Crossref
creative commons
UDC 622.7
IRSTI 52.13.04
DOI: 10.31643/2021/6445.05

Technological improvement of the scheme unit reception and distribution of solution under conditions of high-pressure nature of groundwater

[1] Aliev S. B., [2*] Omarbekov Ye.U.

[1] IPKON, Research Institute of Comprehensive Exploitation of Mineral Resources Russian Academy of Sciences, Moscow, Russia
[2] Satbayev University, Almaty, Kazakhstan

* Corresponding author email: 13s_yernur88@mail.ru; y.omarbekov@stud.satbayev.university

Received: *30 January 2021*
Peer reviewed: *15 February 2021*
Accepted: 24 *February 2021*

ABSTRACT

This paper analyses the experience uranium deposits mine development under conditions of highpressure nature of groundwater proposed technology "pumping wells" and upgrading technological scheme unit receiving and distribution of the solution. The results of experimental study of the use of "pumping wells" in mining deposits of uranium by in-situ leaching mine "Karatau". It is proved that by using the proposed technology and circuits under conditions of the high groundwater pressure reduces the cost of procurement of cables, significantly reduced the cost of acquisition of submersible pumps, savings in the end cap. In practice, one processing unit is equipped with one unit for receiving and distributing the solution, therefore, a leaching solution with the same acidity is supplied to all injection wells. To avoid such cases requires selective supply of different concentrations of acid with the different indicators pH. The modernization of the scheme of the unit for receiving and distributing the solution was carried out by connecting two bypass lines, where one bypass line is designed to transfer the injection wells to the pumping one, and the second one is to transfer the pumping wells to the pumping one. By connecting the two bypass lines, it will be possible to supply a leach solution with a higher acid concentration, selectively to any injection well. As a result, acid consumption will decrease due to its selective supply and pH values in wells will be balanced.

Keywords: In-situ leaching, high-pressure character, «pumping wells», pH factor.

Information about authors:

Aliev Samat Bikitaevich *- Doctor of Technical Sciences, Professor, Research Institute of Comprehensive Exploitation of Mineral Resources Russian Academy of Sciences, Moscow, Russia; https://orcid.org/0000-0002-3699-8322, Email: alsamat@gmail.com*

Omarbekov Yernnur Urazgalievich *- PhD student of Satbayev University, Almaty, Kazakhstan; https://orcid.org/0000-0003-1317-1303, Email: 13s_yernur88@mail.ru; y.omarbekov@stud.satbayev.university*

Introduction

According to the IAEA about 19% of the world's known uranium reserves are concentrated in the Republic of Kazakhstan. The total reserves and resources are estimated at 1,610 thousand tons of uranium, including the reserves of industrial categories (B + C1 + C2) amount to 920 thousand tons [1].

A unique feature of uranium deposits in the Republic of Kazakhstan is that 75% of them are concentrated in rocks associated with regional zones of formation oxidation. This type of deposits is not widespread in the world. It is developed by the most advanced, relatively cheap, and environmentally preferable method of in situ leaching (ISL). In situ leaching (ISL), also known as solution mining involves leaving the ore where it is in the ground and recovering the minerals from it by dissolving them and pumping the pregnant solution to the surface where the minerals can be recovered. Consequently, the soil cover is almost not disturbed, no tailings and waste rock are formed.

One of the stages of development of reserves in the operational unit is a technological step, which includes three stages.

• Ore deposit acidification - supply of working solutions to the ore-bearing horizon in order to change its state and ensure the conditions for the transition of uranium into solution.

• Active leaching - formation and extraction of productive solutions from the block.

• Modification of operating units (additional leaching, “washing” of uranium) is the final stage of uranium mining, which is characterized, as a rule, by a decrease in the uranium content in productive solutions [2].

