Waste water treatment which passed the stage of aerobic digestion

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Abstract

On the laboratory installation of ozonator studied the conditions of ozone using in wastewater treatment, which passed the stage of aerobic digestion from various organic impurities. To minimize the formation of trihalomethanes and other chlorinated compounds in the wastewater proposed to use the method of ozonation. Preliminary experiments showed that the selected method of oxidative degradation makes it possible to achieve the high quality of water. Results of research made it possible to calculate the technological parameters of the ozonation stage, parameters for calculating the performance of ozonator, power of energy rig and the size of ozonator chamber.

Аннотация

На лабораторной установке озонирования изучены условия применения окислителя для очистки сточных вод, которые прошли стадию аэробного сбраживания, от различных органических примесей. Возможная замена стадии хлорирования на стадию озонирования предотвратит образование хлорированных соединений в сточных водах, сбрасываемых в водоемы. Предварительные эксперименты по озонированию сточных вод показали, что выбранный способ окислительной деструкции позволяет достичь высокого качества воды. Произведены расчеты технологических параметров стадии озонирования; по параметрам выбраны: производительность озонатора, мощность энергетической установки и размеры камеры озонирования.

Keywords: ozonation, aerobic digestion, quality of water, organic impurities.

Introduction

On the laboratory installation of ozonator studied the conditions of ozone using in wastewater treatment, which passed the stage of aerobic digestion from various organic impurities.

The process of reducing the amount of organic impurities in the water was carried out using the most active oxidant - ozone-air mixture. Simulation of the purification process of representative samples of industrial water was done on the pilot installation for ozonation, which is presented in the figure 1.

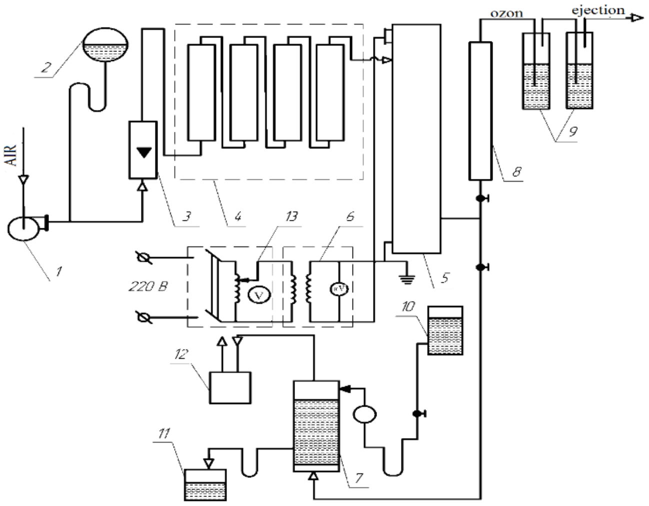

Figure 1 The scheme of installation for ozonation. 1 – compressor; 2 – monostat; 3 – rotameter; 4 – unit for air drying; 5 – ozone generator; 6 – step-up transformer; 7 – column of ozonation; 8 – spectrophotometer; 9 – Drexel glass with a solution of KI; 10 – with solution for cleaning; 11– container with clean solution; 12 – drip pan; 13 – linear autotransformer.

For determining of optimal operation of laboratory installation we investigated the dependence of the productivity of the installation from voltage. Results are shown in the table 1.

Table 1 The dependence of the performance installation from the voltage.

Voltage, kV	**7**	**8**	**9**	**10**	**11**	**12**
Performance of O_3 10^{-2} g/min.	0	0,58	2,5	4,8	7,7	7,4

For determining the ozone in the gaseous phase was used the iodometric method. Measurement and control of ozone concentration was carried out outlet of the ozone generator and output of the contact column of ozonation. The results of analysis are shown in the figure 2.

