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STUDY OF OBTAINING ACCOMPANYING ELEMENTS IN THE PROCESSING OF GOLD-BEARING ORES OF THE MURUNTAU DEPOSIT

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ИССЛЕДОВАНИЕ ПОЛУЧЕНИЯ СОПУТСТВУЮЩИХ ЭЛЕМЕНТОВ ПРИ ПЕРЕРАБОТКЕ ЗОЛОТОСОДЕРЖАЩИХ РУД МЕСТОРОЖДЕНИЯ «МУРУНТАУ»

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ABSTRACT

This article reflects the research conducted on the deposition of silver and other valuable metals from waste sulfuric acid solutions by cementation with zinc powder. The issue of nitric acid dissolution of the resulting precipitate after cementation with zinc powder, with further separation of silver and non-ferrous metals, is considered.

АННОТАЦИЯ

В данной статье отражаются проведенные исследования по осаждению серебра и других ценных металлов из сбросных сернокислотных растворов путем цементации цинковым порошком. Рассмотрен вопрос азотнокислого растворения полученного осадка после цементации цинковым порошком, с дальнейшим разделением серебра и цветных металлов.

Keywords: extraction, precipitation, zinc powder, aluminum and iron chips, ion exchange resin, sulfuric acid treatment, nitric acid treatment.

The possibility of extracting silver, copper and nickel from waste sulfuric acid solutions of the HMP-2 regeneration department by cementation has been studied. The aim of the study was to determine the optimal conditions for the extraction of silver, copper and nickel from waste sulfuric acid solutions of ion exchange resin regeneration.

Several samples of waste sulfuric acid regeneration solutions were selected for the research, the composition of which according to the content of associated precious metals is presented in Table 1.

Table 1.

| Sample of the solution | Ag  | Ni  | Cu  | Zn  | Co  | Pd  | pH |
|------------------------|-----|-----|-----|-----|-----|-----|-----|
| 1                      | 49.7| 488 | 234 | 970 | 0.21| 0.27| 2.2 |
| 2                      | 0.1 | 0.59| 1.2 | 0.6 | 0.01| 0.36| 6.5 |
| 3                      | 27.5| 449 | 64.7| 540 | 0.18| 0.29| 1.9 |
| 4                      | 60.0| 557 | 63.5| 820 | 0.20| 0.48| 2.2 |
| 5                      | 75.5| 836 | 174 | 480 | 0.18| 0.38| 1.6 |

As can be seen from Table 1, the composition of solution No. 2 differs significantly from the composition of other solutions, both in terms of metal concentration and pH value. This is due to the fact that the sample of solution No. 2 was taken at the beginning of the process of sulfuric acid treatment of ion exchange resin. Sulfuric acid treatment of ion exchange resin is carried out for at least 6 hours. Therefore, in order to clarify the composition of solutions from the time of resin treatment, the specialists of GMZ-2 carried out work on removing the output curve of regeneration (Fig. 1.)
From the data presented, it can be seen that during the last hour of resin regeneration, the solution is enriched with associated valuable metals to a concentration at which the extraction of these metals becomes cost-effective.

We selected solution No. 5 for the research. Studies on the extraction of associated precious metals from this solution were carried out by a cementation method using zinc dust. The research methodology was as follows. A certain volume of the test solution was placed in a thermostatically controlled reactor equipped with an electromechanical tube. The calculated amount of zinc dust was dosed into the reactor and the resulting suspension was mixed for a given time at the speed of rotation of the agitator, n = 500 rpm. At the end of mixing, the suspension was transferred to a filter (blue ribbon) and filtered under vacuum. The resulting filtrate was analyzed. In balance experiments, the sediment on the filter was washed, dried and analyzed.

Table 2 presents data on the effect of zinc dust consumption on the completeness of metal deposition. As can be seen from the results of Table 2, the optimal from the point of view of extracting silver and copper from solutions is the consumption of zinc dust equal to 5 g/l. At the same time, the completeness of silver deposition was 99.8%, and copper 99.1%; the pH of the solution increased from 1.6 to 5.1. An increase in the consumption of zinc dust to 7.5 g/l does not lead to a significant increase in the deposition of silver and copper.

At a consumption of zinc dust of 5 g/l, the completeness of nickel deposition was only 35%. The increase in zinc dust consumption to 7.5 g/l did not significantly affect the completeness of nickel deposition, which increased by only 15% (up to 50%). At the same time, cobalt and palladium are not deposited.

Table 2.

The effect of zinc dust consumption on the completeness of metal deposition $t=+20^\circ C$; mixing time, $\tau=30$ min; $n=500$ rpm

| №  | Zn-dust consumption, g/l | Residual concentration of metals, mg/l |  
|----|--------------------------|--------------------------------------|
|    | Ag  | Ni  | Cu  | Zn  | Co  | Pd  | pH  |
| 1  | 0   | 75,5| 836 | 174 | 480 | 0,18| 0,38| 1,6 |
| 2  | 0,25| 45,5| 796 | 144 | 540 | 0,18| 0,38| 2,8 |
| 3  | 1,0 | 19,0| 730 | 117 | 650 | 0,18| 0,38| 3,9 |
| 4  | 2,5 | 9,2 | 664 | 61  | 2210| 0,18| 0,38| 4,3 |
| 5  | 5,0 | 0,16| 544 | 1,5 | 2400| 0,17| 0,38| 5,1 |
| 6  | 7,5 | 0,11| 414 | 1,5 | 2480| 0,17| 0,38| 6,8 |

Kinetics of cementation. At the selected zinc dust consumption of 5 g/l, the kinetics of cementation of metals was studied. The results of the experiments are shown in Table 3.
Table 3.

