Experimental Study on Smelting of Extremely Difficult to Leach Gold Concentrate

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Abstract. A certain flotation gold concentrate is a refractory gold ore with arsenic and carbon containing fine particles embedded in it. The arsenic and carbon (organic carbon) contents are 0.12% and 1.68%, respectively, and the average gold particle size is 3.15 μ m. The gold leaching rate using conventional direct cyanide process (-200 mesh content 90%) is 49.71%, which belongs to extremely difficult to leach gold ore. To improve the gold leaching rate of this gold concentrate, pre-treatment and cyanide leaching experiments such as fine grinding, ultrafine grinding, alkali leaching, and roasting were carried out, and satisfactory gold leaching indicators were obtained.

Keywords: Fine grained embedding; Gold concentrate; Ultrafine grinding; Alkali leaching; roasting

1 Introduction

With the rapid development of the gold industry, easily processed gold resources are gradually depleting, and difficult to process gold resources have become one of the main sources of raw materials for the industry. The characteristics of difficult to process gold mines are the presence of elements such as carbon, arsenic, sulfur, antimony, etc. Gold is mainly encapsulated in fine-grained form in arsenopyrite, pyrite, carbonate, and silicate. Conventional direct cyanide treatment cannot achieve satisfactory gold recovery indicators, and the gold leaching rate is generally less than 80%, or even less than 50%. [1-2]At present, there are four types of treatment methods for refractory gold mines at home and abroad: pre treated cyanide, enhanced cyanide, non cyanide leaching, and pyrometallurgy. The pre-treatment methods before leaching include chemical oxidation treatment, pressure oxidation treatment, calcination treatment, biological oxidation treatment, microwave treatment, ultrasonic treatment, ultrafine grinding treatment, etc. The existing technology for processing refractory metallurgical gold mines has the defects of low gold and silver recovery rate, complex process flow, and high production and operation costs. It is necessary to conduct experimental research and select suitable processing methods based on the actual pro-

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duction site to achieve efficient recovery and high-value utilization of gold and silver in refractory metallurgical resources.[3-4]

2 Sample Analysis

Chemical multi-element analysis was conducted on this gold concentrate sample, and the results are shown in Table 1.

Table 1. Analysis of Main Elements in Samples

element	Au/(g/t)	Ag/(g/t)	Pb/%	Zn/%	Cu/%
Grade	17.1	21.2	0.07	0.01	0.01
element	S/%	Fe/%	As/%		
Grade	30.28	33.34	0.12		

3 Experimental Research[5-7]

3.1 Ultra Fine Grinding Cyanide Leaching Test

The fineness of this gold concentrate sample is -200 mesh with a content of 90% (400 mesh with a content of 60%). The sample is finely ground using a conventional conical ball mill to a content of -400 mesh with a content of 95%. The sample is finely ground using a sand mill to a fineness of P_{90}:10 μ m and P_{90}:5 μ m. Then, cyanide leaching experiments were conducted under four fineness conditions to investigate the gold leaching rate index of the ultrafine ground samples and the experimental phenomena during the leaching process. The experimental results are shown in Table 2.

Table 2. Results of Ultra fine Grinding Cyanide Leaching Test

Grinding fineness	gold leaching rate/%	sodium cyanide consumption/(kg/t)
-400 mesh content：60%	49.71	4.2
-400 mesh content:95%	59.06	9.6
P_{90}:10μm	62.57	16.4
P_{90}:5μm	74.85	18.8

According to Table 2, compared to direct leaching and leaching after fine grinding, the gold leaching rate after ultrafine grinding is significantly improved. When ground to P_{90}:5 μ m, the gold leaching rate reaches 74.85%. However, compared to P_{90}:10 μ m, the time required to grind to P_{90}:5 μ m is significantly prolonged, and the sedimentation and filtration efficiency of the slurry are significantly reduced. The viscosity of the slurry increases significantly, making it difficult to effectively stir during the leaching process and difficult to apply in production. Considering the grinding cost, cyanide consumption index, sedimentation, filtration and other issues, the grinding fineness is determined to be P_{90}:10 μ m. In order to further improve the gold leaching rate and reduce cyanide consumption, alkali leaching, roasting and other pretreatment cyanide leaching experiments were continued on the ultrafine ground ore samples.

3.2 Ultra Fine Grinding Alkali Leaching Pretreatment Cyanide Leaching Test

3.2.1 PH Condition Test For Alkaline Leaching Pretreatment.

Take three equal parts of ultrafine ground ore samples to P_{90}:10 μ m, and pre treat them with alkali leaching at pH 11, 12, and 13 for 12 hours. After washing and pressure filtration, adjust the slurry again for cyanide leaching. The experimental results are shown in Table 3.

