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PRETREATMENT OF GOLD ORE CONTAINED S AND As

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ABSTRACT

In this article, Au cyaniding-leaching method is investigated with the gold ore contained S and As pretreated by two kinds process, oxidizing roasting method and hydrothermal oxidation method. Results indicate that hydrothermal oxidation method is more effect than oxidizing roasting method. In oxidizing roasting method, the proper reaction temperature is at 550~700^{o}C, the proper roasting time is 2 hours or so and the cyaniding-leaching ratio of the gold ore pretreated is 70~85% in that conditions. In hydrothermal oxidation method, the cyaniding-leaching ratio exceeds 95% and the remnant Au content is 0.8~2.0g/t by pretreating the gold ore contained S and As at 200~220^{o}C. And the environmental protection problem is little by using the hydrothermal oxidation method.

KEYWORDS

Gold Ore, Oxidizing Roasting, Hydrothermal Oxidation, Cyaniding-leaching

1. INTRODUCTION

Recently, there are many of gold ores contained S and As found in all places of China. But how to treat the gold ore contained S and As is one of the most difficult technologies. The Au contained in the ore is enwrapped in sulfide and arsenide, so the leaching ratio of Au is only below 20~50%, very low, if the cyaniding-leaching process is introduced. It is necessary to make the pretreatment of decomposition of sulfide and arsenide in the gold ore in order to utilize this type gold ore.

At present, the main methods of treating the gold ore in the world are oxidizing roasting method, microbe method and hydrothermal oxidation in high temperature and high-pressure method.

In the oxidizing roasting process, the gold ore contained S and As is oxidized and roasted in two-segment fluidized bed in order to remove sulfide and arsenide. Then the leaching ratio of Au- cyaniding exceeds 80~90% or so, relatively high, by using cyaniding-leaching method with the ore treated by oxidizing roasting. The advantages of this method are that the process is simple, the equipment cost is low and the production cost also low. When the concentraten of SO_2 in the dust is high, SO_2 can be made into H_2SO_4 to recycle. The arsenide of the dust also can be recovered. But if the S concentraten in the dust is low (S<8%), the SO_2 can not be recovered and As also do not, all these are bad to environmental protection.

In the microbe process, the gold ore is placed in microbe bath, then sulfide and arsenide in the gold ore are decomposed by microbe. The H_2SO_4 produced in the decomposition process is neutralized to deposition by lime. The Au cyaniding-leaching ratio exceeds 90% by using cyaniding-leaching method with the ore pretreated by microbe. The advantages of this method are that the equipment is simple and the production cost is also low. But the production cycle periods is relatively long up to 5~10 days, so the productivity is very low.

In the hydrothermal oxidation process of high temperature and high pressure, the gold ore is treated in an autoclave at 180~220^{o}C. The sulfide and arsenide in the gold ore are oxidized to H_2SO_4, iron sulfate and iron arsenide. The H_2SO_4 produced in the decomposition process is neutralized to deposition by lime. The Au cyaniding-leaching ratio exceeds 90~95% by cyaniding-leaching method with the ore pretreated by hydrothermal. The advantages of this method are that the productivity is high, the recovery ratio of Au is high and there is no environmental protection problem, but the equipment cost is very high.

In our work, the gold ore contained S and As from Benxi county in Liaoning province is treated by two methods, oxidizing roasting and high pressure hydrothermal oxidation. Then the experiment of Au cyaniding-leaching is made with the ore pretreated. The main focuses are the recovery ratio of Au and the desulfuration ratio of the ore pretreated in these two processes.

2.EXPERIMENT

The set-up diagram of oxidizing roasting method is shown as Fig.1. The fluidized bed is made in stainless steel, Φ42mm. 120g gold ore is put into the stainless steel reactor every time and then roasted with air.

The set-up diagram of hydrothermal oxidation method is shown as Fig.2. The volume of the stainless steel autoclave is 500ml. There is corrosion resisting refractory lining inside of the autoclave to proof corrosion.