| №  | Mixing time, min | Residual concentration of metals, mg/l |  |
|----|------------------|--------------------------------------|--|
|    |                  | Ag        | Ni  | Cu  | Zn  | Co  | Pd  | pH  |
| 1  | 0                | 75,5      | 836 | 174 | 480 | 0,18| 0,38| 1,6 |
| 2  | 5                | 12,2      | 830 | 15,5| 1450| 0,18| 0,38| 2,4 |
| 3  | 10               | 2,9       | 795 | 2,1 | 1800| 0,18| 0,38| 4,3 |
| 4  | 20               | 0,18      | 685 | 1,7 | 2390| 0,18| 0,38| 5,0 |
| 5  | 30               | 0,16      | 544 | 1,5 | 2400| 0,17| 0,38| 5,1 |
| 6  | 40               | 0,15      | 542 | 1,5 | 2410| 0,17| 0,38| 5,1 |

As can be seen from the results of Table 3, the optimal time for cementation of silver and copper is 20-30 minutes. With an increase in the cementation time to 40 minutes, the completeness of the cementation of silver and copper does not increase.

**The influence of temperature.** Next, the effect of temperature and consumption of zinc dust on the completeness of nickel and palladium cementation from the mother cells of silver and copper cementation was investigated. For this purpose, a solution was used after cementation of silver and copper, i.e. solution No. 5 (Table 2).

Data on the effect of temperature on the completeness of cementation of nickel and palladium with zinc dust are given in Table 4.

Table 4.

**The effect of temperature on the completeness of carburization of nickel and palladium with zinc dust \( \tau = 30\text{min}; n = 500\text{ob/min} \)**

| Cementation temperature, C | Zn-dust consumption, g/l | Concentration, mg/l |  |
|-----------------------------|--------------------------|---------------------|--|
|                             |                          | Ni                 | Pd | pH |
| 20                          | 0 (solution after Ag and Cu deposition) | 544 | 0,38 | 5,1 |
| 50                          | 5                        | 288                | 0,38 | 6,4 |
| 80                          | 5                        | 86                 | 0,38 | 6,6 |
|                             | 10                       | 50                 | 0,38 | 6,5 |
|                             |                          | 18                 | 0,38 | 6,6 |

As can be seen from the results of Table 4, an increase in the temperature of the cementation process to \(+80\ C\) with a zinc dust consumption of 10 g/l ensures satisfactory completeness of nickel cementation (its residual concentration was 18 mg/l). At the same time, palladium remains completely in solution.

**The effect of pH.** Considering that silver, as well as other metals present in the solution, are prone to hydrolysis and complexation with a change in pH, studies have been conducted on the effect of the pH of the solution on the completeness of precipitation of silver and related metals. Neutralization of the solutions was carried out using a 24% \( \text{NH}_4\text{OH} \) solution. Table 5 presents data on the effect of zinc dust consumption on the completeness of silver deposition under the condition of preliminary neutralization of the solution with ammonia to pH 9.6 (\( \text{NH}_4\text{OH} \) consumption 13.6 ml/l).

Table 5.

**The effect of zinc dust consumption on the completeness of Ag, Cu and Ni deposition at an initial pH of 9.6 \( \tau = +20\text{C}; \text{mixing time}, \tau = 30\text{min}; n = 500\text{ rpm} \)**

| №  | Zn-dust consumption, g/l | Residual concentration of metals, mg/l | Note |
|----|--------------------------|--------------------------------------|------|
|    |                          | Ag        | Ni  | Cu  |  |
| 1  | 0                        | 75,5      | 836 | 174 | The concentration of Co and Pd in the solution did not change |
| 2  | 0,10                     | 5,4       | 798 | 13,0| |
| 3  | 0,25                     | 0,1       | 190 | 0,48| |
| 4  | 0,50                     | 0,1       | 185 | 0,46| |
| 5  | 1,00                     | 0,1       | 178 | 0,46| |

As can be seen from the results of Table 5, increasing the pH with \( \text{NH}_4\text{OH} \) to pH 9.6 provides a significant reduction in the consumption of zinc dust: from 5 g/l (Table 2) up to 0.25 g/l. At the same time, the residual silver content in the solution decreases from 0.16 mg/l to 0.1 mg/l.

Table 6 shows data on the effect of the initial pH on the completeness of Ag, Cu and Ni deposition at a zinc dust consumption of 0.25 g/l.
Table 6.

Effect of the initial pH of the solution on the completeness of Ag, Cu and Ni deposition

Zn-dust consumption 0.25 g/l; t=+20°C; mixing time, τ=30 min; n=500 rpm

| № | pH | Residual concentration of metals, mg/l | Note |
|---|----|---------------------------------------|------|
|   |    | Ag | Ni | Cu     |              |
| 1 | 1.6| 25.5 | 621 | 114     | The concentration of Co and Pd in the solution did not change |
| 2 | 4.0| 0.12 | 348 | 1.2     |
| 3 | 5.2| 0.10 | 336 | 0.8     |
| 4 | 7.2| 0.10 | 242 | 0.56    |
| 5 | 8.0| 0.10 | 190 | 0.56    |
| 6 | 9.6| 0.10 | 190 | 0.48    |

As can be seen from Table 6, increasing the pH of the solution with ammonia to pH 5.0 leads to almost complete precipitation of silver and copper, while nickel is deposited by 60%. The completeness of nickel deposition up to 77% can be increased by increasing the initial pH to 9.6.

Conclusions: optimal conditions for the deposition of silver from waste sulfuric acid solutions have been determined: preliminary neutralization of the solution with ammonia to pH 5 (and higher), consumption of zinc dust – 0.25 g/l; mixing time 20-30 min., ambient temperature. Under these conditions, copper and 60% nickel are also almost completely deposited.

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