When mining blocks at the stage of active leaching, the hydrodynamic equilibrium (balance) of the injected and pumped-out solutions must be strictly observed, both for individual production cells, as well as for blocks and areas [3]. In this case, as a rule, provided optimal solutions hydrodynamic filtering mode in block circuit. In the development of deposits in the conditions of high-pressure nature of groundwater, ensuring optimum hydrodynamic filtering mode solutions unit circuit is very difficult. With an imbalance towards pumping (negative balance, pumping exceeds pumping), productive solutions dilute due to the pulling up of formation water due to the block contour. The imbalance in the direction of pumping (the positive balance exceeds injection pumping) leads to the exit of process solutions beyond ore deposits. Thus, there is a uranium loss due to the spreading and re-sedimentation, increased consumption of leaching reagents. It should also be noted that the unbalance solutions in operational blocks may occur overflow of process solutions between adjacent blocks. This significantly complicates, and often makes it impossible to account for uranium production by block (calculation of the movement of reserves) [4].

Hydrodynamic equilibrium (balance) for individual production cells, blocks and sections is established because of data from measurements of production rates of pumping wells and injectivity of injection wells. As a result of mudding, the flow rates and injectivity of wells can vary significantly [5]. Therefore, timely measurements and repair and restoration work is very important to ensure the balance of injected and pumped out solutions. In connection with the above, the studies carried out in this work are quite relevant.

As is known, the main factors when using the method of in-situ leaching are projection of the ore deposit to the surface that determines the location of the wells and infrastructure, the specified productivity of the processing complex and the number of pumping and injection wells. Thus, binding process begins with arrangement of wells in the upper portion of the exhaust well submersible pump, which is the cause of the borehole drilling large diameter "plant around" the larger diameter pipes to equip the upper end of the well head part correspondingly more expensive. In addition, electric cables are laid to the location of the technological unit and each well from the transformer substation and from the distribution units of solutions. All of these additional costs is inevitable because of pumped well location identified the morphology of the ore body and the need to define solutions underground vector of their movement with the use of a submersible pump [6,7].

Experimental part and discussion of results

The experimental unit is located in the section №2. The area of the block is 40,500 square meters, the ore is represented by hard rocks, the thickness of the aquifer is 8-12 m, the depth is 670 m. The experimental block has 30 injection wells, 14 extraction wells, the distance between the injection and extraction wells is 30 meters. An in-line autopsy scheme was adopted. Drilling is carried out with the drilling machine BFU-1200m (mobile drilling unit). Extraction wells are constructed in the injection format, as shown in Figure 1, cased with 89 mm PVC (poly vinyl chloride) pipe, filter - KDF 118. To carry out experimental work, an improved scheme for connecting technological wells was proposed (Figure 1), the essence of which is the extraction of pumping wells in the injection format; near the transformer substations with a depth of 50-100 meters, "pumping wells" are being built, equipped with a blind filterless column, in which submersible pumps are located. The total power of the pumps is equal to - optimal with a traditional piping scheme [8].

Pumping wells connected to the extract hose and constitute a system of communicating vessels. Apparently, a necessary condition in this case should be - a positive head of groundwater above the surface and the location of the pump below the dynamic level. The minimum number of such “pumping wells” is one per processing unit [9].

In this case, the flow rate in the extraction wells is regulated by means of shut-off equipment. The use of "pumping wells", along with a direct economic effect, makes it possible to use any combination of injection wells in the functions of pumping wells at different stages of block development.

In the new technical solution, adding "pumping wells" to the piping, we create conditions that do not require a pump and infrastructure for it to be located at the desired point of the block; the necessary vector of formation water movement at such a point is created remotely, using "pumping wells". This radically optimizes the operation of the system (at any time, you can use any wells in any ratio, both pumping and injecting ones, constructing them in a pumping-only format), reducing the cost of underground leaching and reducing uranium losses by developing "stagnant" zones.