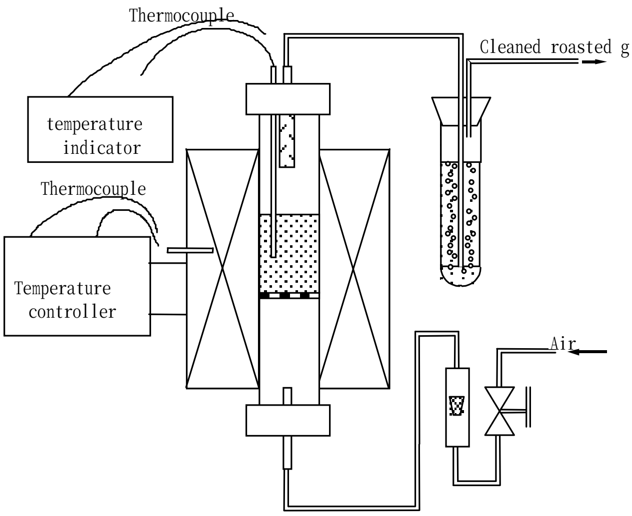

Fig.1 Schematic drawing of roasting experimental setup

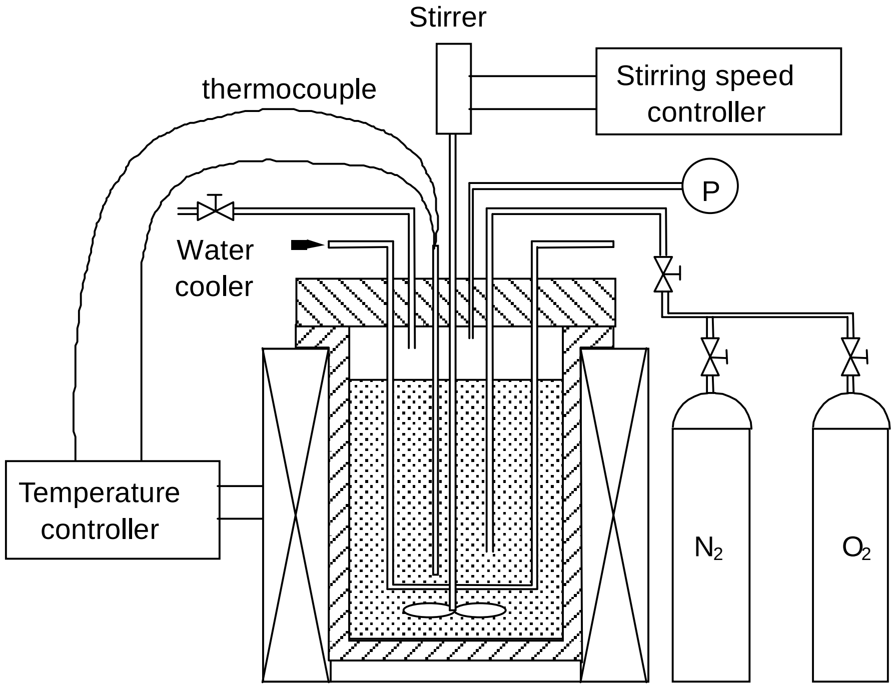

Fig.2 Schematic drawing of autoclave leaching experimental setup

The set-up diagram of Au cyaniding-leaching is given in Fig.3.

The process and conditions of oxidizing roasting is as followed. The predesiccated ore is put into the fluidized bed heated up to 450~750^{o}C and then kept with constant temperature about 30 minutes. Air is introduced into to roast in the same as the electric stove input power is regulated to control the roasting temperature. When the preset time is over, stop blowing air, take out the fluidized bed from the electric stove to cool and then get the ore out after cooling.

