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Identification of Regularities of Metal Extraction When Ozonizing Waste Waters of Metallurgical Production by the Least Square Method

Kholikulov Doniyor B., Rahmonkulov Raimkul

Deputy Director for Research and Innovation Almalyk branch of the Tashkent state technical university, PhD, Almalyk, Uzbekistan;
Associate Professor, Department of Technology Engineering, Almalyk branch of the Tashkent state technical university, Almalyk, Uzbekistan

ABSTRACT: This article discusses the relationship between the evolution of metals during ozonation and finding the functional dependence between the parameters, based on statistical analysis. According to the results of the experiments, calculations were made to determine the degree of extraction of metals from wastewater of metallurgical production. The results are obtained using mathematical formulas between parameters and functions.

KEY WORDS: statistical analysis, correlation coefficient, experience signs, solutions, ozonation, waste water, metals, distribution law, arithmetic mean measurements, mean geometric measurements, smoothing, empirical dependencies.

I. INTRODUCTION

The theory of statistics is a fundamental discipline and serves as a foundation for the application of the statistical method of analysis. At any level and in any field, the effectiveness of statistics is largely determined by the quality of the source information.

Studying the links between different phenomena and processes is one of the most important tasks of statistics. It makes it possible to determine the quantitative characteristics of the links identified as a result of their theoretical essence analysis. The special techniques and methods used for this purpose are varied and their choice on a case-by-case basis depends on the nature of the information used and the purpose of the analysis. The relationship between the various phenomena and their features can be functional or statistical.

Statistical observation - systematic, scientific-organized, systematic collection of quantitative data on phenomena and processes, registration of essential characteristics. Statistics are generated at this stage and are then summarized, analysed and summarized.

Based on the above, the choice of a method for disinfecting waste water from metallurgical production was investigated. On the basis of waste water consumption and quality of treated waste water, conditions of supply and storage of reagents. The choice of decontamination method is determined not only by technical and economic indicators, but also by environmental requirements.
Numerous methods of treatment of process waste water are known as ozonation, chlorination, neutralization, γ-irradiation, uv-irradiation, chemical methods.

Decontamination of process waste water with ozone has advantages over other methods. When ozone is added to water, the enzymes of bacterial cells, inorganic and organic substances that cause chrominance, taste and smell are oxidized due to the high oxidative capacity of ozone. At the same time no foreign impurities are introduced into the water and the substances are not harmful to the environment. The destruction of microorganisms by ozone is based on the breakdown of free oxygen organic compounds upon interaction with them. Free radicals formed by the decomposition of ozone in water are also involved in the degradation reactions of organic and inorganic compounds. The widespread use of ozone is associated with its potentially lower risk to wastewater: residual ozone dissolved in water completely decomposes in 7-10 minutes and does not enter the water basin [1]. It is one of the strongest oxidizers, oxidizes all metals and most non-metals, converts lower oxides to higher oxides, and metal sulfides to metal sulfates.

Treatment of process waste water of copper and zinc production from organic contaminants and metals of heavy non-ferrous metals is currently a pressing task. This issue is acute in regions where industry is developing and technological and man-made pollution of water resources is increasing. Sorption, ion exchange, carbon adsorption, extraction, coagulation and other purification methods are used in water treatment and water treatment of industrial effluents. These methods do not meet the quality requirements of treated waters. More complete removal of heavy metal ions and organic compounds. The best treatment of waste water can be achieved through the process of ozonation of process waste water.

II. SIGHNIFICANCE OF THE SYSTEM

The article, on the basis of statistical treatment, considers the indicators of treatment of waste water of metallurgical production by ozonation method. The results of the experiments, which were obtained in laboratory studies, were processed by statistical analysis and a pattern in the form of a function between the parameters of the experiment was revealed.

In order to further apply the automatic control of the production of zinc cinnamon leaching, a special treatment program has been drawn up.

III. THE SYSTEM OF SIGNIFICANCE

The authors 'works [2-4] describe the basic concepts and define the relations between observations and the application of mathematical statistics in production, finance and economic spheres.

