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APPLICATION OF THE FLOTATION PROCESS IN THE SILVER RECOVERY FROM THE WASTES GENERATED DURING THE SILVERY SEMI-PRODUCTS MANUFACTURING

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In this work, the results of the flotation process application in the silver recovery from the wastes generated during the silvery semi-products manufacturing, are shown. The flotation process parameters, i.e. time of process, rotation frequency, gas flow rate and flotation reagents, were optimized.

Key words: silver, flotation, waste, silver, recycled

Primjena flotacijskog procesa u dobivanju srebra iz otpada nastalog tijekom proizvodnje poluproizvoda od srebra. U ovom su radu prikazani rezultati primjene flotacijskog procesa u dobivanju srebra iz otpada nastalog tijekom proizvodnje poluproizvoda od srebra. Parametri flotacijskog procesa, tj. vrijeme procesa, frekvencija rotacije, protok plina i flotacijski reagensi bili su optimizirani.

Ključne riječi: srebro, flotacija, otpad, srebro, reciklaža

INTRODUCTION

Lately, the significant development of the technologies dealing with the noble metals recovery from the secondary raw materials, is being observed. Such approach is the economical and ecological necessity, due to the rare occurrence of noble metals' primary raw materials and high energy consumption of their ore mining. Since there exist large diversity of secondary raw materials varying in both metal content and physical form, i.e. electronic elements, joints, catalysts, jewelry wastes, the recovery technique has to be customized for each material type separately [1 - 5].

The flotation process is used in the separation of the grains that posses different wetting ability under the gas, usually air, flow. The main product of this process is the concentrate with higher, comparing to feedstock, content of the desired component [6 -10].

In this work, the results of the investigation of the flotation process as a technique for the silver recovery from the wastes coming from the silver-containing semi-products manufacturing are presented. In the course of work the flotation process parameters, i.e. time of process, rotation frequency, gas flow rate and the type of the flotation reagents were optimized

EXPERIMENTAL PART

The wastes coming from the final treatment of silver-containing semi-products were investigated. Their

Figure 1 Laboratory-scale flotation process equipment [1].

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Table 1 **Selected flotation reagents**

Foaming agent	Collecting agent	pH regulator
α-terpineol	X-23	$CuSO_4$
Pine oil	Paraffin oil	
Ethyl alcohol	Oleic acid	
Na_2S	Sodium amyl xanthogenate	
Corflot	Potassium etyl xanthogenate	
4-methyl-2-pentanol, Potassium		

composition was determined qualitatively and quantitatively by means of chemical methods. The main components were Al_2O_3, SiO_2 and silver with the mean content of 10,5 % wt.

The flotation laboratory scale set-up (Figure 1.), that consists of the flotation chamber of 1 dm^3 volume, made from the acid-proof steel and height-control rotor with engine, was applied for the wastes components separation. The liquid phase was mixed by both rotor and the air introduced by the compressor connected to the rotor. The rotation frequency was varied between 100 - 1 500 rot/min. The final product was collected mechanically from the surface of the liquid in the chamber during the process.

The effectiveness of the process was checked by monitoring the silver content in the final product and in the residues remaining in the flotation chamber. The analysis was conducted by means of Atomic Adsorption Spectrometer Unikam.

In order to optimize the flotation process parameters, several preliminary tests were run [11 - 13] analyzing the influence of the process time, rotation frequency, air flow rate, type and amount of the flotation reagents, on the final product properties. It was found that the process was the most effective when the rotation frequency

Table 2 **Results of the flotation process conducted on waste coming from silver-containing semi-products for rotation frequency equal to 500 rot/min**