Table 3. Results of pH condition test for alkaline leaching pretreatment

Alkali leaching pH	gold leaching rate/%	sodium cyanide consumption/(kg/t)
11	62.57	16.4
12	63.74	10.8
13	64.33	9.6

According to Table 3, as the pH increases, the gold leaching rate gradually increases, but the increase is relatively low. Considering that the consumption of sodium cyanide is significantly reduced at pH 12, and the amount of alkali added is significantly reduced compared to pH 13, it is determined that the pH for alkali leaching pretreatment is 12.

3.2.2 Experimental study on stirring strength conditions for alkaline leaching pretreatment.

Take five equal parts of ultrafine ground ore samples to P_{90}:10 μ m, set up leaching mixers with different stirring speeds, and perform alkaline leaching pretreatment for 12 hours under pH 12 conditions. After washing and pressure filtration, adjust the slurry again for cyanide leaching. The experimental results are shown in Table 4.

Table 4. Experimental results of mixing strength conditions for alkaline leaching pretreatment

Mixing speed/(r/min)	Gold leaching rate/%	Consumption of Sodium Cyanide/(kg/t)
400	62.57	10.4
800	63.74	10.8
1200	62.57	12.0
1600	63.74	13.6
2000	64.33	16.0

According to Table 4, as the stirring intensity of alkali leaching pretreatment increases, there is no significant change in gold leaching rate. Considering the increase in equipment energy consumption and cyanide consumption due to high rotation speed, selecting a stirring speed of 400r/min can effectively achieve slurry circulation.

3.2.3 Alkali leaching pretreatment time condition test.

Take a mineral sample that has been finely ground to P_{90}:10 μ m and subjected to alkaline leaching pretreatment at pH 12. Samples are taken at different alkaline leaching times for cyanide leaching experiments. After washing and pressure filtration, the slurry is adjusted again for cyanide leaching. The experimental results are shown in Table 5.

Table 5. Experimental results of alkaline leaching pretreatment time conditions

Alkali leaching time/h	Gold leaching rate/%	Consumption of Sodium Cyanide/(kg/t)
4	61.99	15.4
8	63.16	12.2
12	63.74	10.8
16	64.33	10.8
20	64.91	10.8
24	64.91	10.8

According to Table 5, as the alkaline leaching pretreatment time increases, the gold leaching rate shows an upward trend, but the increase is relatively low, and after 16 hours, the gold leaching rate and cyanide consumption tend to stabilize. Therefore, it is determined that the alkaline leaching pretreatment time is 16 hours.

3.2.4 Summary.

By conducting alkaline leaching pretreatment condition experiments on ultrafine ground ore samples, the pH of alkaline leaching pretreatment was determined to be 12, the stirring intensity was 400 r/min, and the reaction time was 16 hours. However, alkaline leaching pretreatment did not significantly improve the leaching rate of gold, so roasting pretreatment is considered.

3.3 Baking Cyanide Leaching Test

Conduct cyanide leaching experiments on ore samples using a muffle furnace under different temperature conditions for 3 hours to investigate the effects of roasting pretreatment on gold leaching rate and cyanide consumption, and determine the optimal roasting temperature. The experimental results are shown in Table 6.

Table 6. Results of Roasting Cyanide Leaching Test

treatment temperature /°C	Gold leaching rate/ %	Consumption of Sodium Cyanide /(kg/t)
untreated	49.97	4.16
300	41.82	2.83
400	52.32	15.42
450	78.29	16.62
500	86.72	12.16
550	87.04	10.54
600	65.45	10.23
800	63.53	9.13

According to Table 6, this gold concentrate can achieve ideal gold leaching indicators and effectively reduce cyanide consumption after roasting pretreatment. However, due to limitations in local environmental policies, it is difficult to implement and can be used as an alternative technical solution. It is also necessary to provide a technical solution that is environmentally effective and has good comprehensive economic benefits.

4 Conclusion

In response to this extremely difficult to leach gold concentrate, direct conventional leaching, fine grinding conventional leaching, ultrafine grinding conventional leaching, ultrafine grinding alkali leaching pretreatment conventional leaching, roasting cyanide leaching experiments were carried out, and the cyanide leaching rate of gold was increased from 49.71% to 87.04%. Obtained satisfactory gold leaching indicators, which have certain guiding significance for the disposal of gold concentrates in production sites.

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