Study of Optimization Control of Ion-type Rare Earth Ore Leaching Process

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Abstract **- This paper takes ionic rare earth ore, from Jiangxi Ganzhou Zhudong, as the research object, using indoor column leaching method to carry out optimal adjustment of the ore leaching process, investigating the effect of various process factors and result analysis of ion-type rare earth ore before leaching and after leaching. The results show that, when the raw ore about 0.056% rare earth ore, the moisture content is 4%, the ore seam height is 43mm, leaching agent concentration is 4%, leaching solution pH value is 5.0, solid-liquid ratio is 1:0.8, flow rate is 3 mL/min. We can acquire through the test that leaching rate of rare earth is 94.32%, average concentration of rare earth in leaching solution is 1.58 g/L. There are only ion exchange reaction between rare earth ions and electrolyte. Cationic polyelectrolyte is retained in leaching residue when rare earth ions is exchanged leaching. The whole leaching process did not produce other new substance. There was only ion exchange reaction, with no natural crystal texture of rare earth ore change.**

Keywords - Ion-type rare earth ore; Ions exchange; Chemical leaching; Process optimization

I. INTRODUCTION

Ion-type rare earth ore is a new type of rare earth mineral resources, which is in the form of ionic phase, mainly distributed in the south of China, most typical and most abundant reserves is in GanZhou, Jiangxi province [1,2,3]. It has complete rare earth element, contains global shortage medium and heavy rare earth elements, which is closly related to high-tech, sophisticated, new material industry. Now ion-type rare earth ore has become limited exploitation, strategic and economic tight mineral resources [4,5]. Development of ionic type rare earth ore began in the 1970s, has gone through tank leaching, heap leaching and in-situ leaching three process period. Regardless of what kind of technology used, is using more active cations (such as K+, Na+, NH4+,etc) exchange adsorption with rare earth ions, so ions can be concentrated and reclaimed in leaching solution [6,7]. The long-term production practice shows that there is still many problems in the process of leaching, for examples, poor adaptability, low leaching rate, long leaching cycle, high residual reagent of ore, limited the rapid development and extensive promotion of leaching technology. This paper taking ionic rare earth ore, from Jiangxi Ganzhou Zhudong, as the research object, using indoor column leaching method to carry out optimal adjustment of the ore leaching process, investigating the effect of various process factors, controlling the optimum leaching condition, providing the basis for development and utilization of ion-type rare earth ore [8].

A. Test Material And Research Methods

Samples collected from Ganzhou Zhudong, Jiangxi province. According to the study needs, raw ores were processing and test analysis. Multi-elements analysis are listed in Table 1. The XRD result is shown in Figure 1.

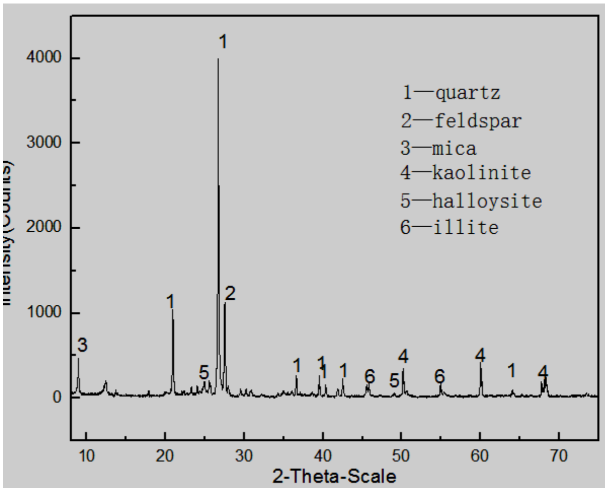

Fig. (1). The XRD Of Rare Earth Ore

The test results show that ore samples mainly composed of SiO2 and Al2O3, followed by K2O, MgO and TFe, mainly hosted in quartz, feldspar, mica, halloysite and illite. Rare-earth elements in ion form output, total for REO is 0.056%. Ore weathering is severe and silt content is high.