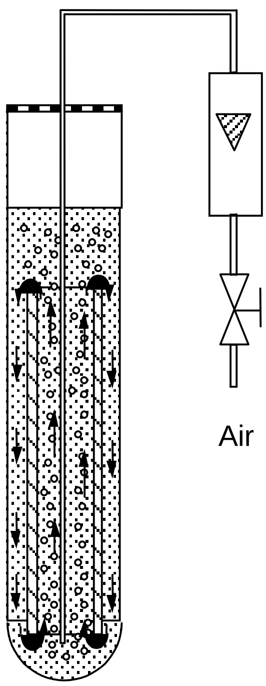

Fig.3 Schematic drawing of leaching experimental

The process and conditions of hydrothermal oxidation is that water and ore are introduced into the autoclave in room temperature together, the autoclave with airproof is put into electric stove and the air in the stove is removed by introducing N_2. The autoclave is stirred and heated up to the preset temperature and kept with constant temperature about 30 minutes. Then oxygen is introduced into the autoclave up to 3.0 M Pa. The temperature of the stove is controlled through cooling water and electric stove. Oxygen is supplied to ensure the pressure inside the autoclave up to 3.0 M Pa when the oxygen-pressure in the stove drops due to oxidation. After the preset time (2~4 hours), the autoclave is taken out from the stove, cooling to room temperature. Release remnant pressure, open the autoclave and then take out the ore and solution. After filtrating, Au can be cyaniding-leached from the ore pretreated.

Table.1 Chemical Composition of Ore

	Au g/T	As %	S %	C %
Gold Concentrate	38.82	3.07	15.55	1.67
Rich Gold Ore	36.65		3.19	
Gold Ore	5.28		1.42	

The experiment and conditions of cyaniding-leaching is as followed. The ore pretreated together with water are put into the air-filled cyaniding-leaching reactor. The PH value of the solution is 10~11 with milk of lime. Then sodium cyanide is introduced to come into being 0.1% sodium cyanide solution. In room temperature, stir with air and extract. After the preset time (about 72 hours), filtrate and wash the ore three times with water. Then analyze the Au content to calculate the recovery ratio of Au.

The composition of the ore in the experiment is shown as Table 1. Gold concentrate with floatation and Au rich crude ore are used in oxidizing roasting experiment and gold concentrate floatation, Au rich crude ore and gold lean ore are used in high pressure hydrothermal oxidation method.

3.RESULTS AND DISCUSSION

3.1 Oxidizing roasting of Gold Ore

3.1.1 Desulfuration and Dearsenication by Roasting

The effects of the roasting time and the roasting temperature on S content is shown as Fig.4. The effect of the roasting time on desulfuration ratio is little in the roasting periods. Although the effect of roasting temperature on desulfuration ratio is great at 500^{o}C in the roasting periods, its effect is very little when the temperature is at 500~700^{o}C. Desulfuration ratio is rather low at 500^{o}C, but when the roasting temperature is over 700^{o}C, desulfuration ratio of the ore also drops.

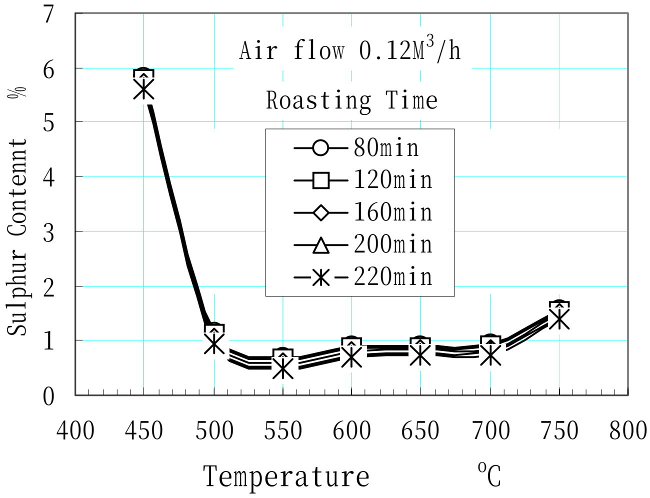

Fig.4 Effect of Temperatures on the Sulfur Content of Sample Ore at Various Roasting Time

As Fig.5 have shown, desulfuration ratio increases with the increase of the roasting air flow. When the temperature is at 500~700°C, the roasting air flow is 0.15M^3/h and 120g gold ore has been roasted over 120 minutes, desulfuration ratio of the ore exceeds 90% in the experiment conditions.

