Control of the Physical and Technical Properties of Water in Technological Processes

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Abstract. The physical and technical properties of water activated by the electrochemical treatment in a two-chamber electrolizer are investigated. The regularities of changes inthe values of acidity, redox potential, ionic composition, concentration of oxygen, structural organization of catholyte and anolyte are revealed. The possibility of controlling the properties of the liquid for more efficient extraction of polymetallic minerals by flotation is described.

1. Introduction

Currently, the most common method for controlling the properties of water is its treatment with external physical impacts or introduction of chemical additives of both organic and inorganic nature. In this case, in water and in aqueous solution there are changes that occur in the structural organization of the entire system, caused by generation of hydrate formations of dissolved ions and gas hydrates, which leads to the disruption of the interaction among the individual structural components of water. In particular, the quantitative ratio of associated and individual dipoles of water molecules changes, as well as its physical and technical properties. The abovementioned processes have a significant impact on the course of technological processes where water is used as a solvent or a dispersed phase. Therefore, for optimum results, in particular, in the flotation technology, it is necessary not only to control its quality but to purposefully regulate its properties as well.

During the electrochemical treatment of industrial water in a diaphragm electrolyzer the following takes place: change in the ionic composition, pH, Eh of water, saturation with finely dispersed electrolytic gases (hydrogen, oxygen), and its division into two products: alkaline water – catholyte, and acidic water – anolyte. Moreover, the final ionic composition depends on the initial composition of water and the quantity of the electricity used for 1 m^3 of solution. The electrochemical treatment of water allows to change the pH by (4 – 5) units, Eh by (300 – 500) mV to the region of negative or positive values, as well as to reduce the content of hardness salts by 50 – 85%. These processes have a significant effect on the flotation of refractory ores. For example, in all cases, the reduction in the redox potential (RP) to the negative direction by more than 200 mV results in an increased recovery of some (zinc) and decreased recovery of other (copper, iron, tin) valuable components [1-4].

The aim of the work is to study the changes in physical and technical properties of water and aqueous solutions during its treatment with the use of the electrochemical method, and to assess the impact of the activated liquid on the effectiveness of polymetallic ores flotation.

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2. Materials and methods

The electrochemical treatment of water was carried out using the device shown in Figure 1.

Plates made of stainless steel X18H9T were used as electrodes. The diaphragm was made of a filter cloth. The electrode spacing was 100 mm. The power was supplied by the rectifier VSA-5. The surface density of the current was varied in the range of (16-24) A/m^2, the volume current density – (0.1 – 0.5) A/l, and the power consumption – 6 kWh/m^3.

The control of the acidity (pH) and the redox potential (Eh) was carried out using anionometer I-120. The quantity of the concentration of the dissolved oxygen was measured using an electrochemical analyzer.

