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Extracting Gold from Pyrite Roster Cinder by Ultra-Fine-Grinding/Resin-in-Pulp

Guo Bingkun[1], Wei Junting[2]
[1] Institution of Metallurgical Physical Chemistry of Central South University, Changsha 410083, P.R.China
[2] Environmental Protection Bureau of Nanhai, Nanhai 528200, P.R.China

Abstract

A new method to extract gold from pyrite roster cinder, which combines ultra-fine-grinding with resin-in-pulp, has been studied in this paper. Compared with traditional leaching technology, it can short leaching time, avoid complex filter process, lower sodium cyanide consumption and increase gold recovery by 35%. During leaching, aluminium oxide ball was used as stirred medium, hydrogen peroxide as leaching aid and sodium hexametaphosphate as grinding aid. With the high efficiency and chemistry effect of ultra-fine-grinding, the leaching process was developed and the gold leaching rate may reach 88%. With AM-2ｂresin as absorber and sulfocarbamide (TU) as eluent, gold was recovered from cyanide pulp by resin-in-pulp .AM-2ｂresin has good adsorbability in cyanide solution(pH=10). It was easy to elude gold from the loaded resin with 0.1mol/L cholhydric acid and 1mol/L sulfocabamide. The effect of contact time, temperature and acidity etc. on the gold absorption had been examined with static methods. The results showed that the adsorption and desorption of gold could both reach over 98%. The effects of flow rate of solution on dynamic adsorption and elution of gold had been examined with dynamic methods. Breakthrough curve and elution curve had been drawn in this paper. A mild condition was determined through a number of experiments: leaching time 2 hours, liquid solid ratio 4:1, sodium cyanide 3kg/t, hydrogen peroxide 0.05%,sodium hexametaphosphate 0.05%;adsorption time 30 minutes, temperature 10-30℃, resin(ml) solid(g) ratio 1:10, eluent resin ratio 10-20:1, velocity of eluent 1.5ml/min. Under the mild condition, the gold recovery may reach 85%.

Key words: ultra-fine-grinding/resin-in-pulp cyanide leaching gold

Introduction

Resin-in-pulp process is an advanced technique of extracting gold without filter. Cold is recovered from cyanide pulp with ion exchanger resin directly. This method avoids liquid solid separation, decreases loss of gold in tail washings and increases the recovery of gold. So people are interested in it[1-2]. It was the fore Soviet that put this technique into practice. 353E resin synthesized by Chinese Academy of sciences had been applied to Yinfang Cold mine in Laiyuan country of Heibei province successfully[3]. However, refractory ores are characterized by low gold recover and high cyanide consumption when subjected to direct cyanide leaching. To these ores a pretreatment step is necessary prior to leaching. The conventional pretreatment methods[4] include roasting, chemical oxidation, bio-oxidation etc. In recent years ultra-fine-grinding technique has been applied to leaching process and the results are satisfactory[5,6]. In this paper, two methods was combined to extract gold from pyrite roster cinder, and the optimum experimental condition was determined through a large number of experiment

Experiment

The pyrite roster cinder used in the experimental study was obtained from Kangjiawang Mine.The samples consisted of 200-mesh granular particles. Ultra-fine-grinding cyanide experiments were carried out in 1.4-L stirred mill with 30g pyrite roster cinder, 150g aluminium oxide ball, sodium cyanide given and tap water. Then, AM-2ｂresin was used to absorb gold after separating sieving with weak acid sulfocabamide, gold was stripped from loaded resin. The concentration of gold in solution and tailing cinder with atomic absorption spectrometry.