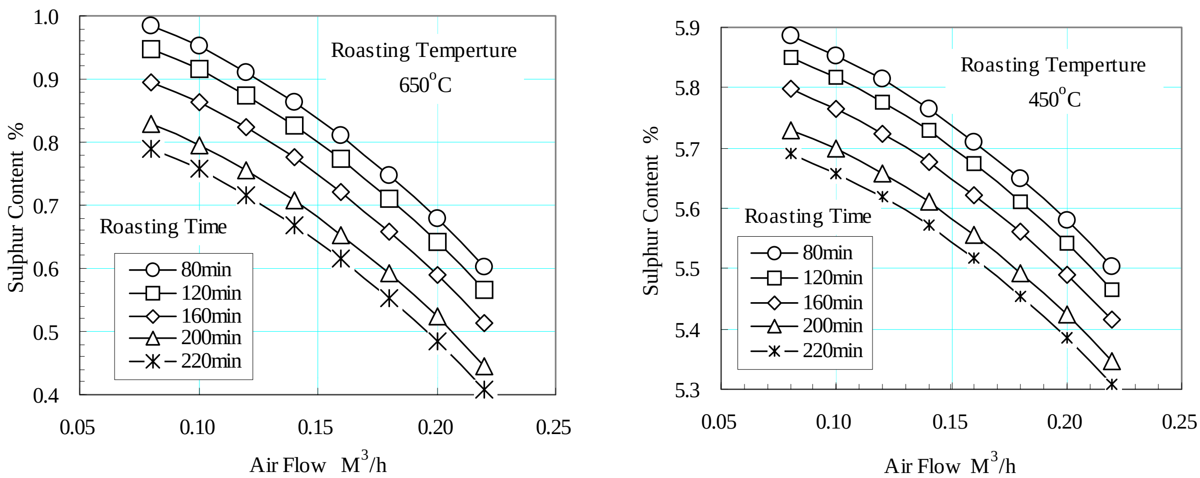

Fig.5 Effect of Air flow on the Sulfur Content of Sample Ore at Various Roasting Time

After roasted, the effects of oxidizing roasting temperature and roasting air flow on As content is shown as Fig.6. The effect of roasting temperature on dearsenication ratio is great in the roasting periods and low

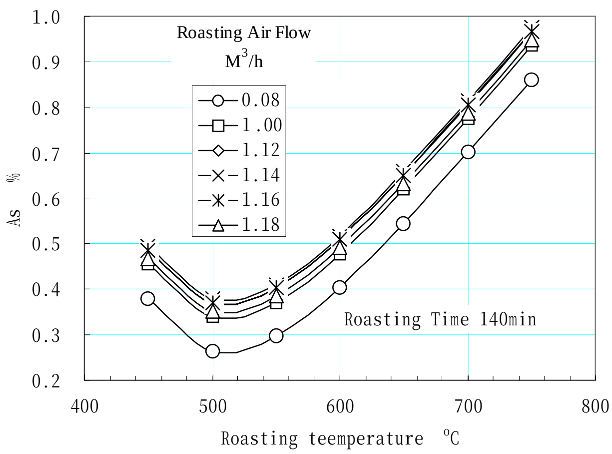

Fig.6 Effect of Temperatures on As Content of Sample Ore at Various Air Flow

roasting temperature is in favor of dearsenication. Dearsenication ratio is maximum when the roasting temperature is near 500°C and dearsenication ratio deteriorates fast with the increase of the roasting temperature. When the roasting air flow is little, dearsenication ratio is high, but if the roasting air flow is over $0.14M^3/h$, the effect of the roasting air flow on dearsenication ratio would diminish.