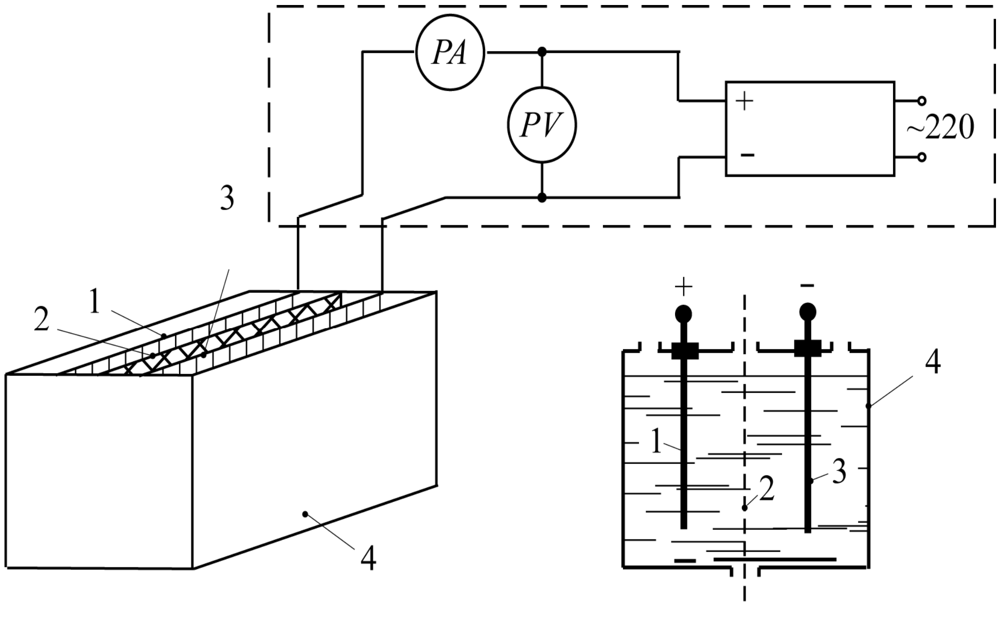

Figure 1. Principal (a) and schematic (b) images of the electrolizer: 1 –anode; 2 – diaphragm; 3 – cathode; 4 – case

The electrical properties of water were controlled using the dielectrometry method [5]. The measuring cell comprises a cylindrical glass vessel with a diameter of 8 cm, in which the tested liquidin the amount of 500 ml and the two plates (electrode) of the capacitor made of a nonmagnetic material (area 64 cm^2 each) located on opposite sides of the vessel are placed (Figure 2).

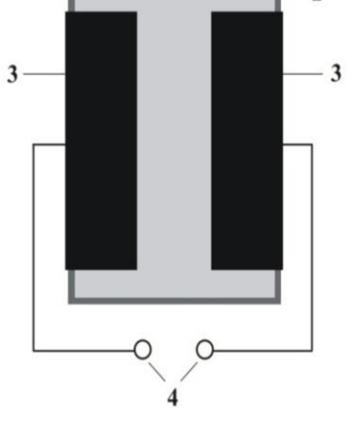

Figure 2. The arrangement of the capacitor plates in the measurement cell: 1 – liquid container, 2 – test liquid, 3 – capacitor plates, 4 – terminals for connecting the signal from the sine wave generator.

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Results and discussion

An installation for measuring liquid parameters allows to register the change in the electric capacity of liquids (based on the change in the value of the reactive current and upon deducting the capacity of the measuring cell without the liquid from the total capacity of the capacitor). The voltage to the measuring cell is applied from a sine wave generator FSG-2007, the cell signal is amplified by an instrumentation amplifier based on the circuit INA 217 and is measured on an oscilloscope PDS5022S. The value of the inductance is measured using a device LCR-9063.

The paper (Figure 3-4, Table 1) shows the results of the research on changes in the physical and technical properties of water passed through a DC electrode pair.

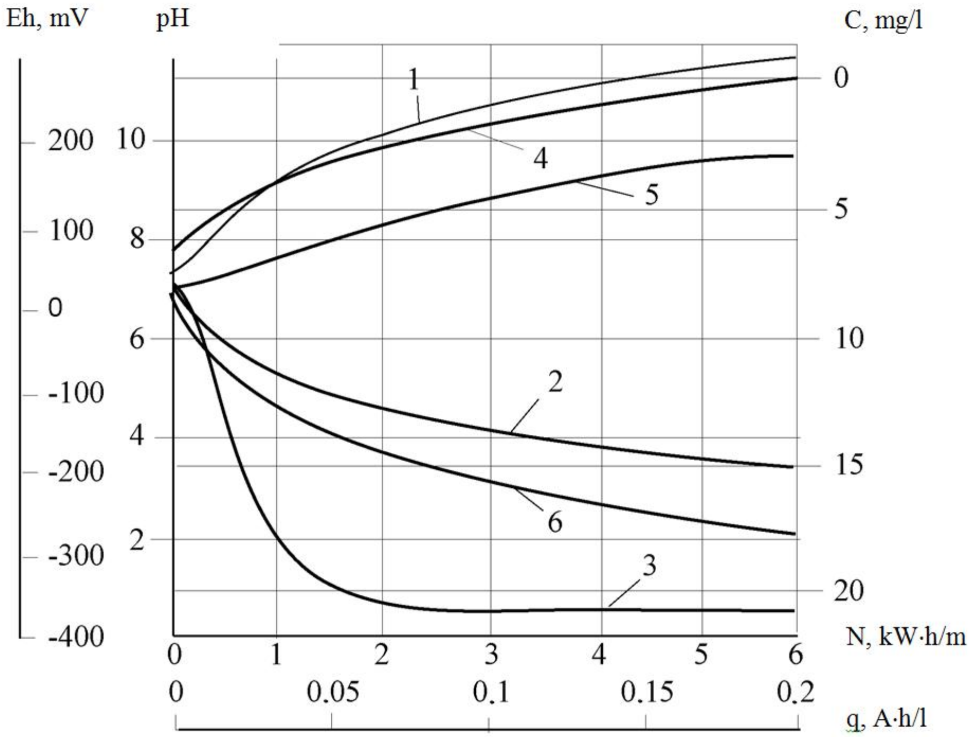

Figure 3.Changes in pH (1, 2), Eh (3, 4), and concentration of the dissolved oxygen (C) (5, 6) depending on the cost of electricity (N) and the quantity of electricity (q) in catholyte (1, 2, 3) and anolyte (2, 4, 6).