[5] The theoretical model of statistical data processing based on the hypothesis developed by the authors that two types of organizational structures - serial and parallel - are alternating, qualitatively changing in the process of growth and development of organizations, but preserve the properties defining the characteristics of the structure and provide a significant increase in the efficiency of their activities.

In [6], the results of the study are presented when modeling stability using an approach based on random disturbances affecting the value of dependent variables.

In [7], a hypothetical model of operation of an ozonizer filter combining filtration and decontamination processes is considered. Parameters of efficient operation are defined. Coefficients of regression equation determining operation of ozonator filter are calculated.

IV. METHODOLOGY

This paper presents the results of statistical processing of ozonation process indicators in order to assess reproducibility of experiments with different parameters (Table 1 [8]). During the ozone-air experiments, the mixture was supplied at a flow rate of 2.5 g/l. Initial pH of medium is within 2-5. The temperature of the process solutions was kept constant at 200C. The results of the change in the concentration of metal ions depending on the PH of the process solution medium are presented in Table 1. The results of experimental studies show that the maximum recovery of metals in the precipitate is observed at the beginning of the process. Degree of waste water treatment from metals is 96-98%.

Table 1.The results of semi-industrial tests of acid sludge sulphate shop ozone

Solution pH	Degree of waste water treatment,%				
	Ni	Cu	Zn	Fe^{+2}	Fe^{+3}
1.1	86,9	78,6	65	26	96
1.12	89,6	73,7	75	34	99
1.13	97,6	94,8	94	64	100
1.14	97,7	95,1	98	92	100
1.15	97,7	95,4	98	98	100

Test conditions: ozone concentration 6 mg/l, ozone consumption 0.1-0.15 g/l, 200C solution temperature, purification time 60 min.

The efficiency of the process depends to a large extent on the PH of the medium of the solution being treated. Metals are precipitated throughout the range of PH values in question. Precipitation takes place most fully in close media when the metal is in the form of hydroxides.

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In order to establish dependence between two characteristics, we find correlation coefficients between the characteristics by formula:

$$r_{xy} = \frac{Cov(X,Y)}{\sigma_x \cdot \sigma_y} \quad (1)$$

where: $Cov(X,Y) = \frac{1}{n}\sum(x_i - \bar{x})(y_i - \bar{y})$ - covariance.

σ_x, σ_y - dispersions $\sigma_x = \sqrt{\frac{1}{n}\sum(x_i - \bar{x})}$ $\sigma_y = \sqrt{\frac{1}{n}\sum(y_i - \bar{y})}$

x_i, y_i signs, $\bar{x}, \bar{y}$ so-so arithmetic signs.

Pair correlation establishes dependence between two features, one of which is factorial and the other is result. The relationship between them may vary. Therefore, it is important to correctly establish the form of the link between the features and accordingly to modify the mathematical equation expressing this link.

The calculated correlation coefficients between the pairs are shown in Table 2.

Table 2

Metals	Ni	Cu	Zn	Fe^{-2}	Fe^{-3}
pH	0,895	0,858	0,931	0,977	0,822

Since the tight relationship is large, you can find least-squares functional relationships.

The Least Squares Method (MNC) is a mathematical method used to solve various problems, based on minimizing the sum of squares of deviations of some functions from the variables sought. It can be used to find a solution in the case of ordinary (not redefined) nonlinear systems of equations, to approximate the point values of some function.