According to the results, the effects of the roasting temperature and the roasting air flow on desulfuration ratio and dearsenication ratio are reverse. Desulfuration ratio rises and dearsenication ratio drops as the roasting temperature goes up and the roasting air flow is increased. The reason of this phenomenon is explained as followed.

For the sulfide in the gold ore, there are two reaction equations,

$FeS+3/2O_2=FeO+SO_2$

$FeS_2+5/2O_2=FeO+2SO_2$

The increase of the roasting air flow is beneficial to oxidation of FeS and FeS_2. Although the reaction is exothermic, it is beneficial at 500~700°C.

There are two equations to the arsenide in the gold ore.

$2FeAsS+9/2O_2=2FeO+As_2O_3\uparrow+2SO_2$

$2FeAsS+11/2O_2=2FeO+As_2O_5+2SO_2$

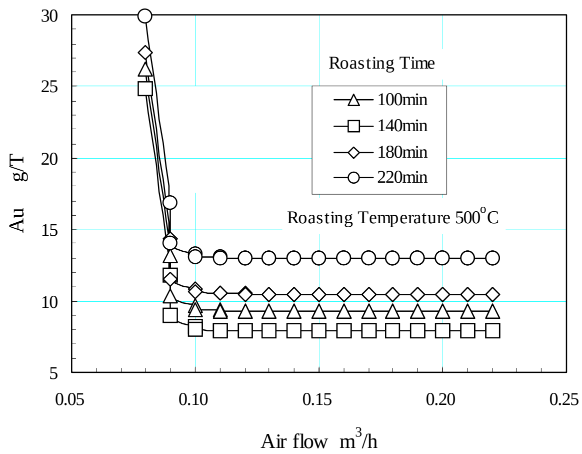

Fig.7 Effect of Roasting Air Flow on the Au Content of Sample Ore at Various Roasting Time

As the increase of the roasting air flow, As_2O_5% from As oxidation rise. Increasing roasting air flow goes against dearsenication because As_2O_3 is volatility but As_2O_5 is not. As is mainly made into As_2O_5 when the roasting temperature is increased, so it goes against dearsenication.

3.1.2 Cyaniding-leaching After Roasted

The ore pretreated by oxidizing roasting is cyaniding-leached with 0.1% sodium cyanide solution. The effects of roasting air flow and roasting time on Au content of the ore extracted is shown as Fig.7. The remnant Au content decreases with the increase of the roasting air flow when the roasting air flow is below 0.10 M^3/h.But when the roasting air flow is up to 0.12 M^3/h, even the roasting air flow is increased further, no great change happens to the remnant Au content.

The effect of the roasting time on the remnant Au content of the ore is shown as Fig.8. The remnant Au content is minimum when the roasting time is up to 120 minutes. And the remnant Au content of the ore extracted is increased when the roasting time is lower than 100 minutes or more over 180 minutes.

The effect of the roasting temperature on the remnant Au content of the ore extracted is shown as Fig.9. The remnant Au content is increased greatly with the decrease of the roasting temperature under 500^{o}C. But the effect of the roasting temperature is little at 550~750^{o}C and the remnant Au content is increased over 750^{o}C.