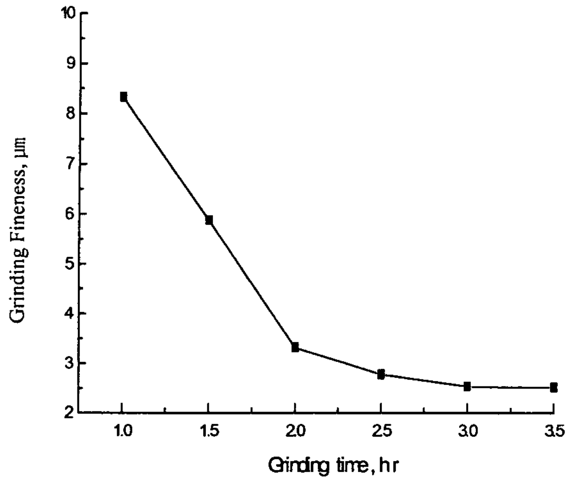
Results and Discussion

Effect of grinding fineness on leaching

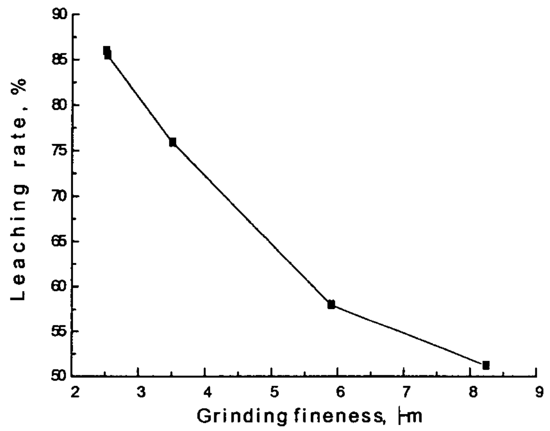
Ultra-fine-grinding is a better way to make gold in pyrite exposured and leached easily and improve diffusion environment of cyanide. Figure 1 presented the effect of grinding time on grinding fineness and Figure 2 showed the effect of grinding fineness on leaching. It was noted that the particle size could reach 2.5 μm after 2.5 hours and corresponding leaching rate was 85%. Furthermore, the small the particle size was, the higher leaching rate was. But 2.5hours later, the particle size didn't decreased much though prolonged grinding time.

Effect of grinding aid on leaching

Grinding aids were added to lower energy consumption and improve grinding efficiency in grinding process. The effect of four different grinding aids namely tri-ethanolamin(TEA),oleic acid, sodium hexameta-phosphate, sodium carbonate was presented in Fig.3. The results showed that sodium hexametaphosphate was the better grinding aid, Only 0.05% sodium hexametaphosphate the grinding fineness might be 2.5μm after 2 hours.



(liquild/solid 4, NaCN 4kg/t)
Fig.1 Effect of grinding fineness on leaching



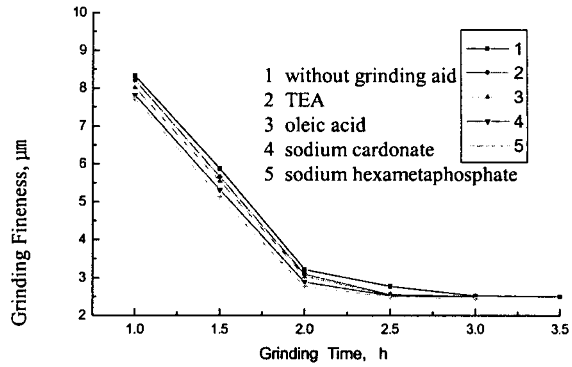
(liquild/solid 4, NaCN 4kg/t)
Fig.2 Effect of grinding fineness on leaching

Effect of liquid solid ratio on leaching

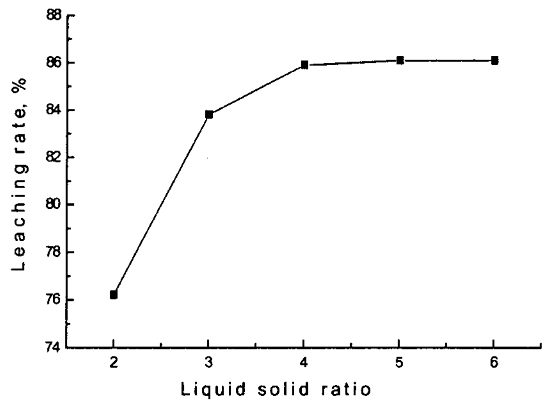
The liquid solid ratio was favorable to improve grinding environment and increase the diffusion of oxygen and CN-.The result (in Fig.4) showed that the initial rate of leaching was rapid, but the rate gradually slowed when liquid solid ratio was over 4.If liquid solid ratio was too low, viscosity was high and drag was great. When liquid solid ratio was too high, the following operation become difficult though it was favorable to leach in dynamic aspect.

Effect of sodium cyanide on leaching

The use ratio of CN- was improved due to ultra-fine-



(liquild/solid 4 ,NaCN 4kg/t)
Fig.3 Effect of different grinding aid on leaching



(time 2.5hr, NaCN 4kg/t)
Fig.4 Effect of liquid/solid on leaching

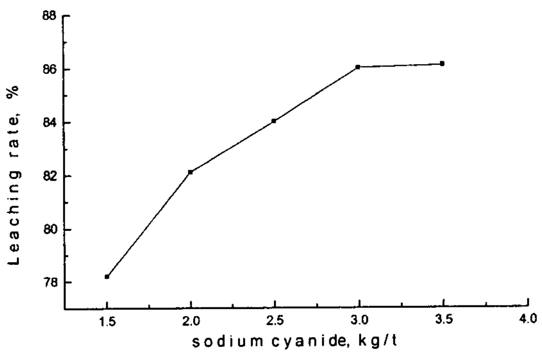
grinding, the sodium cyanide consumption was decreased apparently. But the speed of accompanying foreign substance complex increased and the effect concentration of CN^- was lowered. As seen in Fig.5, at first, the leaching rate increased rapidly, but the rate increased slightly once sodium cyanide consumption was over 3 kg/t.