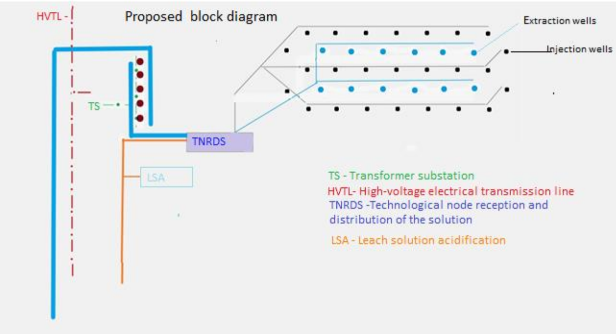

Figure 1 - Experimental scheme of binding the unit

To implement the proposed technology, it is necessary to modernize the scheme of the solution receiving and distribution unit (Figure 2). The main goal of the modernization of the scheme is to supply the leach solution to the wells with different acid concentrations, to minimize the difference in pH values in the wells, as well as other parameters for compiling the leach balance. The pH index is of particular importance in the extraction of uranium by the in situ leaching method [10].

For effective leaching, we need to achieve a pH in the range of 1.5 - 2, where natural uranium dissolves much better in this environment, but it is not always possible to achieve a simultaneous or gradual decrease in pH in all wells. One of the reasons is the close location of previously operated and new technological blocks, namely, wells that are in close proximity to the wells of old blocks have a lower pH value than wells located far from the already acidified technological block.

In practice, one processing unit is equipped with one unit for receiving and distributing the solution, therefore, a leaching solution with the same acidity is supplied to all wells. To avoid such cases, selective feeding with different acid concentrations is required considering different pH values. By making small changes to the scheme of the unit for receiving and distributing the solution, it is possible to supply the leaching solution with different acidities.

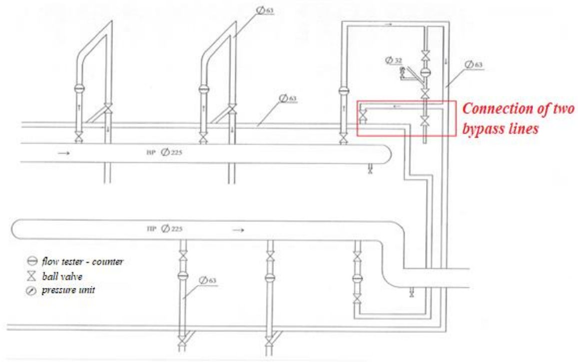

Figure 2 - Proposed scheme unit reception and distribution of solution

The modernization of the scheme of the unit for receiving and distributing the solution was carried out by connecting two bypass lines, where one bypass line is designed to transfer the injection wells to the extraction one, and the second one is to transfer the extraction wells to the injection one. By connecting the two bypass lines, it will be possible to supply a leach solution with a higher acid concentration, selectively to any injection well. This can be avoided above problems.

As a result of the application of the proposed well piping scheme, the costs of purchasing cable products are reduced many times, the costs of purchasing submersible pumps are significantly reduced (the cost of a more powerful pump is much less than the cost of several of the same power), and funds are saved on the end caps.

Modernization of the scheme of the unit for receiving and distributing the solution will allow to reduce the consumption of acid due to its selective supply and balance the pH values in the wells.

Conclusions

In the new technical solution - adding "pumping wells" to the piping, we get a system of communicating vessels, which does not require a pump and infrastructure for it to be located at the desired point of the block; the necessary vector of formation water movement at such a point is created remotely, using pumping wells. This radically, ultimately optimizes the operation of the system (at any time you can use any wells in any ratio, both extracting and injecting ones), thereby working out stagnant zones in the area of blocks and increasing the percentage of block development - without additional costs for drilling wells and building the necessary infrastructure. Technically, these possibilities are realized using a "bypass" piping line directly in the building of the receiving and distribution unit.

The investment effect from the introduction of the new technical solution in the process of underground borehole leaching of uranium, allows to achieve cost savings for the implementation of mining and preparatory work (piping of wells of technological blocks).

Conflicts of interest. On behalf of all authors, the corresponding author states that there is no conflict of interest.

Acknowledgements. The authors of the paper are grateful to corresponding member of NAS RK, doctor of technical sciences, professor Yussupov Kh. A, for rendering a valuable advice and guidance in the preparation of this article.

