Experimental Study of Removal of Organic Matters from Alkaline Uranium Leaching Solution with Ultrafiltration

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Abstract

Organic matters in alkaline uranium leaching solution during CO_2+O_2 in-situ leaching process will make ion-exchange resins polluted and resin beds hardened. Experimental study is carried out to remove the organic matters from leaching solution with an ultrafiltration device. The organic matters can be removed efficiently with ultrafiltration and resin pollution and bed harden can be reduced which makes resin adsorption more stable and continuous.

Keywords: CO_2+O_2 in situ leaching; organic matters; ultrafiltration

Introduction

CO_2+O_2 in-situ leaching uranium mining technology has been successfully applied in sandstone type uranium deposits in Xinjiang and Inner Mongolia, China. A fixed bed ion exchange adsorption method is widely used in the application of uranium recovery. The impurities in the leaching solution will cause resin pollution and resin bed hardened, affecting the followed operation. Through the analysis and test of the burning-loss amount, total carbon, total organic carbon and infrared spectrum of the related resin contaminants and the hardened samples, it is found that the humic organic matter is the main cause of the resin pollution and hardening. Generally, the indicators of organic matter pollution are chemical oxygen demand (COD) and total organic carbon (TOC). COD is a chemical measure of the amount of reductive substances that need to be oxidized in water. It is an important and fast measuring parameter of organic matter. The greater the COD value, the higher the content of organic matter in the water. TOC, or total organic carbon, is a comprehensive indicator of the total amount of organic matter in water. By comparing the COD and TOC in the tail liquid of the bag filter and the resin tower (Fig. 1 and 2), it is found that both COD and TOC in the tail liquid of the adsorption tower are less than the bag filter solution, and the organic matter that causes the resin pollution is determined from the leaching solution formed by the groundwater. The organic matter in the leaching solution is adsorbed by the resin and enters the interior of the resin particles, causing the pollution of the resin. The deposition of organic matter leads to the adhesion of the resin particles to each other, resulting in the hardening of the resin bed. Cleaning and detoxification cannot fundamentally eliminate resin contamination and resin bed hardening problem. It is preferable to remove organic matters before adsorption.

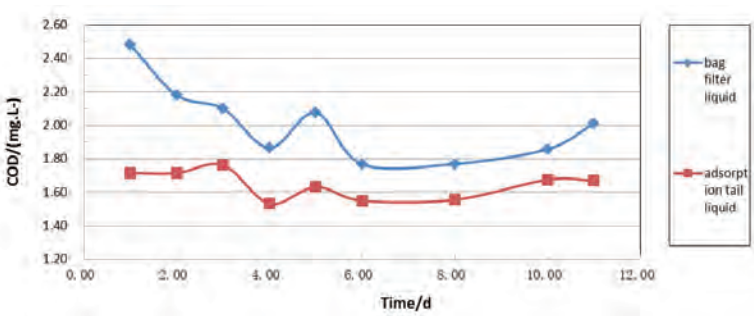

Figure 1 COD test results

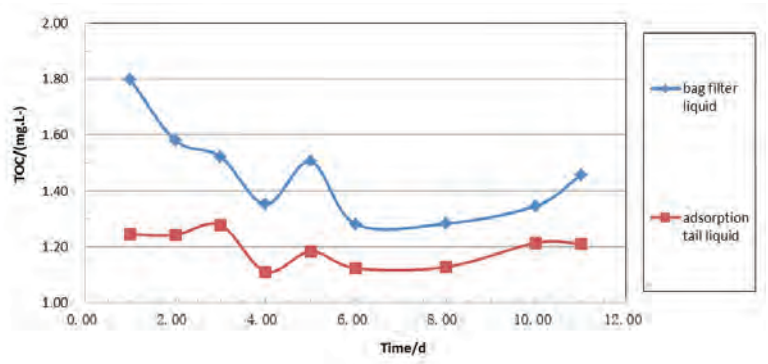

Figure 2 TOC test results

Selection of removal method of organic matter

The ordinary methods of removing impurity from water include adsorption, microfiltration, ultrafiltration and nanofiltration. Compared with other methods, the ultrafiltration has the advantages of less operating pressure, larger water production and higher separation precision. It is more suitable for removing the organic matter in the colloid state, that is, the high suspended organic matter with a particle size below 0.1 μm (<100nm) [1]. The principle of ultrafiltration is that, under the action of external force, the separated solution flows along the surface of the ultrafiltration membrane at a certain velocity, and the solvent in the solution, the low molecular weight material and the inorganic ion, enter the low pressure side through the ultrafiltration membrane from the high pressure side and discharge as the filtrate; The polymer, colloid particles and microbes in the solution are intercepted by the ultrafiltration membrane, and the solution is concentrated and discharged in the form of concentrated solution to achieve the purpose of separation of large and small molecules[2-3]. In conclusion, the ultrafiltration method is used to remove organic matter from uranium leaching solution.