For the purpose of simplify the method of determining the ozone in the gas phase, reduction the detection time, improving the accuracy of analysis, automation of control method was used the method of spectrophotometry. Was built the calibration graph for determination of ozone in the gas phase on the spectrophotometer SF-45 by correlating the results of determining of the optical density of the gas mixture and the actual content of ozone, which was determined by iodometric method. For the construction of the calibration graph the ozone - air mixture from the ozonizer was sent to the gas cuvette of spectrophotometer, and then passed through the vessels of Drexel which prepared for the research the ozone content by iodometric method. Samples were collected outlet of ozonator with constant mode at different air flow rates. At the same time measured the optical density of the gas flow at the wavelength of 254 nm.

The results of the definitions are shown in the table 2. From the obtained data was constructed the calibration graph which used in the research for determining the concentration of ozone in the gas phase by optical density.

Table 2 Dependence the concentration of ozone from the air flow.

№	Rotameter showing	The optical density of the gaseous mixture, nm	The volume 0,1 N $Na_2S_2O_3$, that gone to titration, ml	The ozone concentration in the gas phase , % vol.
1	0	680	3,6	0,29
2	10	650	4,0	0,212
3	20	610	4,7	0,145
4	40	595	5,0	0,118
5	60	575	5,25	0,075
6	80	505	5,3	0,06

Representative sample of water after aeration tanks and irrigation fields contains in its composition some organic impurities because of incomplete aerobic fermentation. To minimize the formation of trihalomethanes and other chlorinated compounds proposed to use the method of ozonation. Preliminary experiments showed that the selected method of oxidative degradation makes it possible to achieve the high quality of water. Decreasing the amount of organic contaminants in the working solution is easily achieved by single-stage ozonation.

The main indicators of ozonation process are the following factors:

1. The specific ozone consumption (g/m^3 of solution).
2. The contact time of the liquid and gas phases which are necessary for color reduction or COD reduction to the predetermined level.
3. Effect of pH on the time of ozonation and ozone consumption.
4. Effect of temperature on the bleaching solution and COD.
5. Kinetics the color change of the solution and COD reduction of solutions (the kinetics of oxidation reactions of organic compounds was not studied).
6. The coefficient of ozon using.
7. The amount of residual ozone in the liquid phase by varying the contact time (testing the possibility liquid-phase oxidation by bypass).

Methods of carrying out of experiments of ozonation the working solutions consisted of the following steps:

1) preparation the installation of ozonation for launch, sorbent regeneration from the water vapor;
2) preliminary work of ozonators for output the discharge tubes to mode;
3) adjusting the parameters of gas supply, stabilization of the ozone content in the gas stream, determining the concentration of ozone, ejection the ozone into the atmosphere is made by the bypass line to the atmosphere;
4) Connection the mixer in the ozonation column. There is a sample of the solution (the volume of the sample of ozonation is 250 ml). The value of volume of the sample is related to performance of the laboratory ozone generator and with the need (While studying the kinetics of bleaching solution and reducing COD) to eliminate the influence of diffusion processes of dissolution of ozone. While studying the kinetics of ozonation in the stationary conditions (expenditures of the liquid and gas phase are constant) establishment of expenditure of the liquid phase carried out in parallel with stage 3, depending on the expenditure of the gas phase.

5) determination of kinetic parameters is performed by measuring the concentration of ozone in the gaseous and liquid phases, by the response function of the ozonation column; measured by the speed of change the optical density of ozone while keeping constant the flow rates of the liquid and gaseous phases, the temperature in the an ozone generator, tension of high-voltage electrode, ozone concentration at the inlet of reactor.

The described technique of ozonization not different from known methods of studying the kinetics of ozonolysis, where the main parameters are changing the concentration of O_3 in the gaseous phase at the outlet of the reactor. The kinetic parameters of discoloration the liquid phase were determined by the changing the optical density of ozonated solution in the visible region of the spectrum (transparent for ozone).

To monitoring the changes in the amount of the organic impurities selected the change in the degree of cleaning solution by chemical oxygen demand (COD). COD was determined by dichromate method.