As can be seen from figure 3, pH and Eh of process water change significantly even when the electricity consumption reaches0.5 kWh/m^3 and the amount of electricity reaches 0.017 A·h/l. In the future, changes in pH and Eh are exponential. The catholyte is characterized by the values pH=11.4; Eh=460 mV (Figure 5, curves 1 and 3); Anolyte– pH=3.45; Eh=260 mV (curves 2, 4) at the electricity cost 6 kWh/m^3 and the amount of electricity 0.2 A·h/l.

The ionic composition of process water significantly changes in both the anolyte and the catholyte. (Table 1). This is especially important for hardness salts, as its reduction leads to an intensification of flotation processes [6].

The total hardness of water during the electrochemical treatment decreases with an increase in its acidity and alkalinity. In the anolyte, at pH 3,45the total hardness reduces by 4.6 times, and in the catholyte at pH 11.38 by 2.3 times. The experimentally obtained optimum hardness of water is in the range of 1-2 mg-eqv/l. At this value, the extraction of fine particles of minerals with a grain size of (10÷5) micron increases due to the strengthening of the mineralization of air bubbles. With an increase in the water hardness above 3 mg-eqv/l the extraction of slurry particles significantly reduces (Figure 4). It has been revealed that anions of hardness salts hardly affect the flotation.

The indicated values of the content of calcium and magnesium salts are optimal, because further decrease in water hardness requires additional power consumption. The decrease in the total hardness can be attributed to the transition of calcium and magnesium ions from the anolyte to the cathode space and to the formation of low-solubility precipitations in the catholyte.

It is known that the change in the structure of water solutions may also influence the course of various processes [6]. Figure 5 shows that after carrying out the electrolysis of distilled and technical water there is a significant change in its electrical capacitance, measured at frequencies of (1-300) kHz, which indirectly indicates a change in the structural organization of the solution, in particular, in the field of ion hydration, associative formations of water dipoles via hydrogen bonding and other.

Table 1. The ionic composition and the physical-chemical parameters of process water and products of its electrochemical treatment

Indicators		Process water	Anolyte	Catholyte
pH		7.23	3.45	11.38
Eh, mv		+95	260	-450
Total hardness, mg-eqv/l		6.45	1,4	2.75
Solids, mg/l		597	487	608
Cations mg/l	Ca^{2+}	68.0	10.0	4.0
	Mg^{2+}	24.0	17.1	54.2
	NH_4^+	1.8	2.3	1.9
	Fe_{tot}	0.0625	1.05	0.0
Anions mg/l	Cl^-	39.2	52,27	24.5
	CO_3^{2-}	18.0	0.0	168.2
	HCO_3^-	426.0	0.0	180.0
	NO_3^-	0.0	0.31	0.0
	NO_2^-	1.29	1.08	0.47
	S^{2-}	9.14	7.85	5.77
	SO_4^{2-}	58.65	79.85	38.29
	$S_2O_3^{2-}$	7.26	7.26	7.26
	SO_3^{2-}	7.21	3.2	2.4
Oxygen content, mg/l		6.8	22.2	3.1

Thus, the electrochemical treatment of water leads to substantial changes in pH, redox, ionic composition, concentration of dissolved oxygen in water, structural organization of the solution, which can be controlled by specifying the quantity of electricity and electricity costs. When implementing technological processes that are sensitive to these parameters it is possible to achieve their intensification. In particular, flotation of fine-grained mineral ores relates to such technologies [7].

The paper includes an assessment of the effectiveness of the flotation of polymetallic ores with the use of electrochemically activated process water. In particular, it has been revealed that the catholyte significantly activates the flotation of tin: thus, the recovery of this metal into a concentrate of the primary cleaning of the tin-lead flotation increases by more than 40 times (from 1.34% in the basic mode up to 64.45%). In the anolyte, the enrichment effect is significantly lower and it depends on the concentration of the dissolved oxygen.