The experiment used indoor column leaching device. Ammonium sulfate (analytical pure) be used as leaching agent. Experimental water uses tap water. Unit test sample weight at 500g. To study the effect of concentration and flow rate of leaching agent, leaching solution pH, ore granularity and moisture content, high of the seam on leaching process. To analyse the influence degree of different factors on leaching process. Finally achieve the optimization and adjustment of the leaching process.

TABLE I. THE ANALYSIS RESULTS OF ORE CHEMICAL ELEMENTS

Element	Content	Element	Content
REO	0.056%	CaO	0.14%
SiO2	66.23%	TFe	0.65%
Al2O3	15.44%	K2O	3.78%
MgO	0.21%	Na2O	1.22%

II. EXPERIMENTAL RESEARCH AND PROCESS OPTIMIZATION

A. Effect of Leaching Agent Concentration on Process

Leaching agent concentration has a great impact on leaching rate and ion exchange during leaching process [9]. The leaching agent flow rate is 3mL/min, solid-liquid ratio is 1:0.8 in this experiment. The effect of leaching agent concentration on ion rare earth leaching process was examined, as shown in Figure 2.

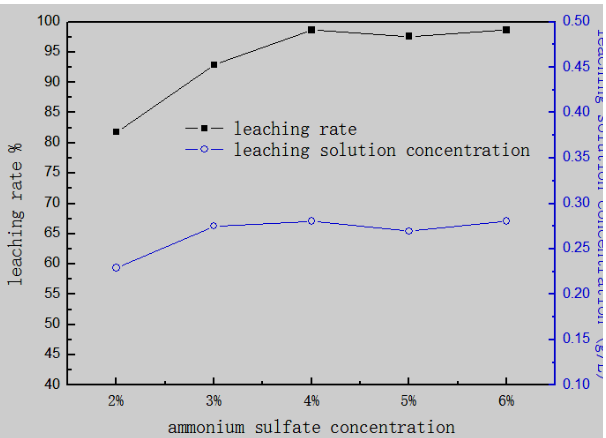

Fig. (2). Effect of Leaching Agent Concentration On Process

As can be seen from the Figure 2, with the increase of ammonium sulfate concentration, the peak value of the rare earth concentration in leaching solution and the rare earth leaching rate increased gradually. When concentration of the leaching solution is increase, not only increase concentration gradient of electrolyte NH4+, leaching agent penetration and diffusion layer thickness, but also strengthen diffusion driving force in leaching process accelerate leaching rate and enrichment effect of rare earth ions.

B. Effect of Leaching Agent Flow Rate On Process

Leaching agent flow rate has great influence on the leaching process of rare earth ions. If velocity is slow, exchanged leaching rare earth ions cannot into the leaching solution timely, ions will re-adsorption with the original adsorption carrier mineral. It reduce the leaching efficiency of rare earth, extend the leaching cycle. If the flow rate is too fast, leaching agent cannot be thoroughly exposed to mineral grains, cannot exchange with rare earth ions effectively. It causes “leaching channelling phenomenon”, reduces leaching efficiency. In this experiment, leaching agent concentration is 4%, solid-liquid ratio is 1:0.8. The effect of leaching agent flow rate on ion rare earth leaching process is examined, as show in Figure 3.

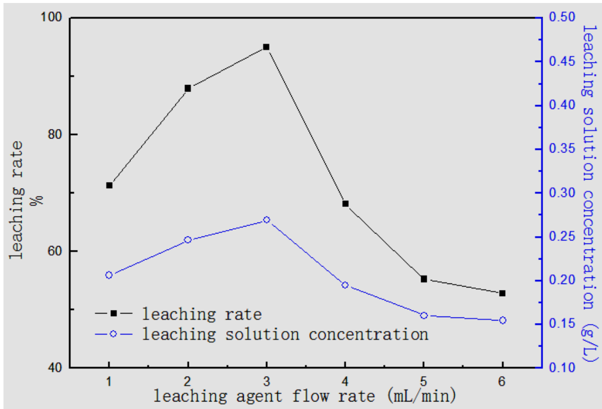

Fig. (3). Effect of Leaching Agent Flow Rate On Process

As can be seen from the Figure 3, with the increase of leaching agent flow rate, rare earth leaching rate and concentration showed increase-decrease trend. When the velocity of leaching agent is more than 3 mL/min, with speeding up of leaching agent flow rate, the leaching agent electrolyte contact with mineral surface incompletely, the ion exchange reaction is not sufficient, the leaching rate of rare earth is gradually reduced. So the optimal flow rate of leaching agent is 3 mL/min.

