

MEMBRANE TECHNOLOGIES IN JV LLP KATKO PRODUCTION

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Aim: creation and implementation of a membrane nanofiltration unit for uranium eluate concentrating

Abstract

Specialists of JV LLP KATKO in cooperation with Chimerical (South Africa), ORANO Group (France) and LLP IHT developed and tested nanofiltration technology for uranium eluate and then designed and created membrane unit for nanofiltration.

The feasibility of the invented nanofiltrating unit is justified by necessity to reduce the operating costs in the production cycle of the company and, accordingly, reduce the cost of manufactured uranium.

Research works, design, engineering, installation, start-up and testing of the unit are carried out as part of the R&D project "Development work on creation of commercial eluate nanofiltration sector on Moyinkum South site."

Installation and commissioning of the membrane unit on site is planned to Autumn 2019.

Introduction

Membrane technologies are used to separate ions and molecules by their size by passing through a semipermeable membrane that allow pass molecules or ions of no more than a certain size. As a rule, to intensify the process, it is carried out under high pressure (up to 40 bar). To date four types of filtration using membrane technologies are used (Fig. 1). Electrodialysis is a separate type of membrane process when transfer through a membrane occurs under the influence of an electric field (only for charged ions).

The applied membrane technology is based on high-pressure nanofiltration processes through a membrane with a charged active surface. Nanofiltration allows the passage through the membrane solution of monovalent molecules called Filtrate and the retention of solution containing divalent and multivalent molecules called Concentrate, as shown in Figure 2.

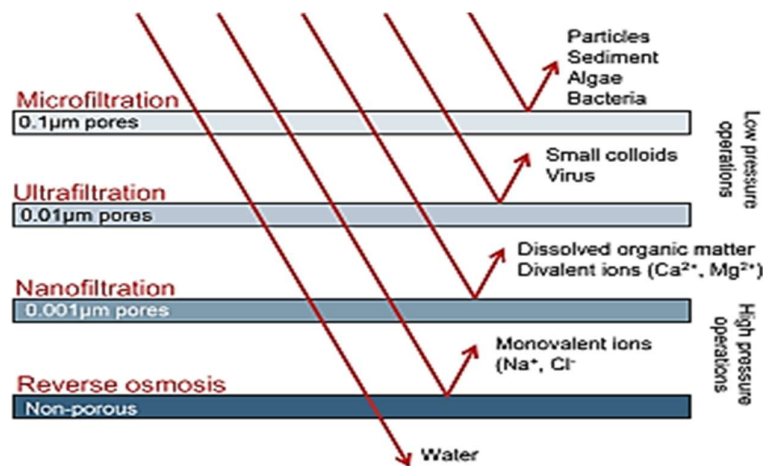


Figure 1. Membrane filtration processes types

In the developed nanofiltration technology uranium eluate serves as the initial solution for the process. The final uranium product after nanofiltration is diverted to the Concentrate stream. Nanofiltrating separation changes the concentration of ions in solutions, i.e. increases the concentration of uranium in concentrate solution and, accordingly, reduces the volume of the concentrate. The filtrate contains low concentrations of multivalent ions and same concentration of monovalent ions as the precursor uranium eluate, which allows the reuse of acid, nitrates and sulfates. Monovalent ions freely pass into the flow both filtrate and concentrate, causing almost the same concentration in both streams. The degree of concentration in the concentrate stream is determined by the operating parameters of the membrane, which are affected by such properties of the feed material as pH, temperature, pressure and the total dissolved solids.

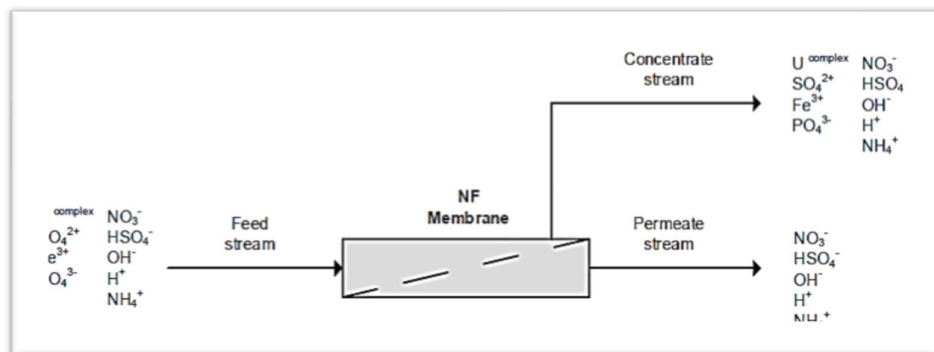


Figure 2. Nanofiltration process diagram

The operating parameters of the membrane correspond to the characteristics of the membrane material. The main operating parameters of the membrane are permeability and retention coefficient of divalent measurements. However, the passage of monovalent ions due to the presence of sulfuric acid in the form of free acid and bisulfate is also of interest in this field of application. Membrane permeability is the rate of diffusion of certain molecules in solution through the active layer of the membrane. Permeability is determined by the flow rate of the filtrate and

the area of the active surface of the membrane. The retention of divalent molecules depends on the ionic charge of the molecules, the charge on the surface of the membrane and the cut-off border on the molecular weight of the retained components of the membrane pores. The range of cut-off boundaries for the molecular weight of the delayed components for nanofiltration is 100-1000 Da.

Regeneration is the volume ratio of the filtrate stream and the feed solution stream. This is an indication of the volume of the feed stream that can be recovered as a Filtrate. This parameter is individual for each application and significantly affects the efficiency of the system. As a rule, the range of regeneration by means of a membrane system in industrial areas is 50-85%. Higher regeneration rates usually result in lower filtrate quality.