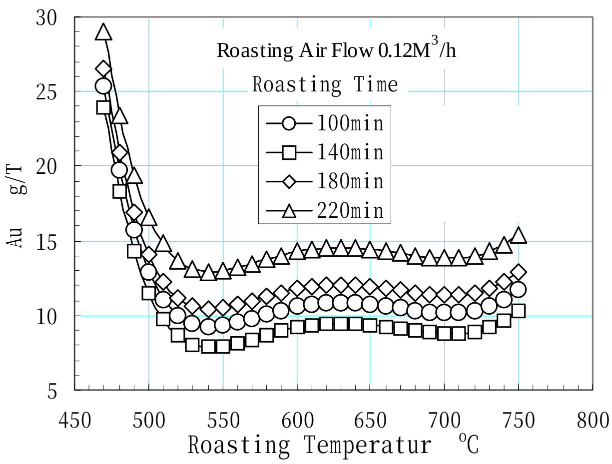

Fig.9 Effect of Temperature on Au Content of Sample Ore at Various Roasting Time

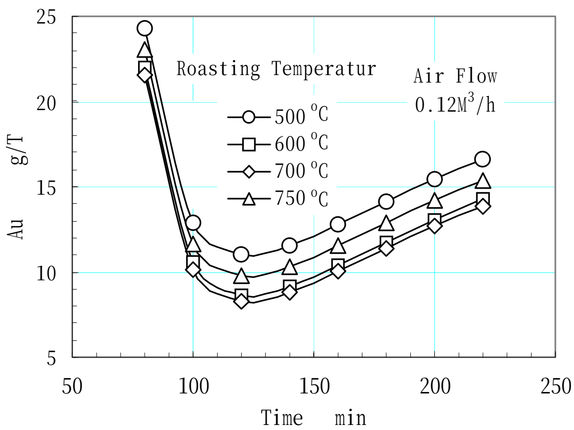

Fig.8 Effect of Time on the Au Content of Sample Ore at Various Temperatures

In directly cyaniding-leaching experiment, the Au extracted ratio of the ore is very low. As the gold concentrate as is concerned, the Au content of the ore is 38.82g/t before extracted and 43.6g/t after extracted. To the Au rich crude ore, the former is 36.65g/t, and the latter is

34.39g/t. Correspondingly, if the gold concentrate is roasted at proper roasting conditions, the Au content is 44g/t or so before extracted and 6.8~12g/t after extracted, And to the Au rich crude ore, the former is 37g/t or so and the latter is 13.4g/t or so. According to the above results, the Au extracted ratio is below 10%, very little, by the method of the directly cyaniding-leaching the gold ore contained S and As. The Au cyaniding-leaching content is about 70~85% under proper conditions. Comparing with the gold ore unroasted, the extracted ratio is greatly improved, but it is difficult to make the extracted ratio exceed 90% and the remnant Au content is decreased to 3g/t.

3.2 Hydrothermal Oxidation

The effects of reaction temperature and pulp density on the remnant Au content are shown as Fig.10. The optimum temperature is at 200~220^{o}C. The remnant Au content of the gold ore cyaniding-leached is below 1.5g/t under proper conditions. The Au extracted ratio is very high, over 95%, but the Au extracted ratio greatly decreases below 200^{o}C. The effect of the pulp density pretreated by the hydrothermal oxidation method is very great. When the pulp density is 200g/L, the Au extracted ratio is very high, but the extracted ratio is largely drops if the pulp density is 480g/L.

The effects of reaction temperature and pulp density on the remnant Au content of the gold lean ore cyaniding-leached and pretreated by hydrothermal oxidation method is shown as Fig.11. The remnant Au content is decreased with the increase of the reaction temperature. But even if the remnant Au content is only 0.78g/t, the Au extracted ratio hardly exceeds 90%. It is because the initial Au content of the gold lean ore is rather low (about 5.28g/t).

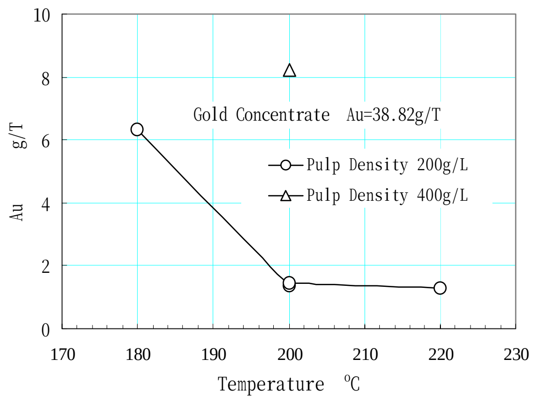

Fig.10 Effect of Temperatures on Au Content of Sample Ore at Various Pulp Density

