ABSTRACT

dissertation for the degree of Doctor of Philosophy in the specialty **8D07203** – "Mining Engineering"

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DEVELOPMENT OF AN INNOVATIVE COMBINED WELL REGENERATION METHOD FOR UNDERGROUND BOREHOLE URANIUM LEACHING

Underground borehole leaching of uranium is the main method of extraction of strategic raw materials in Kazakhstan, providing high productivity and minimal impact on the environment. However, during the operation of technological wells, one of the most serious problems arises — a progressive decrease in their productivity.

The reason for the decrease in flow rate is the coloration of filters and filter zones caused by the accumulation of mechanical, chemical and biological deposits. This leads to a reduction in the inter-repair cycle, an increase in operating costs and a decrease in the efficiency of the production process. The applied methods of repair and restoration work (RVR) provide only partial restoration of well performance and do not consider the specifics of the geological and hydrogeological conditions of specific deposits, which limits their effectiveness. This problem is particularly acute in areas with a complex structure of productive horizons and a high content of carbonates, such as the «Karamurun» deposit. Under these conditions, the efficiency of operation is directly determined by the features of the geological structure, the nature of uranium mineralization, tectonic disturbances and hydrodynamic parameters.

The current challenges of the uranium mining industry — the rising cost of reagents, the need to reduce environmental risks and increase productivity — require the search for new technological solutions. One of the promising areas is the development of an innovative combined well regeneration method based on the consistent application of physical and chemical influences. The key element of the method is a combined mobile well cleaning unit (KPUOS), which allows to quickly and comprehensively eliminate the causes of coloration, reduce logistical costs and increase technological flexibility.

The development and justification of this method, conducting pilot tests and evaluating its technical and economic efficiency form the basis of the presented research, which has both scientific novelty and significant practical significance for the uranium mining industry in Kazakhstan.

Justification of the need for dissertation research:

The need for this research work is dictated by the need to apply new approaches and scientific and technical solutions aimed at developing methods to eliminate coloration phenomena in the productive horizon, to increase the degree of

uranium extraction, reduce reagent consumption and, thereby, reduce the company's costs.

Relevance of the research topic:

In the context of the sustainable development of nuclear energy and the growing global demand for uranium, Kazakhstan's uranium mining industry is faced with the task of increasing the efficiency and profitability of production. At the same time, the main production method, PSV, faces the problem of degradation of production wells, which reduces the overall performance of the industry.

Colmatation of filters and filter zones is a key factor limiting the productivity of wells and increasing the cost of repair and restoration work. Standard regeneration methods do not always take into account the peculiarities of geological conditions and often give only a temporary effect. This is especially true for the Karamurun deposit, where the complex structure of the productive horizons and the high content of carbonates exacerbate the problem.

Under these conditions, the development of an innovative combined well regeneration method, including a complex of physical and chemical effects adapted to specific geological and hydrogeological conditions, is an urgent task. Its implementation will increase productivity, extend the life of wells, reduce costs and ensure the sustainable development of the uranium mining industry in Kazakhstan.

The purpose of the study is to develop and experimentally substantiate an innovative combined method for the regeneration of technological wells aimed at increasing their productivity and increasing the inter–repair cycle in conditions of underground borehole uranium leaching at the Karamurun deposit.

The idea of the work is to scientifically substantiate and develop a highly effective combined well regeneration method based on the integrated application of physical and chemical influences, considering the specifics of the geological and hydrogeological conditions of the uranium deposit.

Research objectives:

In order to achieve this goal, the following tasks were identified in the framework of this thesis:

1. To study the geological, hydrogeological and technological conditions of the Karamurun site to substantiate the feasibility of using an innovative combined well regeneration method.

2. Analysis of existing methods of well regeneration during underground borehole leaching of uranium with the formation of model dependencies on the effectiveness of traditional technologies and assessment of their technical and economic indicators.

3. Creation and research of a combined well regeneration method.

Scientific novelty:

- A combined method of well regeneration has been developed, characterized by a combination of hydrodynamic flushing and metered treatment with ammonium

bifluoride, with a pneumatic pulse air wave, which allows to increase well productivity and increase the inter-repair cycle in the conditions of a uranium deposit;

- A technology has been developed for the use of a combined well regeneration method with the modernization of a mobile installation, characterized by the possibility of simultaneously/separately conducting chemical and hydrodynamic treatment and flushing wells directly at geotechnological landfills;

- The dependences of the flow rate and MPC of technological wells with high-strength deposits or closed filters during their decompression with various chemical reagents and their concentration have been established.

Scientific statements submitted for protection:

- A method for restoring technological wells with the integrated use of cyclic chemical and mechanical action to clean the filter part;

- The technology of applying a chemical and mechanical method of well regeneration at geotechnological landfills using an advanced mobile installation that provides both simultaneous and separate treatments.;

- In wells characterized by the presence of high-strength deposits or partial (complete) closure of the filter zone, the restoration of flow rate requires the use of chemical reagents of various concentrations.

The object of the study is the underground borehole leaching of uranium at the «Karamurun» deposit.

The subject of the study is the regeneration of wells using physical and chemical effects.

Methodological base of scientific research:

Analysis and generalization of mining and geological conditions, well regeneration experience. Development of a methodology and conducting pilot tests of the proposed well regeneration technology. Time-lapse observations, collection and comparative analysis of geotechnological characteristics of wells before and after testing using a combined multifunctional method.

Compliance of the work with the directions of scientific development or government programs:

The dissertation work was carried out within the framework of the IRN grant financing project No. AR26198685 "Development of universal chemical and mechanical technologies for cleaning filtration columns and a pre-filter zone during uranium leaching".

Publications and approbation of the work:

The results of the work were reported at international scientific, technical, scientific and practical conferences and published in the Scopus database.:

- Utility model Patent dated 12/13/2022 No. 8349, RSE "National Institute of Intellectual Property", Ministry of Justice of the Republic of Kazakhstan, Astana, Bulletin No. 32, https://gosreestr.kazpatent.kz/;

- 5th International Scientific and Technical Internet Conference “Innovative Development of resource-saving technologies and sustainable use of natural resources". Collection of abstracts. - Petroshani, Romania: UNIVERSITAS Publishing House, 2022. - pp. 157-160, ISSN 2734-6935;

- X Anniversary Scientific and Practical International Conference dedicated to the 25th anniversary of NAC Kazatomprom JSC and the 20th anniversary of Institute of High Technologies LLP "Actual problems of the uranium industry", November 24-26, 2022, part 1, 222-226, according to ISBN 978-601-269-502-1;

- NUCLEAR POTENTIAL OF KAZAKHSTAN: Collection of reports, issue 17, 2022 / Association "Nuclear Society of Kazakhstan". — Astana, 2022, 48-54, according to ISBN 9965-32-597-9.

- An article was published in the international journal Geomechanics and Geoengineering, London, UK, on the topic: "Research of an innovative method for optimizing the repair and renewal of production wells in the central area of the Mynkuduk field" 62+ Q2, Scopus database.

- An article in the journal "Development of mineral deposits", Ukraine, on the topic: "Investigation of the influence of various factors on repair and restoration work in technological wells using uranium geotechnology in difficult mining and geological conditions" 78+ Q1, Scopus database.

- An article was published in the journal "Geological Quarterly" on the topic: "Improvement of maintenance and repair of technological wells in the conditions of the North and South Karamurun field, Kazakhstan", 46+ quarter 3, Scopus database.