Preliminary experiments of ozonation of solutions found that for preventing the diffusion effects in the studies of kinetics of discoloration and reduction the COD for the liquid phase volume of 250 ml volumetric rate of gas flow is 7,7g / min. Specific consumption of ozone which was used for bleaching and absorption determined by the integral method, by calculation the equation of the material balance. Considering that bleaching for any class of organic compounds is the act of breaking one of ties in the molecule. Gross reaction of ozone - mixture of organic compounds can be considered as a first-order reaction (by ozone), based on this the kinetics of the bleaching phenomenon should be comply with the exponential function, which corresponds to the reaction of the 2nd order.

To eliminate the effects of various mineral impurities, accurate determination of the necessary parameters of ozonation, and above all the dose of ozone and the time of contact of phases, previous experiments were carried out on the model solutions, which contained some organic compounds with concentration of COD in the range of 150 - 220 mg/L.

1. To determine the dose of ozone (Do_3) constructed the graphical dependence of ozone concentration at the inlet and outlet of the ozonator ($CO_3 = f(\tau)$) from the time of handling the solution. A dose of ozone which is necessary for complete cleaning the sample of solution, defined as the difference between the amount of ozone, which was filed on the handling of solution in an amount of not absorbed ozon.

Graphical integration depending $Do_3 = f(\tau 0, \tau)$, on the figure 2, determined the area which corresponds to the unit costs of ozone. After scaling the values of the area and the graphical integration were identified the real unit costs of oxidant. Calculated Do_3 is 4,44.10-3 g/ml.

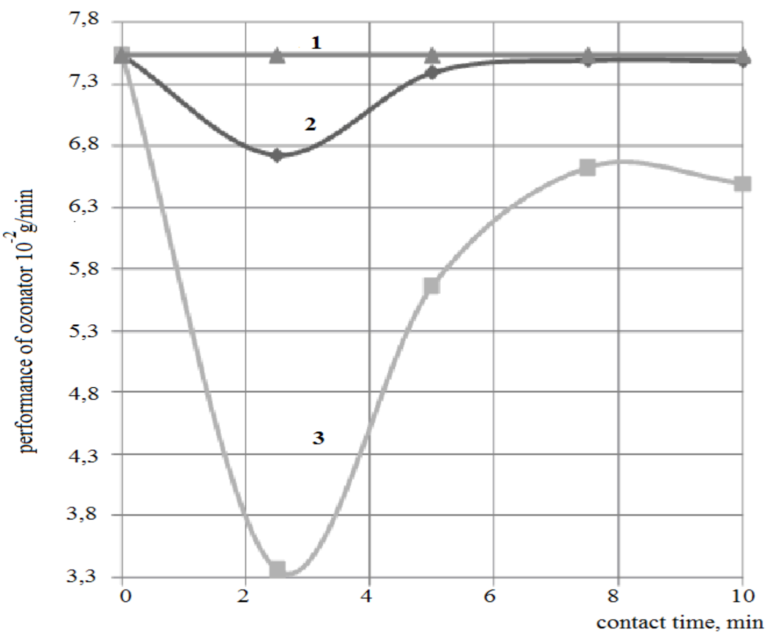

Figure 2 The dependence of the amount of ozone which is absorbed from time.
1 – O_3 content in the ozone - air mixture inlet of the bubbling apparatus,
2 – change the concentration of O_3 during processing of distilled water,
3 – change the concentration of O_3 during processing of waste water.

2. Investigated the dependence of the COD from the dose of ozone, the height of the liquid layer, the concentration of ozone in the initial ozone - air mixture, time of ozonation. Experimental data are presented in table 3.