C. Effect of Leaching Agent Dosage On Process

During ion-type rare earth ore leaching process, the ratio of rare earth ore quality and leaching agent volume (solid-liquid) was be used to represent the leaching agent dosage. In this experiment, leaching agent concentration is 4%, flow rare is 3 mL/min. The effect of leaching agent dosage on ion-type rare earth ore leaching process is examined, as show in Figure 4.

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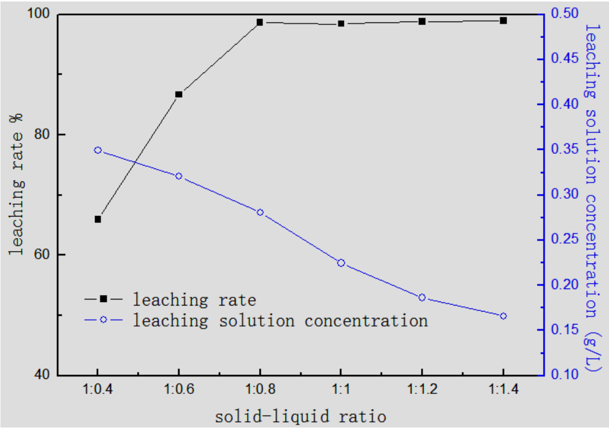

Fig. (4) Effect of Leaching Agent Dosage On Process

As can be seen from the Figure 4, the leaching rate of rare earth is low when leaching agent dosage is low. With the increase of leaching agent dosage, rare earth leaching rate gradually increased. When the leaching solid-liquid ratio is 1:0.8, rare earth leaching rate is higher. Leaching rate would change little and concentration decreased significantly when continue to increase leaching agent dosage. Therefore, the optimal solid-liquid ratio is 1:0.8.

D. Effect of Solution pH On Leaching Process

Rare earth ion can be exchange by H+, so pH of leaching solution has a great influence on the leaching process. In the experiment, leaching agent concentration is 4%, leaching flow rate is 3 mL/min, solid-liquid ratio is 1:0.8. The effect of leaching solution pH on rare earth leaching process is examined, as show in Figure 5.

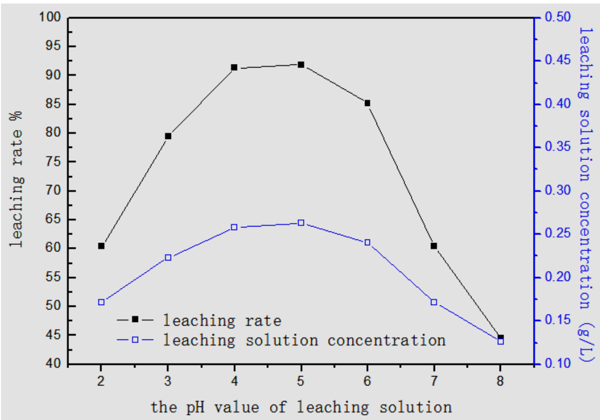

Fig. (5). Effect Of Solution pH On Leaching Process

As can be seen from the Figure 5, leaching solution pH has great influence on the leaching process. When leaching solution pH in the range of 4.0~5.5, the leaching result is better, leaching rate is greater than 90%. When leaching solution pH is less than 4.0 or more than 5.5, the leaching rate is reduced significantly. So, the optimal pH value is 4.0~5.5.

E. Effect of Ore Moisture Content On Leaching Process

Ion-type rare earth ore contains a large number of clay mineral. Clay mineral has a strong hydrophilic. Ore moisture content affect leaching agent concentration in mineral surface directly [10]. Before the test, first dry rare earth ore. Then place in constant temperature and pressure environment for ten days according to different water ratio, until samples reach to adsorption equilibrium for water. Finally, acquire rare earth ore with different moisture content. In the experiment, leaching agent concentration is 4%, flow rate is 3 mL/min, solid-liquid ratio is 1:0.8. The effect of ore moisture content on rare earth leaching process is examined, as show in Figure 6.