Flotation agent	Air flow rate / dm^3/min	Ag content in flotate / % wt.	Ag content in chamber residues / % wt.
Corflot, oleic acid	2	35,48	0,96
	4	47,20	0,68
	6	30,74	1,22
Pine oil, oleic acid	2	23,99	4,06
	4	27,75	3,01
	6	25,36	3,32
α-terpineol, oleic acid	2	24,73	5,61
	4	30,72	4,21
	6	26,17	5,47
Corflot, Sodium amyl xanthogenate	2	23,17	3,74
	4	40,58	1,96
	6	20,45	3,87
Corflot, Sodium amyl xanthogenate	2	24,41	3,74
	4	25,56	4,81
	6	18,12	6,01
Corflot, X-23	2	16,31	9,71
	4	18,00	8,97
	6	16,42	8,84
Corflot, paraffin oil	2	18,97	10,32
	4	18,99	9,30
	6	18,21	9,55
4-methyl-2-pentanol, Potassium / Sodium metyl and ethyl xanthogenate	2	15,32	10,17
	4	15,12	9,39
	6	13,55	9,28
α-terpineol, X-23	2	16,51	9,57
	4	17,08	10,06
	6	16,90	10,11
Ethyl alcohol, X-23	2	16,74	8,97
	4	17,09	8,61
	6	16,62	9,74
Corflotu, acrylonitrile	2	16,79	9,74
	4	16,97	9,39
	6	16,62	9,41

Table 3 **Results of the flotation process conducted on waste coming from silver-containing semi-products for rotation frequency equal to 700 rot/min**

Flotation agent	Air flow rate / dm^3/min	Ag content in flotate / % wt.	Ag content in chamber residues / % wt.
Corflot, oleic acid	2	23,45	0,98
	4	37,54	0,54
	6	23,16	8,26
Pine oil, oleic acid	2	21,21	5,11
	4	24,44	3,12
	6	20,38	3,72
α-terpineol, oleic acid	2	23,87	5,99
	4	28,00	4,97
	6	27,10	5,06
Corflot, Sodium amyl xanthogenate	2	33,85	0,85
	4	31,17	1,04
	6	13,43	5,07
Corflot, Sodium amyl xanthogenate	2	19,01	5,77
	4	20,15	5,99
	6	17,12	6,28
Corflot, X-23	2	15,02	9,62
	4	14.97	9.97
	6	14,07	9,09
Corflot, paraffin oil	2	18,00	8,97
	4	17,45	9,23
	6	17,03	9,87
4-methyl-2-pentanol, Potassium / Sodium metyl and ethyl xanthogenate	2	15,01	9,98
	4	15,22	9,72
	6	14,55	9,38
α-terpineol, X-23	2	16,43	9,06
	4	16,28	9,99
	6	15,19	9,42
Ethyl alcohol, X-23	2	17,62	8,21
	4	17,21	9,84
	6	17,33	9,41
Corflotu, acrylonitrile	2	17,23	9,09
	4	17,72	9,08
	6	17,12	9,04

was equal to 500 or 700 rot/min, while the air flow rate was between 2 and 6 dm^3. The highest silver content in the final product, in comparison to the initial material, was obtained after 15 min of flotation. The further increase in the process time leads to the decrease in the silver content.

The flotation reagents, given in the Table 1, were selected in the preliminary tests as the most promising. In the course of this work, it was found that the best results, i.e. stable foam, were obtained when 2 cm^3 of foaming agent was introduced into flotation bath. The formation of the foam was ineffective or too excessive, when the amount of the reagent was reduced or increased, respectively. Moreover, the amount of the collecting agent was balanced to 0.2 cm^3 and pH to 8, so the appropriate amount of pH regulator was introduced.

RESULTS

Tables 2 and 3 present results obtained during the flotation process of the wastes coming from silver-containing semi-products manufacturing.

CONCLUSIONS

Based on the presented results, we can state that for this type of silvery wastes generated during the semi-product polishing, the highest silver recovery was obtained by applying flotation process with the rotation frequency equal to 500 rot/min and air flow rate equal to 4 dm^3/min, with one of the following mixtures of the flotation reagents employed:

- corflot- oleic acid,
- α-terpineol – oleic acid,
- corflot- sodium amyl xanthogenate

The highest silver content in the final product was equal to 47,2 % wt., which was almost fivefold increase in comparison to initial silver concentration. Such product was obtained with corflot as a foaming agent, oleic acid as a collecting agent and process parameters: 500 rot/min and air flow rate equal to 4 dm^3/min.

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Note: Nowak P is responsible for English language, Katowice, Poland