Ultrafiltration test device

The ultrafiltration device used in the experiment is based on field test condition, commissioned by professional manufacturers. The core of ultrafiltration device design is ultrafiltration membrane material and membrane module selection. Ultrafiltration membrane materials include cellulose and its derivatives, polycarbonate, PVC, polypropylene, modified acrylic polymers, etc. Polyacrylonitrile (PAN) has good water permeability, good pressure resistance, stable retention of molecular weight, and a wide range of acid and alkali resistance. It is suitable for low organic matter content and poor water quality in water, and is also a kind of low price among many membrane materials. Referring to the previous analysis and testing of pollutants and the characteristics of the test site, polyacrylonitrile (PAN) was selected as an ultrafiltration membrane material, and a preliminary selection of polyacrylonitrile (PAN) membrane material with a molecular weight of 100 thousand was selected in the explored test. In order to ensure the continuous and stable operation of the ultrafiltration test, self-cleaning ultrafiltration test device is adopted and two membrane components are used in parallel to realize automatic flushing and backwashing. Figure 3 is a picture of a self-cleaning decontamination and impurity removal device. Fig. 4 is a normal working flow chart for self-cleaning, decontamination and impurity removal devices. The test parameters of the ultrafiltration device: membrane module diameter: 90mm; water production: 8L/min; cleaning cycle: 3 months; interception of molecular weight 50 thousand; 4 membrane components, single area 2m^2, single membrane flux 125L/ (m^2/h).

Figure 3 Ultrafiltration device

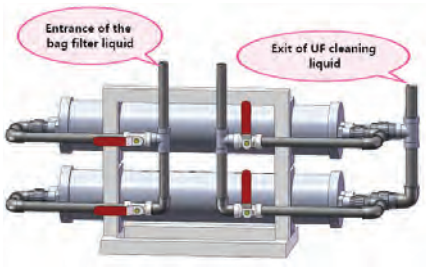

Figure 4 Flow in the ultrafiltration device in working condition

Methods

At the same time, resin adsorption and ultrafiltration were used to compare the removal efficiency of organic matter in the processing plant in Inner Mongolia. Two main branches are separated from the main pipe of bag filter after bag filtration. A branch directly connected with an ion exchange column 1 (as column 1) is used to evaluate the removal of organic matter by adsorption; The other branch is first connected with the ultrafiltration device, and then the ultrafiltration device is connected to the ion exchange column 2 (as column 2), which is used to evaluate the ultrafiltration method for removing organic matter. The evaluation test procedure is shown in Figure 6. The test conditions are as follows:

1) D231 type strong basic anion exchange resin was used for tests, which is same as the resin used for ion exchange adsorption in the uranium mine. The volume of the column 1 bed is 1L, 20L of column 2.
2) The original sorbent used in the test is the feed liquor of the bag filter, of which the uranium concentration is 19mg/L_0Initial inlet velocity of column 1 is 0.3L/min, as to column 2 the velocity is 6L/min.
3) The samples were collected from the feed liquor, column 1 tail fluid and ultrafiltration tail liquid respectively, and the relevant water quality parameters were analyzed and tested. The sampling period was 24h.

Change of water quality parameters

The analysis of COD and TOC were carried out in the feed liquor, tail liquid of column 1 and UF to evaluate the effect of two means of removing the organic matter in the leach solution by adsorption and ultrafiltration. The results of the COD test are shown in Figure 7. The results of the TOC test are shown in Figure 8.