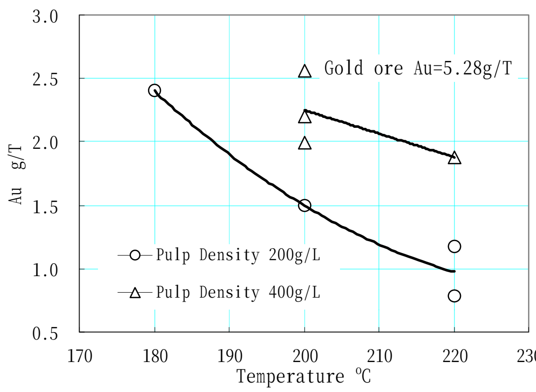

Fig.11 Effect of Temperatures on Au Content of Sample Ore at Various Pulp Density

After the gold rich crude ore is pretreated by hydrothermal oxidation method, the effect of the reaction temperature on the remnant Au content of the gold ore cyaniding-leached is shown as Fig.12. From the drawing, the Au extracted ratio is increased with the increase of the ore grade. And the cyaniding-leaching ratio is equal to the gold concentrate's and can exceed 95%.

According to the experiment results of the hydrothermal oxidation method, the most important factors affecting the Au cyaniding-leaching ratio of the gold ore pretreated by hydrothermal oxidation are the reaction temperature and the pulp density (The effects of the reaction temperature and the pulp density are in evidence even to the gold lean ore.). According to the above analysis and experiment, the proper pulp density is 200g/L and the proper reaction temperature is 200~220°C. In this case, the remnant Au content of the gold ore cyaniding-leached is 0.8~2.0g/t. Higher the reaction temperature, more beneficial to deduce the remnant Au content. The experiment shows that low remnant Au content can be obtained after 2 hours' hydrothermal oxidation.

The results shows that there are no great relationship between the initial Au content and the remnant Au content and all of them is 0.8~2.0g/t.

4.CONCLUSION

The results of the two kinds of processes (Oxidizing roasting and Hydrothermal Oxidation), which are made under experiment conditions, are shown as followed.

In the oxidizing roasting method, the proper reaction temperature is at 550~700°C and the proper roasting time is 2 hours or so. As the results are shown from the experiment treating Benxi county gold ore contained S and As through oxidizing roasting method, the cyaniding-leaching ratio of the gold ore pretreated is 70~85%. It is very difficult to treat the gold ore contained low S with self-thermal oxidizing roasting method and the SO_2 made in the process can not be recovered to generate H_2SO_4. In addition, there are many

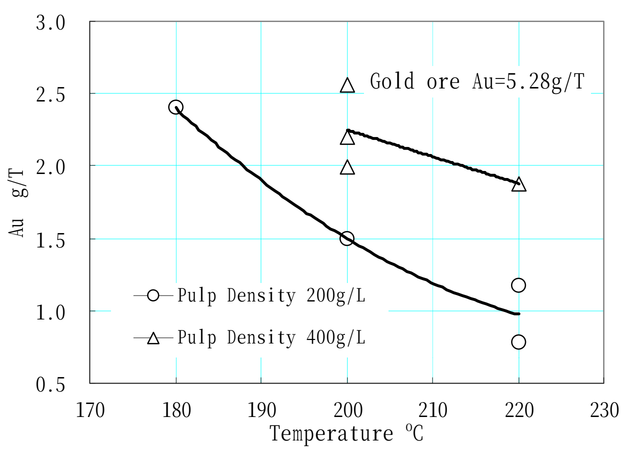

Fig.12 Effect of Temperatures on Au Content of Sample Ore at Various Ore

environmental protection problems. It is in effect to pretreat the gold ore contained S and As by the hydrothermal oxidation method at 200~220^{o}C. The cyaniding-leaching ratio exceeds 95% and the remnant Au content is 0.8~2.0g/t. In the same time, the gold lean ore can be treated in the same way as the gold rich ore. It is sure that the Au recovery ratio must be higher if the gold lean ore is pretreated through floatation before extracted. And the environmental protection problem is little by using the hydrothermal oxidation method.