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Prerequisites for Processing a Foam Product in the Process of Bacterial Oxidation of Gold-Bearing Concentrates in a Separate Cycle

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Abstract. The recovery of gold from refractory ores and concentrates is a significant problem in the modern gold processing industry. The use of bacterial oxidation technology at the Navoi Mining and Metallurgical Combine (Uzbekistan) made it possible to increase the share of recoverable gold during the processing of refractory ores from the Kokpatas and Daugyztau deposits. However, during the operation of the biological installation, a problem arose of abundant foaming in bacterial oxidation reactors. This article is devoted to the issue of foaming during biooxidation and its negative impact on the oxidation process. Methods of combating foaming and the choice of the optimal solution, providing for the processing of bio-oxidation foam in a separate cycle, have been analyzed.

1 Introduction

The prospects for gold mining directly depend on the technical capabilities of mankind, because placer deposits are quite rare, and processing of indigenous ones requires efficient technologies and expensive equipment to extract gold from great depths. Therefore, today there is a kind of competition between all developed countries in the field of invention of new methods of extraction and purification of gold-bearing rock.

Over the past decades, in view of the decline in the quality of mineral raw materials of the developed deposits, the proportion of gold recovered from refractory ores has increased, the effective processing of which requires the development of more complex and improved schemes, including preliminary processing before cyanidation, ensuring the most complete opening of gold grains [1-3].

Among the ways to increase the efficiency of the process of leaching gold from refractory ores and concentrates, intensification of the process of opening the refractory matrix by chemical, biological and physical methods is distinguished [4, 5]. Research is also underway to eliminate the stubbornness of mineral raw materials using the methods of ultrafine grinding, microwave irradiation, electrohydraulic processing, magnetic pulse processing, etc. [6-9].

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2 Materials and Methods

Bacterial oxidation is one of the promising and rapidly developing directions in the field of processing refractory gold-bearing raw materials [5, 10-12]. Currently, more than 100 firms and organizations in countries such as South Africa, Ghana, Zimbabwe, Australia, Uzbekistan, USA, Brazil, Canada, Russia, Peru, China, etc. are engaged in the development of bacterial oxidation and leaching processes [13]. This technology has become widespread due to a wide range of advantages, among which one can note a low consumption of reagents, a higher reactivity and rate of solid phase deposition in bacterial solutions compared to solutions without bacteria, acceleration of the oxidation of formed elemental sulfur by bacteria, ease of maintenance and, accordingly, low operating and capital costs, etc. [14].

At the same time, like other methods of opening refractory gold, the technology of bacterial oxidation also has disadvantages, among which specialists of the Navoi Mining and Metallurgical Combine (NMMC) pay close attention to the problem of foaming. The technology of bacterial oxidation at this enterprise has been used since 2008 for the processing of ores from the Kokpatas and Daugyztau deposits, where gold is in close association with arsenopyrite and pyrite, in addition, carbonaceous substances are found in the ore, which are natural sorbents of gold.

The process of foaming during bacterial oxidation of concentrates remains poorly understood. However, the studies carried out suggest that foam is formed under the influence of the following factors: a decrease in the activity of bacteria, a change in the mineralogy of the concentrate, a too high dosage of flotation reagents, etc.

The mechanism of foam formation in bioreactors can be described as follows. For aerobic cultures, oxygen is supplied by injecting compressed air into the bottom of the reactor. Since the solubility of oxygen in an aqueous medium is very low (about 7-8 mg / l) and the oxygen demand of microorganisms is very high, the transfer of oxygen from air bubbles to the liquid phase must be strongly optimized. In practice, this is achieved by increasing the air flow rate through the reactor and, in the case of stirred bioreactors, by increasing the stirrer speed. In all cases, the oxygen transfer process is optimized by increasing the dispersion of the gas inside the vessel. Ascending bubbles cross the surface of the liquid inside the reactor and, in the presence of surface-active molecules, cause the formation of foam [15].

An increase in the level of foam reduces the effective working volume of the reactor, which leads to a decrease in the bio-oxidation time and an increase in the residual under-oxidized sulfur, which ultimately reduces the recovery of gold in the subsequent sorption cyanidation. In this regard, the suppression of foaming in the process of bio-oxidation is an urgent task.

3 Results

To solve this problem, NMMC specialists applied two methods: chemical and mechanical.