Table 3 Experimental data of changing the value of COD from the time of ozonation

№	COD, mg O_2/L	The height of the liquid layer, cm	C of ozon, % об	The time of ozonation, min	
	before ozonation	after ozonation			
1	150	125	100	0,075	10
2	150	85	100	0,075	30
3	150	65	100	0,075	60
4	150	110	100	0,212	10
5	150	65	100	0,212	30
6	150	35	100	0,212	60
7	150	90	100	0,29	10
8	150	30	100	0,29	30
9	150	30	100	0,29	60
10	150	145	10	0,29	10
11	150	135	10	0,29	30
12	150	120	10	0,29	60
13	150	115	50	0,29	10
14	150	75	50	0,29	30
15	150	55	50	0,29	60
16	150	90	100	0,29	10
17	150	35	100	0,29	30
18	150	30	100	0,29	60

Relevant depending of changes the COD during the ozonation of solutions are shown in the figure 3.

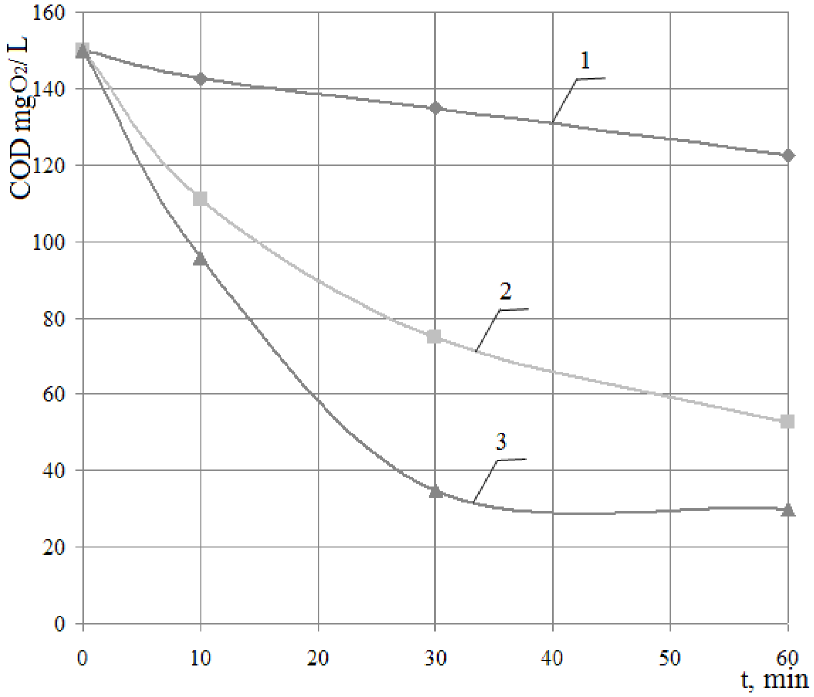

Figure 3 Dependence the COD from the concentration of ozone in the ozone - air mixture, % vol.: 1 - 0,075; 2 - 0,212; 3 - 0,29 .

The initial value of COD is 150 mg/L.

For further studies chosen C of ozon is 0.29 % vol. as the optimal mode of operation of industrial ozonators.

To determine the dose of ozone were calculated the settlements with integrating the area of the total costs of ozone - the dependence g1 = f (δ); the actual costs of ozone considering height of the liquid layer $g_i = f_i (\tau)$. Graphical integration carried out with using the standard program of Microsoft Office Excel 2003, distributed with the operating system.

3. To determine the extent of absorption, the real amount of ozone, that has gone to the oxidation of organic matter (according to experience) constructed the response functions of ozone reactors (figure 5). Dependence corresponds to the line 1, which corresponds the concentration of ozone at the inlet of ozonator - contact bubble chamber at the initial concentration of ozone in the ozone - air mixture of 0.29%. Line 2 obtained by ozonization the solution (1560 ml), which corresponds to the height of the bubble layer of 10 cm. Line 3 obtained by ozonization the solution (1580 ml), which corresponds to the height of the bubble layer of 30 cm. Line 4 obtained by ozonization the solution (1500 ml), which corresponds to the height of the bubble layer of 100 cm. The main difficulty of this research was the careful selection of glass tubes. The equation of the reaction volumes and selection the height achieved by introducing into the reaction zone of thin tubes which were sealed at the bottom.