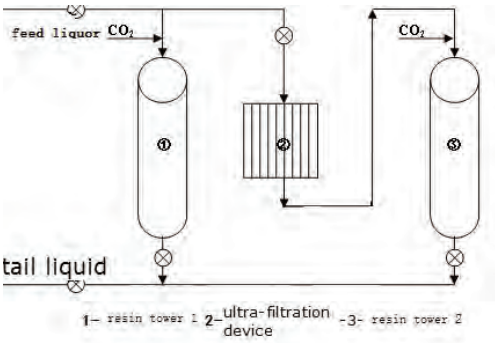

Figure 5 Evaluation tests process

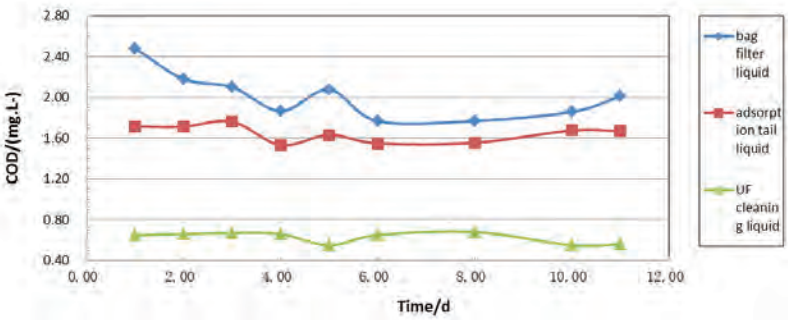

Figure 6 Results of COD test

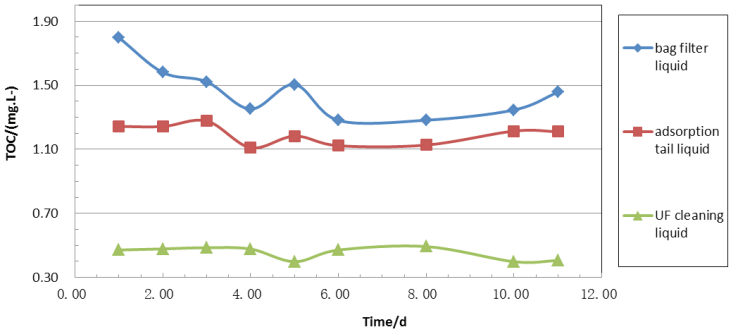

Figure 7 Results of TOC test

According to Figure 7 and figure 8, the values of COD and TOC in the column 1 tail liquid and the ultrafiltration liquid are lower than that in the feed liquor, indicating that the organic matters in the feed liquor can be removed by adsorption and ultrafiltration. Comparing the COD and TOC curves, the values of COD and TOC in ultrafiltration solution were much lower than those in the 1 column tail solution. Ultrafiltration can remove organic matter in leaching solution better than resin adsorption.

Comparison of characters of resin beds

Figure 8 View of resin beds before adsorption

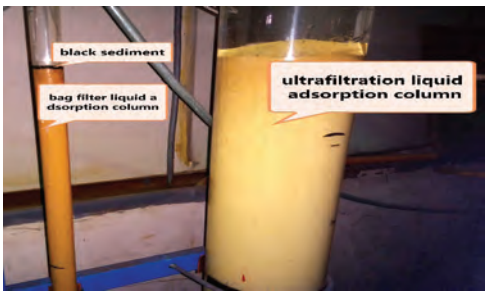

Figure 9 View of resin beds after 5 times adsorption

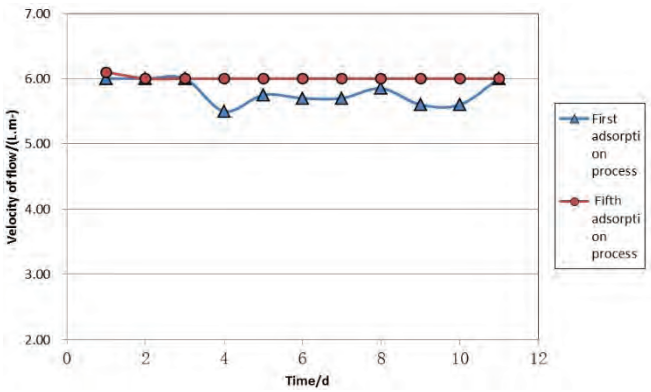

Figure 10 Change of flowrate after several times of adsorption

Figure 10 shows the appearance of the resin adsorption columns before the start of the experiment. Fig. 11 shows the appearance of the columns when the resin is saturated for the fifth time. From the figure, no black solid is found in the adsorption column 2 (right tower), while the adsorption column 1 (the left tower) has a black layer on the top. Analysis shows that the black thing is hardened organic matter. Compared with figures 10 and 11, ultrafiltration can remove organic matter from the feed liquor and reduce resin contamination and hardening. Fig. 12 shows the change of flow rate of the two adsorption process of ultrafiltration resin. It shows that after the treatment of leaching solution the resin in the adsorption column does not have the phenomenon of pollution and hardening. The adsorption process can maintain a very stable continuous operation without the need for the back flushing operation.

Conclusion

The evaluation test shows that both resin adsorption and ultrafiltration can remove the organic matter in the leaching solution. In contrast, the removal efficiency of the ultrafiltration method is more obvious. After ultrafiltration, 2 adsorption cycles were run without resin contamination and resin bed hardening. Ultrafiltration has obvious effect on removing organic matter from leaching solution, eliminating resin pollution and resin bed hardening. The ultrafiltration treatment can improve the continuity and stability of adsorption operation.

References

Jianqiu Ding, Yanan Zhu, Xiaoqin Cai Research and development of UF in treatment of micro polluted water sources treatment, J Guizhou Chemical Industry 2009, 34 (3): 39-43.

Xuehua Duan (1976), Lihong He Application of Ultrafiltration Technology in Treatment of Wastewater,J Environmental Science and Technology, 2010, 23 (1): 36-39.

Jianxin Ren – Membrane Separation Technology and Its Application – 2003: 50-61. Chemical Industry Press, Dongcheng District, Beijing, China.