The essence of the least squares method. Let x – set

$f_i(x), i = 1 \dots n, m > n$

Where n unknown variables (parameters), m- the set of functions from this set of variables. The task is to select values of x so that the values of these functions are as close as possible to some values. It is essentially a "solution" to the redefined system of equations, in the specified sense of maximum proximity of the left and right parts of the system. The essence of MNK is to choose as a "measure of proximity" the sum of squares of deviations of left and right parts. Thus, the essence of the MNC can be expressed as follows:

$$\sum_i e_i^2 = \sum_i (y_i - f_i(x))^2 \to min$$

In case the system of equations has a solution, the smallest value of the sum of squares will be zero, and exact solutions of the system of equations can be found analytically or, for example, by various numerical optimization methods. If the system is redefined, that is to say, the number of independent equations is greater than the number of variables sought, the system has no exact solution and the least squares method allows to find some "optimal vector" x in the sense of the maximum proximity of vectors y and f (x) or the maximum proximity of the deviation vector to zero. Using the MNK method and from the values of the tables it is possible to judge that all signs of participants on experience have a functional dependence.

V. EXPERIMENTAL RESULTS

To detect functional dependence, the program of finding a kind of function, compiled by the authors, was used and the following results were obtained:(Ni; pH)Ni(g/l)=297 pH(g/l)+58,26(g/l)

$$(\text{Cu; pH})\ Cu\left(\frac{g}{l}\right) = 150.4 - \frac{7.34}{\text{PH}}\left(\frac{g}{l}\right)$$

$$(\text{Zn; pH})\ Zn\left(\frac{g}{l}\right) = 890\text{PH}\left(\frac{g}{l}\right) - 20.8\left(\frac{g}{l}\right)$$

$$(\text{Fe}^{+2};\text{ pH})\text{Fe}^{+2}\left(\frac{g}{l}\right) = 2020\text{PH}\left(\frac{g}{l}\right) - 179.68\left(l\,\frac{g}{l}\right) \quad (2)$$

$$(\text{Fe}^{+3};\text{ pH})\text{Fe}^{+3}\left(\frac{g}{l}\right) = 90\text{PH}\left(\frac{g}{l}\right) + 88.2\left(\frac{g}{l}\right)$$

The graphs of these functional dependencies are shown in the figures (Fig. 1- Fig. 5).

To obtain information on influence of other parameters, we find coefficients of paired correlation using formula (1). The calculation results are shown in Table 3.

Here (Ni; pH) means the functional bond between nickel and ozone. The rest of the expression (2) is clear to the reader.

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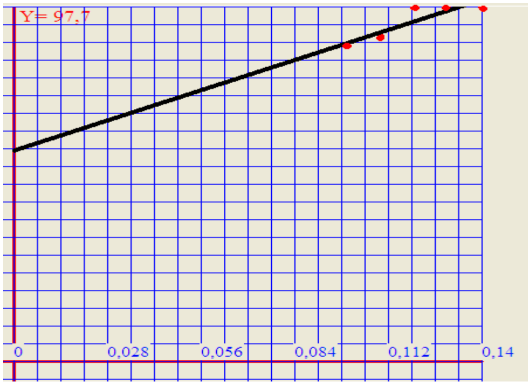
1)


Figure 1.

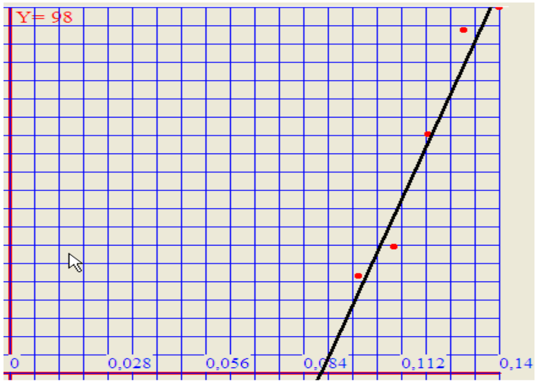
2)


Figure2.

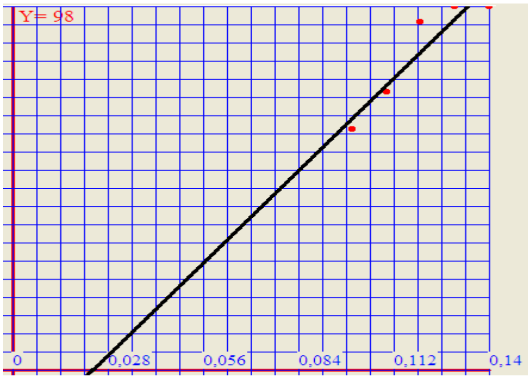
3)


Figure3.