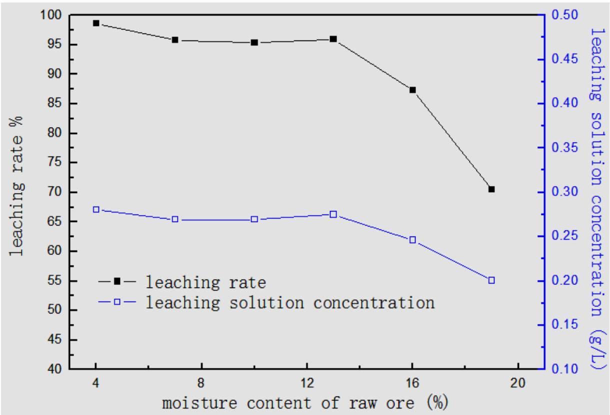

Fig. (6). Effect of Ore Moisture Content On Leaching Process

As can be seen from the Figure 6, with the increase of moisture content, rare earth leaching rate and leaching agent concentration showed decrease trend. When raw ore moisture content is more than 13%, rare earth leaching rate decreases greatly. So, make sure ore moisture content is 13% or lower.

F. Effect of Ore Granularity On Leaching Process

The granularity of rare earth ore is different, its permeability and effect on leaching process is also different. Pre-classification is applied to rare earth ore before the test. Ore is divided into +0.02mm, -0.02mm+0.25mm, -0.25mm three natural grain grade, and yield of each size fraction is 47.61%, 32.25%, 30.14%. In the experiment, leaching agent concentration is 4%, flow rate is 3 mL/min, solid-liquid ratio is 1:0.8. The effect of ore granularity on rare earth leaching process is examined.

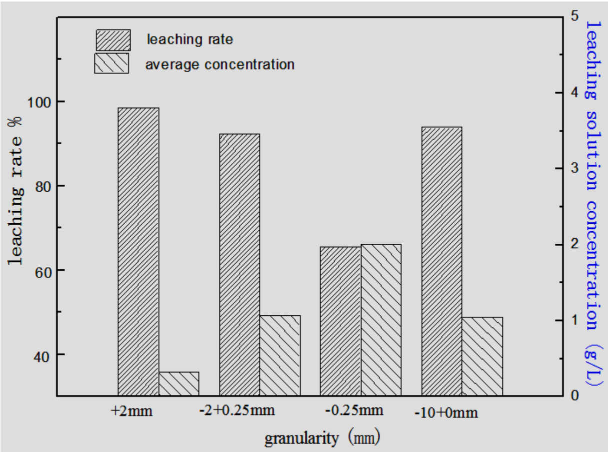

Fig. (7). Effect of Ore Granularity On Leaching Process

As can be seen from the Figure 2.7, rare earth leaching rate is high when the ore partial is large, the permeability is better and the capillary is unobstructed. When ore granularity is less than 0.25mm, the permeability of the ore is bed, the capillary is obstructed. These lead to the occurrence of the phenomenon of effusion easily, and rare earth leaching rate is low.

G. Effect of Ore Seam Height On Leaching Process

In the experiment, leaching agent concentration is 4%, flow rate is 3 mL/min, solid-liquid ratio is 1:0.8. The effect of ore seam height on leaching process is examined by change the height of rare earth ore seam, as show in Figure 8.

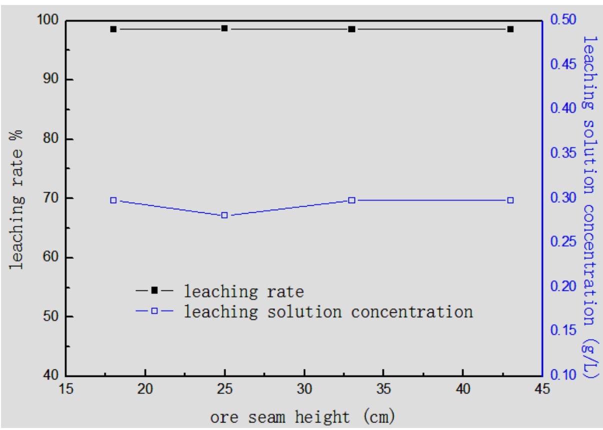

Fig. (8). Experimental study on regulation of leaching process of ion-type rare earth ore

As can be seen from Figure 8, ore seam height only have little effect on rare earth leaching process. With the increase of ore seam height, the moving route of the leaching agent and flowing distance extended accordingly. Part of rare earth ions which were exchanged by leaching agent re-absorb carrier minerals in the ore body. It causes the decrease of leaching rate. So, ore seam height should be controlled reasonably.