Cite this article as: Aliev S. B., Omarbekov Ye.U. Technological improvement of the scheme unit reception and distribution of solution under conditions of high-pressure nature of groundwater. *Kompleksnoe Ispol’zovanie Mineral’nogo Syr’a. = Complex Use of Mineral Resources = Mineraldik Shikisattardy Keshendi Paidalanu.* 2021. №1(316), pp. 40-45.
https://doi.org/10.31643/2021/6445.05

Жер асты суларының жоғары қысымды сипаттағы жағдайында ерітіндіні қабылдау және тарату қондырғысының сызбасын (схемасын) жаңарту

[1] Алиев С.Б., [2*] Омарбеков Е.У.

[1] Н.В. Мельникова атындағы жер қойнауын кешенді игеру проблемалары институты, Ресей ғылым академиясы, Мәскеу, Ресей

[2] Сәтбаев Университеті, Алматы, Қазақстан

** Автордың электрондық поштасы: 13s_yernur88@mail.ru; y.omarbekov@stud.satbayev.university*

Мақала келді: *30 қаңтар 2021*
Рецензенттен өтті: *15 ақпан 2021*
Қабылданды: 24 *ақпан 2021*

ТҮЙІНДЕМЕ

Бұл жұмыста жер асты суларының жоғары қысымды сипаттағы жағдайында уран кен орындарын игеру тәжірибесі талданған, «сорғы ұңғымалары» технологиясы және ерітіндіні қабылдау және тарату қондырғысын жаңарту (модернизациялау) сызбасы ұсынылған. «Қаратау» кенішінде ұңғымаларды жерасты шаймалау әдісімен уран кен орындарын игеру кезінде «сорғы ұңғымаларын» қолдануды эксперименттік зерттеу нәтижелері келтірілген. Ұсынылған технология мен сызбаны жер асты суларының жоғары қысымды сипаттағы жағдайында қолданған кезде кабель өнімдерін сатып алуға кететін шығындар азаятындығы, су асты сорғыларын сатып алуға кететін шығындар едәуір азаятындығы және ұңғыма басына жұмсалатын қаражат үнемделетіндігі дәлелденді. Тәжірибеде бір технологиялық блокта бір ғана қабылдау және тарату қондырғысы болады, сондықтан барлық айдау ұңғымаларына шаймалау ерітіндісі бірдей қышқылдықта беріледі. Осындай жағдайларды болдырмау үшін іріктеп қышқылды әр түрлі концентрациялармен pH көрсеткішіне байланысты беру қажет. Қабылдау және тарату қондырғысының жаңартылған сызбасы екі байпасты линияларды бір-біріне жалғау арқылы іске асты, ондағы бір байпас линиясы айдау ұңғымаларын сорғыш ұңғымаларына ауыстыру үшін, ал екіншісі сорғыш ұңғымаларын айдау ұңғымаларына ауыстыруға арналған. Екі байпас линияларын қосу арқылы шаймалаушы ерітіндіні жоғары концентрацияланған қышқылмен кез келген айдау ұңғымасына іріктемелі түрде жіберуге болады. Нәтижесінде қышқылдың шығыны азаяды және pH көрсеткіші барлық сорғыш ұңғымаларында теңгеріледі.

Түйін сөздер: жерасты шаймалау, жоғары қысымды сипат, «сорғы ұңғымалары», pH көрсеткіші.

Авторлар туралы ақпарат:

Алиев Самат Бикитаевич — *- Техника ғылымдарының докторы, Н.В. Мельникова атындағы жер қойнауын кешенді игеру проблемалары институты, Ресей ғылым академиясы, Мәскеу, Ресей; https://orcid.org/0000-0002-3699-8322, Email: alsamat@gmail.com*

Омарбеков Ернур Уразгалиевич — *- Satbayev University PhD докторанты, Алматы, Қазақстан; https://orcid.org/0000-0003-1317-1303, Email: 13s_yernur88@mail.ru; y.omarbekov@stud.satbayev.university*

Модернизация схемы узла приема и распределения раствора в условиях высоконапорного характера подземных вод

[1] Алиев С.Б., [2*] Омарбеков Е.У.