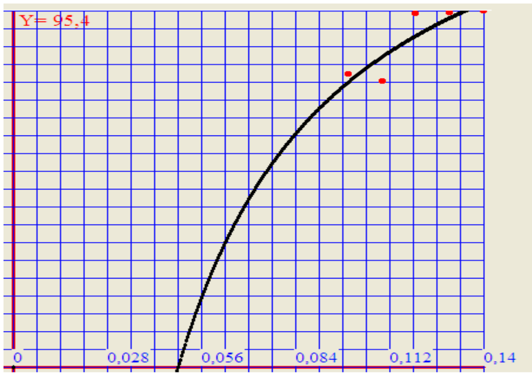
4)


Figure4.

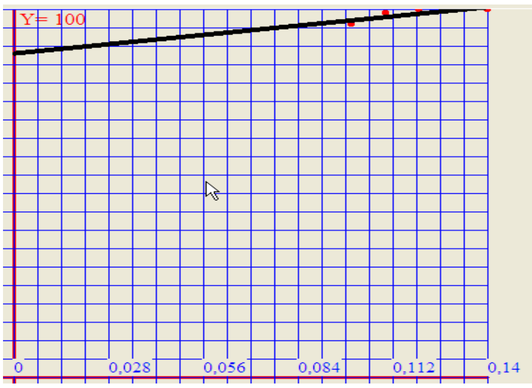


Figure5.

Table3.

	Ni	Cu	Zn	Fe^{-2}	Fe^{-3}
Ni	1	0,968	0,993	0,777	0,889
Cu	0,968	1	0,949	0,915	0,746
Zn	0,993	0,9493	1	0,947	0,907
Fe-2	0,777	0,9153	0,947	1	0,777
Fe-3	0,889	0,7455	0,907	0,777	1

Table 3 shows that the influence of these parameters is closely related and can separate the following groups:
- Ni, Cu, Zn - first group

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- Fe-2, Fe-3 - the second group.

One method of determining the number of groups is to use a standard deviation. It is known that the measure of variation is a variance and the root square of the variance is a standard deviation. In some literature, this indicator is called standard deviation and is defined by the formula:

$$\sigma_j = \sqrt{\sum_{i=1}^{n} \frac{(x_{ij} - \bar{x}_j)^2}{n}} \quad (3)$$

Whire$\bar{x}$ -the average value of the characteristic in the aggregate, which is calculated by the formula:

$$\bar{x}_i = \frac{\sum_{i=1}^{n} x_i}{n}$$

- I-th value of varying feature.

Based on formula (3), the following table of standard deviations is obtained:

Ni	Cu	Zn	Fe^{-2}	Fe^{-3}
2,09819	3,833474	6,046487	13,07945	0,69282

VI. CONCLUSION AND FUTURE WORK

This paper shows that the treatment of waste water with ozone-air mixture increases the degree of purification as the PH concentrate increases. This process is approved by the data in Table 1 of the graphical results in Fig. 1-5.

In addition, a pattern of ozonation for wastewater treatment has been identified, with the aim of raising the form of conservation. It is clear that, according to 5 tests, it is difficult to identify exact functional dependencies of wastewater treatment parameters, but take into account what, expensive equipment for carrying out the experience. We think these are the first steps in this direction. The work was introduced into industry.

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AUTHOR'S BIOGRAPHY

№	Full name place of work, position, academic degree and rank	Photo
1	**Kholikulov Doniyor Bakhtiyorovich**, Deputy Director for Research and Innovation Almalyk branch of the Tashkent state technical university, PhD, associate professor. Uzbekistan, Tashkent region, Almalyk. 110100	
2	**Rahmonkulov Raimkul,** Associate Professor, Department of Technology Engineering, Almalyk branch of the Tashkent state technical university, Almalyk,Uzbekistan