INTENSIFICATION OF MASS EXCHANGE PROCESSES IN NEUTRALIZING
THE TECHNOLOGICAL SOLUTIONS OF CYANIDATION

A. A. Kochanov, A. A. Ryazantsev, and A. A. Batoeva*  UDC 66.074.3: 66.023.23 + 628.543

The results are presented for neutralizing the solutions of cyanide gold leaching by a new method. It is shown that the rate of chemical reaction proceeding in a centrifugal-bubble apparatus and the efficiency of HCN removal depend on the intensity of mass exchange which is determined by the value of rotational velocity of gas-liquid layer. The rate of all reactions was 9.5 – 13.7 mol/l·h, which is larger than their rate at the existing method by a factor of 45 – 46.

Cyanides, thiocyanates, waste waters, purification

INTRODUCTION

Cyanides are widely spread in industry: in tanning, production of electronic boards, cathodic reduction of metals, flotation processing of sulfide ores, extraction of finely dispersed gold, silver, and other metals from them. The waste waters of such productions contain toxic elementary or complex cyanides, thiocyanates, and ions of heavy metals; therefore, they must undergo deep purification which is usually performed by destructive oxidation of cyanides, cyanates, and thiocyanates by hydrogen peroxide, ozone, mixture of air oxygen and SO₂, and reagents containing active chlorine (bleaching powder, calcium hypochlorite, and chlorine water) [1 – 5].

The high cost of sodium cyanide favored the development of regenerative procedures of waste water neutralization by ion exchange, electrochemical oxidation, or the acidification – distillation – neutralization method which is one of the basic methods used in gold mining and processing enterprises [6]. This method is based on the distillation of volatile HCN which formed under acidification of the solutions containing elementary and complex cyanides up to pH = 6 – 2.5. Distillation is realized by air, sometimes with simultaneous heating of the solution.

As the coal-in-pulp technology was used in practice of processing the gold-containing ores, the works describing this method appeared. It is realized according to the following scheme: pulp acidification up to pH ≤ 3, separation of the solid phase, and removal of HCN from the gold-free cyanogen solutions [7]. In all cases, HCN is absorbed by alkaline solutions, and NaCN is sent to cyanidation once again.

Depending on the composition of ore undergone cyanidation, in the case of acidification of spent solutions, not only binding of free cyanides in HCN takes place, but also destruction of complex cyanides of heavy metals with isolation of additional quantity of HCN and appearance, for example, insoluble thiocyanates [8]:

Siberian State University of Railways, E-mail: raastu@irs.ru, Novosibirsk, Russia. *Baikal Institute of Nature Management, Siberian Branch, Russian Academy of Sciences, E-mail: abat@binm.baikal.net, Ulan-Ude, Russia. Translated from Fiziko-Tekhnicheskie Problemy Razrabotki Poleznykh Iskopaemykh, No. 4, pp. 103–109, July-August, 2002. Original article submitted August 20, 2002.
\[ \text{H}^+ + \text{CN}^- = \text{HCN} \uparrow, \]  
\[ [\text{Ag(CN)}_2]^- + 2\text{H}^+ + \text{SCN}^- = 2\text{HCN} \uparrow + \text{AgSCN} \downarrow, \]  
\[ [\text{Cu(CN)}_4]^{3-} + 4\text{H}^+ + \text{SCN}^- = 4\text{HCN} \uparrow + \text{CuSCN} \downarrow, \]  
\[ [\text{Cu(CN)}_4]^{3-} + 3\text{H}^+ = \text{CuCN} \downarrow + 3\text{HCN} \uparrow, \]  
\[ \text{Cu(SCN)}_2 + \text{S}_2\text{O}_3^{2-} + \text{H}^+ = \text{CuSCN} \downarrow + 2\text{S}^- + \text{SO}_3^{2-} + \text{HCN} \uparrow. \]

If there are [Fe(CN)_6]^{4-} ions in the solution, then complex ferrocyanides of copper, nickel, zinc, and iron precipitate:
\[ [\text{Fe(CN)}_6]^{4-} + 2\text{Me}^{2+} = \text{Me}_2[\text{Fe(CN)}_6] \downarrow, \quad (\text{Me} = \text{Cu}^+, \text{Cu}^{2+}, \text{Ni}^{2+}, \text{Zn}^{2+}), \]  
\[ 3[\text{Fe(CN)}_6]^{4-} + 4\text{Fe}^{3+} = \text{Fe}_4[\text{Fe(CN)}_6]_3 \downarrow. \]

The character and rate of chemical reactions proceeding with acidification of spent cyanidation solutions, as well as the efficiency of HCN removal substantially depend on the intensity of mass exchange and the quantity of air oxygen dissolved in water. The results of neutralization of spent cyanide-containing technological solutions are presented in this paper.

**EXPERIMENTAL PART**

We investigated solutions containing elementary and complex cyanides — 200–2000 mg/l, thiocyanates — 250–2000 mg/l, iron — 20–50 mg/l, copper — 300–1000 mg/l, zinc — 20–50 mg/l, sulfates > 1000 mg/l, and chlorides > 300 mg/l; pH = 9.5–11. The concentration of CNS^- ions in the solution was found by iron (III) thiocyanate photometry, cyanides — using the Bukshteg method, sulfites, thiosulfates, and sulfides — by iodimetric method [9], and the ions of heavy metals — by atomic-adsorptive method.

The operational principle of centrifugal-bubble apparatus (CBA) is based on gas transmission through rotating liquid layer retained by the stream of gas in the vortex chamber. Constructively, the apparatus consists of cylindrical case 1 separated into the upper part containing separation zone 2, fan 3, as well as branch pipe for gas withdrawal 4 and the lower part, where the branch pipes for supply 5 and discharge of liquid 6, branch pipe for gas supply 7, and guide vane 8 made in the form of a ring with tangential slots are located (Fig. 1).