Effect of leaching aid on leaching

Degussa company in German suggested that hydrogen peroxide was used as liquid oxidant to speed up the leaching[7]. The function of hydrogen peroxide followed in two methods:

1) attend to reaction directly as oxidant
$$2Au + 4CN^- + H_2O_2 = 2AuCN_2^- + 2OH^-$$
2) supply oxygen in following way
$$2H_2O_2 = 2H_2O + O_2$$
$$4Au + 8CN^- + O_2 + 2H_2O = 4AuCN_2^- + 4OH^-$$

The leaching ratio of gold may reach 88% after grinding 2 hours with 0.05% hydrogen peroxide. Although grinding time was prolonged, the effect of hydrogen peroxide was not apparent.



(time 2.5hr, liquid/solid 4)
Fig.5 Effect of sodium cyanide on leaching

Effect of temperature on absorption

To study the effect of temperature on absorption with AM-2b resin, experiments were conducted at five different temperature, namely 10, 20, 30, 45, 60℃. 3ml resin was added to cyanide solution and the stirring time was kept at 30min. Table 1 showed the effect of temperature on absorption. It was seen that within the temperature range of 10 to 45℃, the absorption increased with the increasing temperature. However when temperature reached 60℃, the adsorption tended to decreased. This was because that resin denaturated and decomposed at high temperature(over60℃).

Tab.1 Effect of temperature on absorption

Temperature,℃	10	20	30	45	60
Adsorption Rate,%	98.59	9928	99.32	99.38	98.45

Effect of stirring time on absorption

As shown in Fig.6, the absorption rate increase rapidly with the stirring time increasing at the same temperature. In general, the absorption rate might reach 99% within 30min.

Effect of acidity on absorption

The absorption experiments were carried out only in alkaline condition due to CN^- in pulp. The pH value varied from 8 to 13 and the amount of resin kept unchangeable. Table 2 showed tha the absorption rate nearly didn't change in pH value range investigated. The reason was that AM-2b resin included quaternary ammouniam strong base functional group.

Tab.2 Effect of acidity on absorption

PH	13	12	11	10	9
Absorption Rate,%	99.22	99.24	99.22	99.21	99.15

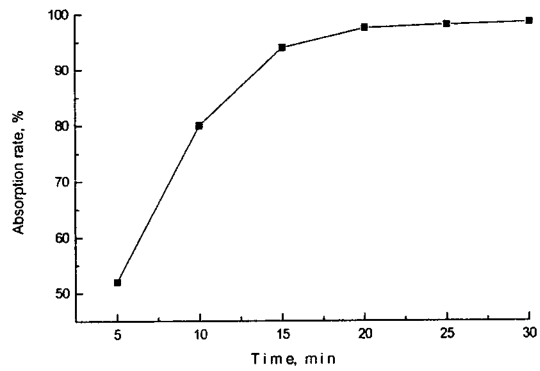


Fig.6 Effect of stirring time on absorption

Effect of the amount of AM-2b resin on absorption

Experiment was conducted using various amount of AM-2b resin to examine the absorption rate. The amount of AM-2b resin was varied from 1ml to 5ml, and the experimental result was showed in Tab.3. It was apparent that absorption rate increased with increasing the amount of resin. When the a mount was 3ml, the absorption rate reached 98%. Too much resin not only made sieving difficultly but also decreased the use ratio of AM-2b resin.

Tab.3 Effect of the amount of AM-2b resin on absorption

pH	1	2	3	4	5
Absorption Rate,%	65.23	94.25	99.26	99.25	99.30

Effect of acidity on adsorption

With HCl to adjust acidity the effect of different pH value was examined individually. As seen in Fig.7, the concentration of HCl had a significant influence on the adsorption of gold. As the pH value approached to neutrality, the adsorption rate may reach 100%. Additionally, the adsorption rate decreased with increasing concentration of HCl. The reason was that TU decomposed at high pH value and the speed of decomposing in creased with pH value. Therefore, weak acid TU was used to strip, and the mild concentration of HCl was about 0.1mol/L

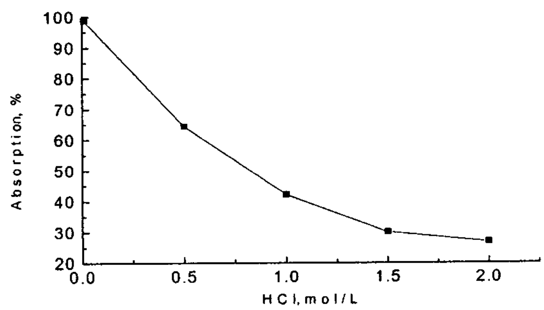


Fig.7 Effect of acidity on adsorption

Effect of concentration TU on adsorption

The result of experiment was shown in Fig.8. It was noted that the initial rate of adsorption gradually increased with concentration but the rate slow down since the concentration was 1.0mol/L. TU was oxided to sulfur and the solution became cloudy.