[1] Институт проблем комплексного освоения недр им. академика Н.В.Мельникова Российской академии наук ИПКОН РАН, Москва, Россия
[2]Satpayev University, Алматы, Казахстан

** Электронная почта автора: 13s_yernur88@mail.ru; y.omarbekov@stud.satbayev.university*

Статья поступила: *30 января 2020*
Рецензирование: *15 февраля 2021*
Принята в печать: *24 февраля 2021*

АННОТАЦИЯ
В данной работе проанализирован опыт разработки уранового месторождения в условиях высоконапорного характера подземных вод, предложены технология «насосных скважин» и схема модернизации узла приема и распределения раствора. Приведены результаты экспериментальных исследовании применения «насосных скважин» при отработке месторождений урана методом подземного скважинного выщелачивания на руднике «Каратау». Доказана, что при использовании предлагаемой технологии и схемы в условиях высоконапорного характера подземных вод уменьшаются затраты на закупку кабельной продукции, существенно уменьшаются затраты на приобретение погружных насосов, экономятся средства на оголовниках. На практике на один технологический блок установлен один узел приема и распределения раствора, поэтому на все закачные скважины подается выщелачивающий раствор с одной и той же кислотностью. Во избежание таких случаев, требуется выборочная подача с разными концентрациями кислоты с учетом разных показателей pH. Модернизация схемы узел приема и распределения раствора была осуществлена за счет соединения двух байпасных линий, где одна байпасная линия предназначена для перевода закачных скважин в откачную, а вторая-для перевода откачных скважин в закачную. Соединяя две байпасные линии, можно будет подавать выщелачивающий раствор с более высокой концентрацией кислоты, выборочна на любую закачную скважину. В результате снизится расход кислоты за счет выборочной ее подачи и сбалансируются pH показатели в скважинах.

Ключевые слова: Подземно-скважинное выщелачивание, высоконапорный характер, «насосные скважины», показатель pH.

Информация об авторах:

Алиев Самат Бикитаевич
- Доктор технических наук, Институт проблем комплексного освоения недр им. академика Н.В.Мельникова, Российской академии наук, Москва, Россия; https://orcid.org/0000-0002-3699-8322, Email: alsamat@gmail.com

Омарбеков Ернур Уразгалиевич
- PhD докторант Satbayev University, Алматы, Казахстан; https://orcid.org/0000-0003-1317-1303, Email: 13s_yernur88@mail.ru; y.omarbekov@stud.satbayev.university

Литература

[1] Суходолов А.П. Мировые запасы урана: перспективы сырьевого обеспечения атомной энергетики. // Известия Иркутской государственной экономической академии. 2010. № 4(72) С.166-169

[2] Boytsov A. Worldwide ISL Uranium Mining Outlook: presentation//Proceedings of the International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM-2014),23-27 June 2014.-Vienna: IAEA, 2014. P.1-23

[3] Носков М.Д. Добыча урана методом скважинного подземного выщелачивания, Учебное пособие Северск 2010

[4] Kenzhaliyev, B. K., Surkova, T. Y., & Yessimova, D. M. (2019). Concentration of rare-earth elements by sorption from sulphate solutions. Kompleksnoe Ispol'zovanie Mineral'nogo syr'â/Complex Use of Mineral Resources/Mineraldik Shikisattardy Keshendi Paidalanu, 3(310), 5–9. https://doi.org/10.31643/2019/6445.22

[5] Юсупов Х. А., Алиев С.Б., Джакупов Д.А., Ельжанов Е.А. Исследование применения бифторида аммония для химической обработки скважин. Горный журнал, Москва (Россия), №4, 2017, с.57-60. DOI 10/17580/gzh.2017.04.11

[6] Алиев С.Б., Захаров В.Н., Кенжин Б.М., Смирнов Ю.М.Адаптивный метод вибрационно-сейсмического воздействия на повышение эффективности подземного выщелачивания металлов// «Уголь», № 2, 2019 г. С. 76-80. DOI: 10.18796/0041-5790-2019-2-76-80.