The chemical method consists in adding defoaming reagents to bioreactors. A similar method was also used on the Fosterville project, where a special reagent supply and dosing system was installed. Antifoam reagents reduce the surface tension of the slurry at the liquid-air interface, which prevents the stagnation of air bubbles on the surface of the slurry and, in turn, reduces foaming. However, with this method, it is worth considering the cost of reagents, which are quite expensive, and the additional consumption of water, which affects the pulp density in bioreactors.

For mechanical destruction of foam, engineers of NMMC have developed special spray nozzles, which are installed above the surface of the bioreactors. A distinctive feature of this method is that through these nozzles, not water is supplied to the foam, but the pulp from the bioreactors, thereby not affecting the pulp density in the bioreactors.

In order to study the structure of the foam, samples were taken from the bio-oxidation reactors and studies were carried out to study its composition. It was found that the gold content in the primary reactors is about 44 g / t and its value increases towards the last reactor, where the gold content reaches 286 g / t. The sample contains silver as an accompanying element, the average content of which is about 98 g / t. During the research, the following chemical composition of the average sample of the foam product of the bio-oxidation process was obtained, %: 0.05 Cu; 0.03 Ni; 0.3 As; 0.3 Ti; 0.07 Sb; 15 S; 17 C; 0.01 Cr; 0.01 Zn.

Considering that the enrichment process is a set of processes and methods for the concentration of valuable components in the processing of minerals, and the fact that in the foam product of bio-oxidation the gold content is several times higher than its content in the flotation concentrate (on average 150-160 g / t versus 18-20 g / t), therefore, it can be argued that the foam of BIOX reactors is a product of enrichment of the bio-oxidation process, and the bio-oxidation process itself can be attributed to a biological enrichment method.

4 Conclusion

Thus, instead of fighting foaming in bio-oxidation reactors, it is advisable to remove foam and conduct research on the development of technology for its separate processing in order to extract valuable components. This will optimize the process of bacterial oxidation and translate the lack of bio-oxidation technology into its next advantage.

References

1. W.J. Li, Y.S. Song, Y. Chen, L.L. Cai, G.Y. Zhou, IOP Conf. Series Mater. Sci. Eng., **231**, 12169 (2017)
2. X. Guo, Y. Xin, H. Wang, Nonferrous Metals Soc. China, **27**, 1888-1895 (2017)
3. A.Ya. Baudouin, S.B. Fokina, G.V. Petrov, M.A. Serebryakov, Modern problems of science and education, **6** (2014) URL: https://www.science-education.ru/ru/article/view?id=15619
4. R.K. Asamoah, W. Skinner, J. Addai-Mensah, Powder Technol. **331**, 258-269 (2018
5. Xu Wang, Wenqing Qin, Fen Jiao, Congren Yang, Yanfang Cui, Wei, Zhengquan Zhang and Hao Song, *Mineralogy and Pretreatment of a Refractory Gold Deposit in Zambia* (Minerals, Manchester, 2019). URL: https://www.mdpi.com/2075-163X/9/7/406/pdf
6. O. Celep, P. Altınkaya, E.Y. Yazici, H. Deveci, *Effect of ultrafine-grinding on cyanide leaching of copper bearing pyritic gold concentrate* (15th International Mineral Processing Symposium, Istanbul, 2016)
7. S. Ellis, *Ultra-Fine Grinding - A Practical Alternative to Oxidative Treatment of Refractory Gold Ores*. URL: https://www.isamill.com
8. Choi N.C., Kim B.J., Cho K., Lee S., C.Y. Park, Metals, **1**, 404 (2017)
9. Xiaoliang Zhang, Chunbao Sun, Yi Xing, Jue Kou, Min Su, Hydrometallurg, **180**, 210-220 (2018)
10. R.K. Asamoah, W. Skinner, J. Addai-Mensah, Journal of Hydrometallurgy, **179**, 79-93 (2018)

11. D. Frank, L. Jean-Paul, *Foam formation and control in bioreactors*. URL: https://onlinelibrary.wiley.com/doi/epdf/
12. N.V. Fomchenko, T.F. Kondrat'eva, M.I. Muravyov, Hydrometallurgy, **164**, 78-82 (2016)
13. M. Mubarok, R. Winarko, S. Chaerun, I. Rizki, Z. Ichlas, Hydrometallurgy, **168**, 69-75 (2017)
14. K. Sanakulov, U.A. Ergashev, R.A. Khamidovm Mining Bulletin of Uzbekistan, **4**, 45-49 (2020)
15. L.N. Krylova, K.A. Wigandt, L.E. Sarokhanova, E.V. Adamov, Zheng Zhihong, Non-ferrous metals, **11**, 25 (2013)