H. Effect of Ore Seam Height On Leaching Process

By using the single factor test results and the optimal leaching conditions, the experimental study on regulation of leaching process of ion-type earth ore is carried out. In the experiment, the ore moisture content is 4%, the ore seam height is 43mm, leaching agent concentration is 4%, leaching solution pH value is 5.0, solid-liquid ratio is 1:0.8, flow rate is 3 mL/min. The experiment result shows that the process conditions determined by single factor tests are stable and feasible. We can know through the test that leaching rate of rare earth is 94.32%, average concentration of rare earth in leaching solution is 1.58 g/L.

III. THE INFRARED RAY TEST AND RESULT ANALYSIS

In the experiment depicted in this paper, the raw ore and leaching residue was measured under ultra red spectrum respectively. The infrared ray test points for further studies of ion exchange between ion-type rare earth ore and leaching electrolyte. As show in Figure 9.

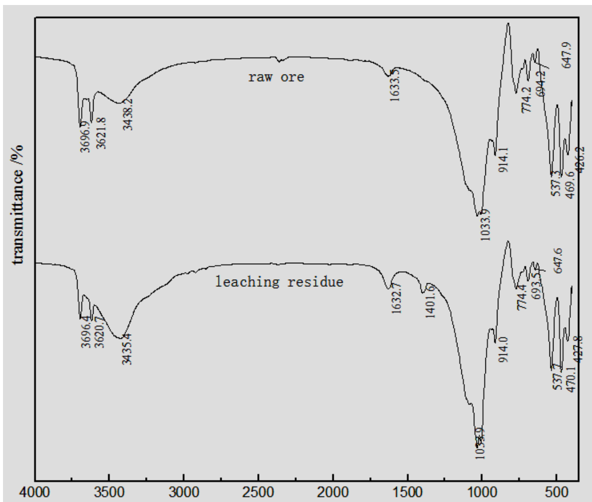

Fig. (9). The Infrared Ray Test of Ion-type Rare Earth Ore Before Leaching and After Leaching, λ /cm-1

Infrared spectrums show that a new absorption peak was appeared at the wavelength of 1401.6 cm-1. The characteristic peak is stretching vibration absorption of NH4+. There are only ion exchange reaction between rare earth ions and electrolyte. Cationic polyelectrolyte is retained in leaching residue when rare earth ions is exchanged leaching. The whole leaching process did not produce other new substance. There was only ion exchange reaction, with no natural crystal texture of rare earth ore change.

IV. CONCLUSION

1) The leaching process optimization of ion-type rare earth ore is studied. The experimental result indicated that with the increase of leaching agent concentration and decrease of flow rate, leaching rate of rare earth is higher and higher. However, the leaching solution pH value is too high or too low, the moisture content or seam height is too high and granularity is too fine may influence leaching efficiency, reduce leaching rate.

2) The leaching process regulation of ion-type rare earth ore is studied. In the experiment, the raw ore about 0.056% rare earth ore. The moisture content is 4%, the ore seam height is 43mm, leaching agent concentration is 4%, leaching solution pH value is 5.0, solid-liquid ratio is 1:0.8, flow rate is 3 mL/min. We can acquire through the test that leaching rate of rare earth is 94.32%, average concentration of rare earth in leaching solution is 1.58 g/L.

3) The raw ore and leaching residue is measured under ultrared spectrum respectively. There are only ion exchange reaction between rare earth ions and electrolyte. Cationic polyelectrolyte is retained in leaching residue when rare earth ions is exchanged leaching. The whole leaching process did not produce other new substance. There was only ion exchange reaction, with no natural crystal texture of rare earth ore change.

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