mine waters (AMW) in the regions of extraction and reprocessing of mineral resources (using Urals as example)

Unrestricted Summary of Technical Report

on the work performed from 01.05.2010 to 30.04.2012

Federal State Unitary Enterprise Russian Federal Nuclear Center – Zababakhin All-Russia Research Institute of Technical Physics

Project Manager	**Barysheva Nina Mikhailovna PhD in physics and mathematics**
Scientific leader of institute RFNC-VNIITF	**Rykovanov Georgy Nikolayevich RAS academician**

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Project Manager:	Barysheva Nina Mikhailovna

Leading Institute:	Zababakhin RFNC-VNIITF
Address	13, Vasiliev St., P.O. Box 245 Snezhinsk, Chelyabinsk Region, Russia 4567770
Phone	7-(351-46)-56329
Fax	7-(351-46)-55118
Email	n.m.barysheva@vniitf.ru

Objectives / scope of work and technical approach / expected results

The objective of the Project: Develop (using Urals as example) typical technology using powerful ultra-sound impacts and pilot stand for combined purification of acid mine water in the regions of extraction and reprocessing of mineral resources.

The Project aims to

- develop appropriate ultrasonic equipment using results of ISTC Project #1556-2;
- develop an advanced technological scheme for the combined ultrasonic treatment (CUT) of acid mine water (AMW) up to the state corresponding to domestic-use standards, and perform its theoretical and experimental substantiation; and
- assess its efficiency with regard for seasonal variations in AMW quantitative and qualitative compositions using Urals as an example.

The depth and efficiency of purification will be achieved through

- ultrasonic intensification of basic processes (coagulation, flocculation, flotation, galvanic coagulation, sorption, chlorination, ozonization, ultra-violet impact);
- the use of smaller amounts of expensive additions and reagents;
- the use of cheap but effective man-made sorption-precipitation materials obtained and patented under ISTC Project #1872; and
- the use of up-to-date membrane technologies and materials which allow not only the complete removal of toxic substances, but also the selective extraction of valuable components from AMW (copper, zinc, silver and gold).

The Project will be completed with the development of Technical Proposals for the design of a purification system in a selected region of the Urals.

Obtained results

The basic sets of ultrasonic generators, magnetostrictive and piezoelectric transducers, and waveguide-emitter systems with developed surfaces were developed, manufactured and tested on the pilot stand. Characteristics of the equipment overlap the range of possible parameters for ultrasonic systems developed under the project. A system for controlling acoustic parameters was developed and tested in the operation of ultrasonic equipment.

Technological hardware schemes were proposed for purification; they are based on ultrasound intensified floatation and reagent methods. Plants which include appropriate units were developed, designed and manufactured both for laboratory and for semi-industrial research.

New proposals for the AMW purification scheme were justified, including

- A new generation of inorganic materials from the class of complex silicates; Technology was developed for producing a granulated sorbent – a potentially marketable product which can be used in removable cartridges and natural barriers; The granules do not lose the sorption properties of the source material, mechanical strength, and diffusion permeability in a wide range of pH values and concentrations of metal cations;
- A new class of membrane materials for AMW purification and co-extraction of valuable components; A procedure was developed for producing nano-composite tracking membranes with a conducting coating by ion-plasma spraying; A prototyped double-chamber cell was used to demonstrate feasibility of the effective (60-80 mass % and higher) extraction of Cu, Zn, Fe, Al, and Mn on the cathode in the process of AMW separate electrolysis;
- A sonoplasma discharge generated in a cavitating bubble-liquid medium filling the region between the electrodes; Experiments demonstrated the bactericidal effect of the sonoplasma discharge to be much stronger and to be reached much faster than the effect of water disinfection with traditional methods.

For the effective simultaneous use of the developed methods on a semi-industrial scale, a combined AMW purification system was proposed and implemented as a pilot facility. The facility successfully underwent demonstrational testing with model AMW solutions. Some of its components exhibit qualitatively new properties.

On the basis of obtained results, 3 possible variants were proposed for the system of AMW fine purification. To assess their efficiency for specific conditions, (i) AMW types were identified for the basic geotechnical systems in the Ural region; (ii) a specific area and the basic AMW type were selected for study; (iii) the compositions of surface water and traction suspension were investigated within the framework of an AMW monitoring program, and flow rates were directly measured; and (iv) drain characteristics (annual, maximum and minimum during winter and summer-autumn low water periods, within-year variability) were determined for the years of different water flows.

A place where the complete purification system will be located, its structures and their relative positions were chosen. Basic parameters of the purification structures were calculated. AMW purification conditions were optimized with account for seasonal variations and real compositions. Estimates were made for the annual market value of the cathodic precipitate resulted from AMW purification with electrochemical methods. Its cost after reprocessing into individual metals exceeds 0.5 million US dollars per year.

Keywords: acid mine water, purification, equipment, technology, ultrasound, sorbent, membrane, electrochemical methods