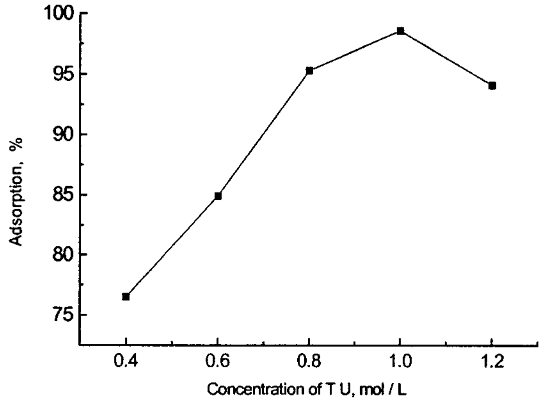


Fig.8 Effect of concentration TU on adsorption

Effect of temperature on adsorption

With 50ml eluent experiment was carried out at five different temperature. The results was presented in Tab.4. It was obvious that temperature in range of 20℃ to 45℃, had litter effect on adsorption, but when the temperature was over 60℃, bubbles dropped from solution[8] due to decomposing of TU:

$$SC(NH_2)_2+2H_2O \rightarrow CO_2+2NH_3+H_2S$$

Tab. 4 Effect of temperature on adsorption

Temperature,℃	10	20	30	45	60
Adsorption Rate,%	78.35	98.24	99.21	99.33	95.54

Effect of velocity of eluent on adsorption

The adsorption was examined at different velocity of eluent with 60ml weak acid TU and the experimental result was shown in Tab.5. It was believed that the adsorption rate was over 98% when the velocity lowered to 1.5ml/min.

Tab. 5 Effect of velocity of eluent on adsorption

Velocity, ml/min	0.5	1.0	1.5	2.0	2.5
Adsorption Rate,%	99.31	99.24	99.02	96.85	78.52

Effect of amount of eluent

Table 6 showed the result of effect of eluent on adsorption. The amount of loaded resin was 3ml in this experiment. It was seen that when resin elent ratio was 10, the adsorption was 98% about; when resin eluent ratio was 20, adsorption may be over 99%.

Tab.6 Effect of amount of eluent on adsorption

Amount of Eluent,ml	10	20	30	40	50	60
Adsorption Rate,%	55.2	81.2	98.2	98.5	99.2	99.6

Elution curve

Resin loaded 3mg gold was stripped with 0.1mol/L HCl and 1 mol/L TU, each 3ml breakthrough solution was collected and the elution curve was drown (Fig.9)

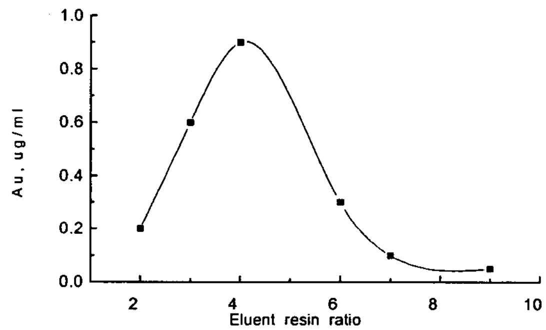


Fig.9 Eluent curve

The shape of cure was good and the adsorption rate reached 98% when eluent resin ratio was 10. The results showed that it was easy and thorough to elude gold from loaded resin with 0.1mol/L HCl and 1mol/L TU.

Synthetical experiment

Considering leaching, absorption and elution as a whole, as well as optimizing process parameters, the recovery of gold might reach 85%.

Conclusion

Ultra-fine-grinding/resin-in-pulp process is a new and effective technology of extracting gold. With grinding aid leaching aid in leaching process, the leaching rate reached 88%, and leaching time was shorten by 0.5hr compared with traditional teaching method. Resin-in-pulp technique simplified flow chart, decreased the loss of gold in tailing washings. The results of synthetical experiment: leaching time 2 hours, liquid solid ratio 4:1, sodium cyanide 3kg/t, hydrogen peroxide 0.05%, sodium hexametaphosphate 0.05%; adsorption time 30minute, temperature 10-30℃, resin(ml) solid(g) ratio1:10; eluent resin ratio 10-20:1, velocity of eluent 1.5ml/min. Under the mild condition, the gold recovery may reach 85%.

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