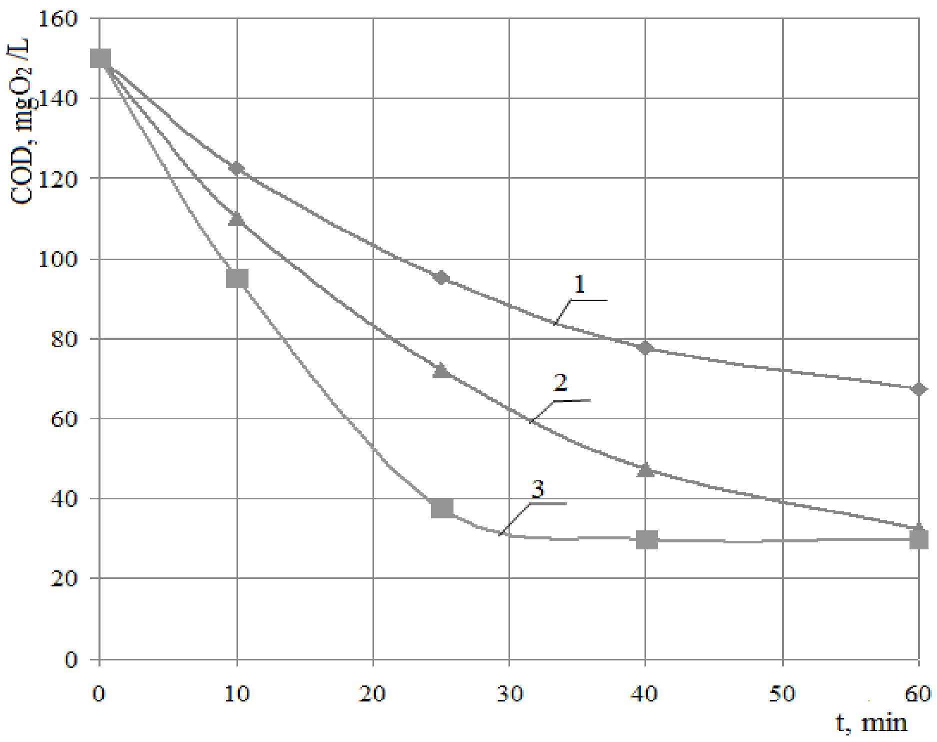

Figure 4 Dependence the COD doring the ozonation the solutions from the height of the liquid layer, mm: 1 - 100; 2 - 500; 3 - 1000 (the system of g - g).

The concentration of ozone in the ozone - air mixture is 0.29%.