Methods, discussion and results

Background for membrane unit creating

JV LLP KATKO uranium processing technology includes:

1. Pregnant solution processing and uranium eluate obtaining at site #1 "South" (Moyinkum);
2. Pregnant solution processing and uranium eluate obtaining at site #2 "Tortkuduk"
3. Uranium eluate transportation using special trucks from site #1 to site #2;
4. From both sites' uranium eluate processing at the refining plant on site #2.

The proposed technology of uranium eluate membrane nanofiltration and developed membrane unit will be operated at the part of production of eluate at site #1 to concentrate natural uranium containing in eluate.

Concentration of uranium from eluate will significantly reduce the volume of transported uranium solution and correspondently the number of shipments from site #1 to site #2.

In addition, it will be possible to reuse Filtrate solution enriched by nitrates on the plant on the desorption process.

The developer of the technical solution for the use of membrane technologies for the regeneration of acid and the concentration of uranium from eluate solution is the South African design and technology company "Chimerical". The company specializing in the use of membrane systems and related technologies in the industrial, mining and processing sectors.

The stages of unit creating

R&D project on the development of the membrane unit consisted of the following main steps:

1. Experimental nanofiltration of uranium eluate on a Pilot membrane unit to determine the effectiveness of the proposed technology
2. Economic efficiency calculation
3. Development of technical specification documentation for the project industrial implementation
4. Manufacturing and FAT
5. Delivery, installation and commissioning

Currently, stages ## 1- 4 have been completed and the project is on its final fifth phase of implementation.

Pilot Experiment

Eluates nanofiltration experiments were conducted on a pilot membrane unit designed by Aveng (formerly Chimerical). Results of the pilot tests are presented in Table 1.

Table 1 – Ions' concentration before and after nanofiltration

Ion	Unit	Concentration in Eluate	Concentration in Filtrate	Concentration in Concentrate
U	g/l	39,6	1,7	84,0
H2SO4	g/l	44,85	35,91	57,35
NO3	g/l	30,4	35,9	30,6
PO4	mg/l	269	28	522
SO4	g/l	93,9	37,6	152,0
Na	mg/l	283	138	432

According to the data presented in table 1, an increase in the concentration of uranium ions in the concentrate by more than two times was achieved in comparison with the initial eluate. As a result, the solution volume decreases by more than two times with more than 95% extraction of uranium into concentrate (Fig. 3).

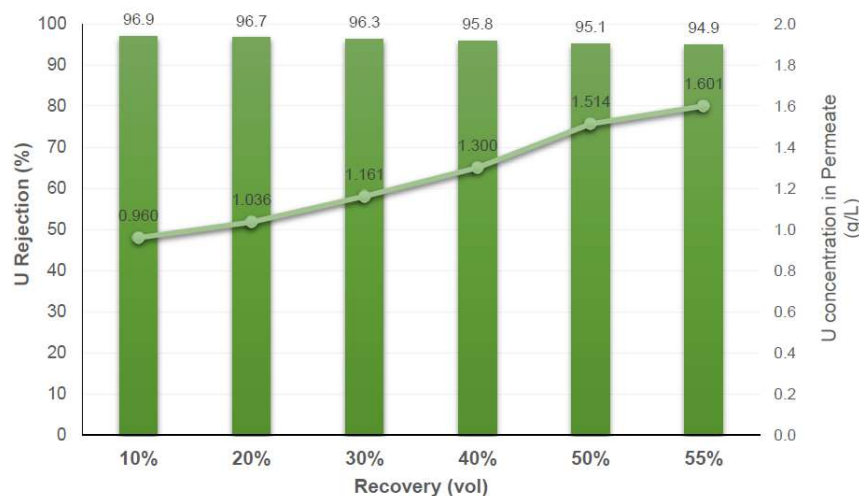


Figure 3. Recovery and rejection rate

As a not very desirable effect should be noted that in the concentrate also increased the concentration of harmful impurities, such as phosphate ions. However, the proportional ratio of those impurities to uranium in the obtained concentrate is equivalent to the same ratio in initial uranium eluate.

Cost-effectiveness

The economic efficiency of the implementation of the described technological unit for nanofiltration of the eluate is obvious, since more than halving the transportation volumes, which is a rather expensive service, will significantly reduce the cost of product.

Design

The design of the unit was carried out by Chimerical.

LLP Institute of High Technologies provided legal support and approval of the project in Kazakhstan.

The main requirements reflected in the technical specification for the design of the unit were as follows:

- before applying to the nanofiltration membrane uranium eluate should undergo a two-stage mechanical impurities filtration
- eluate pressure on the membrane should be 25 bar
- average eluate flow rate of 9 m³/h
- automatic pressure relief during depressurization must be provided
- automatic control of the unit's functioning
- the pipeline must be made of acid resistant materials
- unit should be independent and installed in 40-foot sea container, to which all production lines will be brought
- connection to the actual uranium eluate line is carried out at the eluate stock on the site #1 and does not affect the existing production process of the pregnant solutions processing section.

Manufacturing and FAT

The membrane unit was completed under the contract by Chimerical in July 2019. Figure 4 shows some photographs of the unit made by KATCO specialists in August 2019 during FAT in South Africa.

Commissioning

Delivery, installation and commissioning of the unit are scheduled for autumn 2019.

Conclusion

Technology for uranium eluate concentrating through membrane nanofiltration unit was developed and on site tested. Industrial tests of the pilot membrane unit were carried out. An industrial version of the membrane nanofiltration unit in an autonomous container design has been manufactured. A significant economic effect is expected. Installation and commissioning are planned in Autumn 2019.



Figure 4. Unit inside view