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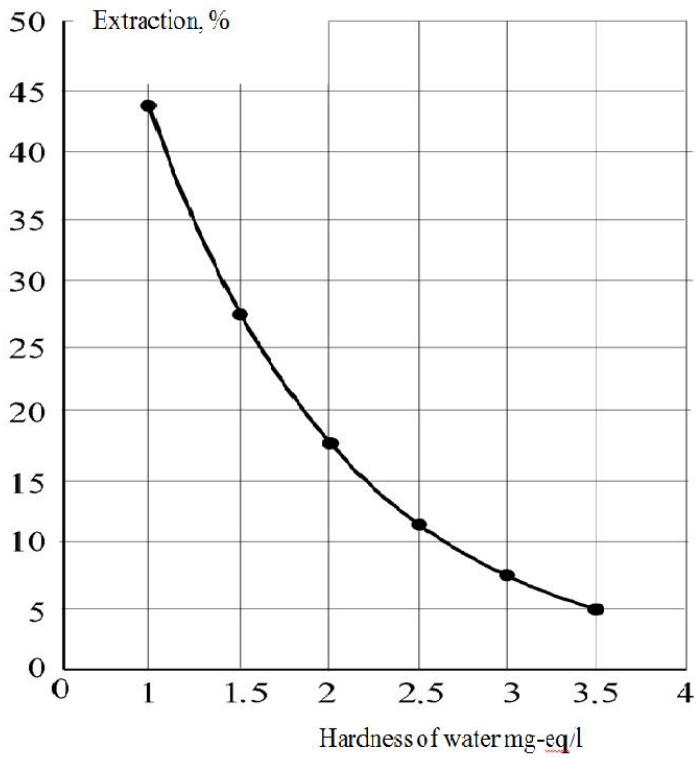

Figure 4. The effect of water hardness on the extraction of dispersed particles (10-15 microns) of minerals.

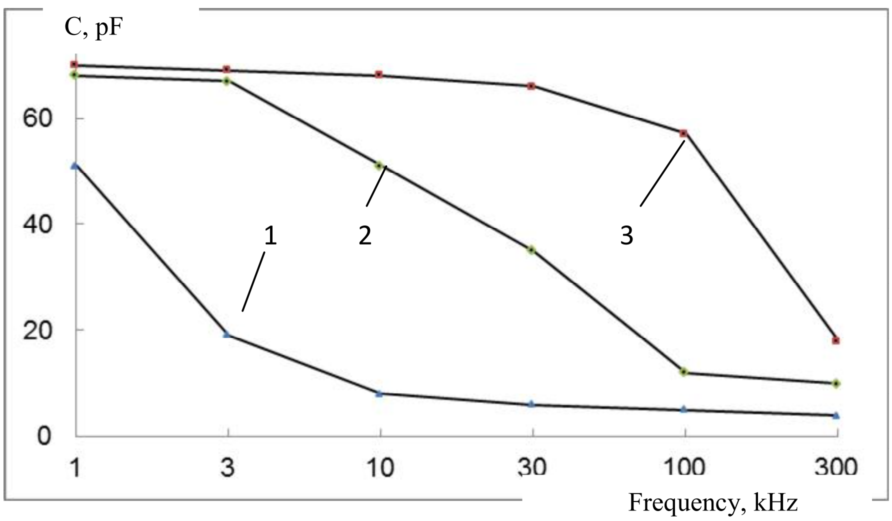

Figure. **5**. The dependence of the electric capacitance of the catholyte and the anolyte as compared to distilled water on the reactive current frequency: 1 – distilled water, 2 –anolyte; 3 –catholyte.

Conclusion

1. It has been shown that during the electrochemical activation of liquids in a two-chamber cell the physical and technical properties of water significantly change. These parameters can be adjusted by setting the amount of electricity and the cost of electricity.

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2. It has been established that the use of the catholyte in the flotation process of refractory finely-disseminated oxidized tin-lead ores leads to a significant increase in the extraction degree of tin mineral particles. The effect of the process intensification of fine particles extraction from aqueous media is caused by formation of electrolysis gases, reduction in the water hardness indicator, and formation of a new structural organization of the solution.

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