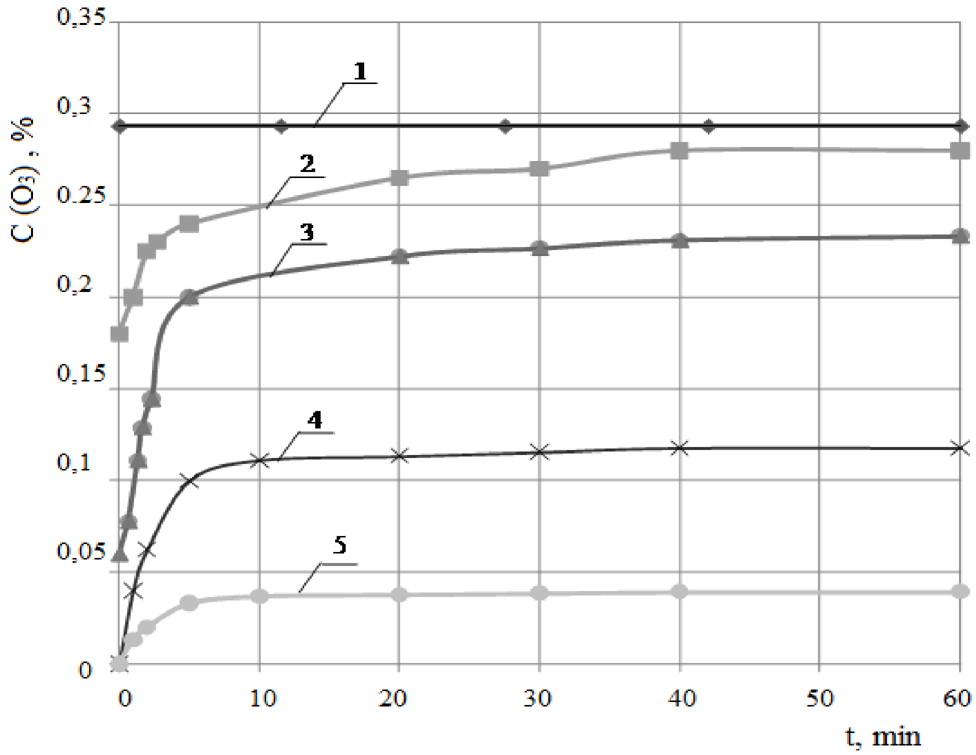

Figure 5 The influence of the height of the liquid layer to the degree of ozone using.
1 - ozone concentration at the inlet of the reaction zone; 2 - 5 - ozone concentration at the outlet at the layer height, mm: 2 - 100 (g-g); 3 - 300 (g-g); 4 - 1000 (g-g); 5 - 1000 (g-l-g);

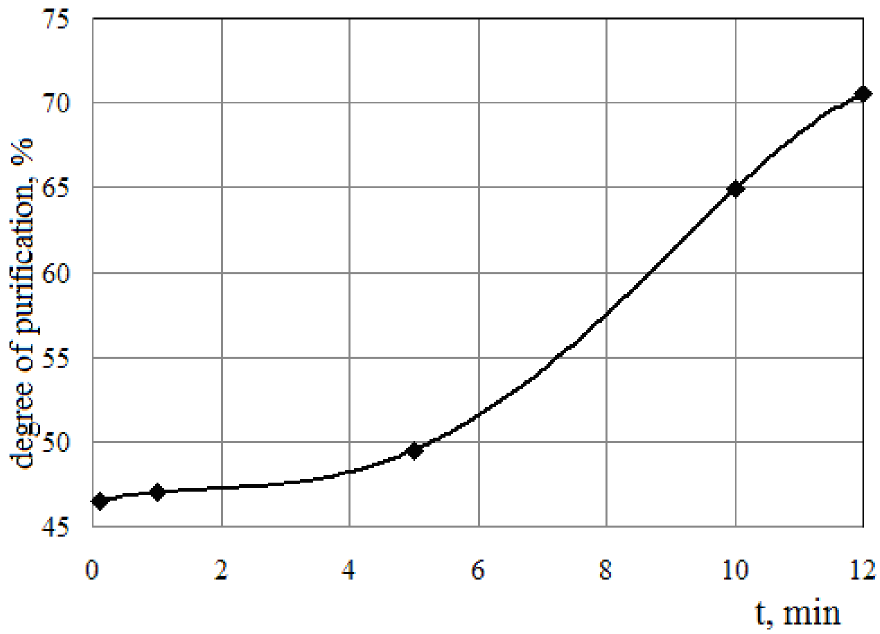

Figure 6 Dependence the degree of purification from the treatment time of working solution (by change the COD).

4. The results in the figure 5 which shows the actual amount of consumed ozone from the height of the liquid layer. Thus for the decomposition and oxidation of high-molecular compounds need the high dose of ozone, 3.5-3.8 g/L of solution.

5. Results of research made it possible to calculate the technological parameters of the ozonation stage, parameters for calculating the performance of ozonator, power of energy rig and the size of ozonator chamber.

Conclusions

1. It was found that to achieve the desired quality of water should be used a method of oxidative degradation.
2. It was determined that best results are achieved at the optimal dose of ozone of 3.5 - 3.8 mg/L.
3. Reduction of COD after processing solutions reaches 70.5% at the time of ozonation of 12 min, the concentration of ozone in the ozone - air mixture is 0.29% vol. at the height of the aqueous layer of ozonation is more than 1 meter.

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