[7] Manual of acid in situ leach uranium mining technology. - IAEA, Vienna, 2001, IAEA-TECDOC-1239, ISSN 1011–4289, © IAEA, 2001 // Printed by the IAEA in Austria, August 2001

[8] Omarbekov Ye., Yusupov Kh. Improving the technology of uranium mining under the conditions of high groundwater pressure. Mining of Mineral Deposits, 14(3), 112-118, 2020

[9] Юсупов Х. А., Омарбеков Е. У. Влияние технологии «насосных скважин» на дебит откачных скважин // Комплексное использование минерального сырья. -2020. -№2 (313). -С.14-18. https://doi.org/10.31643/2020/6445.12

[10] Omarbekov Ye.U. Application of leach ing techn ology at the uranium deposits sites with sig nificant static leve ls of underground water. Proceedings of the IV International Scientific and Practical Conference (April 1–3, 2020, Ivano-Frankivsk), In Two Volumes, Volume 2.

Reference

[1] Sukhodolov A.P. Mirovyye zapasy urana: Perspektivy syryevogo obespecheniya atomnoy energetiki (World Uranium Reserves: Prospects for nuclear power raw materials). Izvestiya IGEA = Proceedings of the ISEA. **2010**. 4(72), 166-169 (in Russ.).

[2] Boytsov A. Worldwide ISL Uranium Mining Outlook: presentation//Proceedings of the International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM-2014),23-27 June 2014.-Vienna: IAEA, 2014. P.1-23

[3] Noskov M.D. Dobicha urana metodom skvazhinnogo podjemnogo vyshelacivnya, Uchebnoe posobie Sebersk 2010

[4] Kenzhaliyev, B. K., Surkova, T. Y., & Yessimova, D. M. (2019). Concentration of rare-earth elements by sorption from sulphate solutions. Kompleksnoe Ispol'zovanie Mineral'nogo syr'â/Complex Use of Mineral Resources/Mineraldik Shikisattardy Keshendi Paidalanu, 3(310), 5–9. https://doi.org/10.31643/2019/6445.22

[5] Yusupov Kh.A., Aliyev S.B., Djakupov D.A., Yelzhanov Ye. A. Issledovanie primenenya biftorida ammoniya dlya khimisheskoi obrabotki skvajin. Gorniy journal, Moskva (Rossiya), №4, 2017, p. 57-60. DOI 10/17580/gzh.2017.04.11

[6] Aliyev S.B., Zakharov B.N., Kenjin B.M., Smirnov Yu.M. Adaptivniy metod vibrachionno-seicmicheskogo vozdeistviya na povisheniye effectivnosty podzemnogo vychelashivaniya metallov// «Ugol», №2, 2019 g. p. 76-80. DOI: 10.18796/0041-5790-2019-2-76-80.

[7] Manual of acid in situ leach uranium mining technology. - IAEA, Vienna, 2001, IAEA-TECDOC-1239, ISSN 1011–4289, © IAEA, 2001 // Printed by the IAEA in Austria, August 2001

[8] Omarbekov Ye., Yusupov Kh. Improving the technology of uranium mining under the conditions of high groundwater pressure. Mining of Mineral Deposits, 14(3), 112-118, 2020

[9] Yusupov Kh. A., Omarbekov E. U. Vliyaniye tekhnologii «nasosnykh skvazhin» na debit otkachnykh skvazhin [The effect of «pumping wells» procedure on the flow rate of extraction wells] // Kompleksnoe Ispol'zovanie Mineral'nogo Syr'a = Complex Use of Mineral Resources. - 2020. - No. 2 (313). - S. 14-18. (In Russian). https://doi.org/10.31643/2020/6445.12

[10] Omarbekov Ye.U. Application of leach ing techn ology at the uranium deposits sites with sig nificant static leve ls of underground water. Proceedings of the IV International Scientific and Practical Conference (April 1–3, 2020, Ivano-Frankivsk), In Two Volumes, Volume 2.