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REASONABILITY OF PRELIMINARY CAVITATION TREATMENT APPLICATION OF SOLUTIONS IN ADSORPTION PROCESSES

Available methods of disinfection of milk-processing industries wastewater have been analyzed. The possibility to apply hydrodynamic cavitation modules at the stage of adsorption finish disinfection has been proposed. Experimental results, which testify the reasonability of its effectiveness, have been obtained.

Key words: disinfection wastewater, cavitation modules, adsorption.

Проаналізовано доступні методи дезінфекції стічних вод молокопереробних підприємств. Запропоновано можливість застосування гідродинамічних кавітаційних модулів на стадії адсорбції фінішної дезінфекції. Отримані експериментальні результати свідчать про його доцільність та ефективність.

Ключові слова: дезінфекція стічних вод, кавітаційні модулі, адсорбція.

Water in food-processing industry is one of the main factors affecting the quality of products in whole that is why the bore well water without additional disinfection is usually used. Whereas, the problem of harmful effect on the environment, caused by the penetration of wastewater in the municipal disinfection network is worth being studied more. Let us analyze the milk-processing industries as an example. Wastewaters of these enterprises are considered to be high-concentration sewage. Because of season nature and great variety of goods produced, composition, quantity and correlation of wastewater in these branch enterprises are unstable (so-called volley throws). It results in sufficient problems of sewage installations operation sewage turning sour, their composition being unstable, causing the decrease of the available disinfection systems effectiveness. Substances, which do not oxidize easily, make the processes of biological purification more complicated and having penetrated into water affect harmfully the environment.

It should be stressed, that in average while processing 1 ton of milk about 5 tons of wastewater is obtained. It is obtained from rinsing and disinfection of the processing equipment and pipes, shops tidying up and accident leakage of milk products and buttermilk (90%). Such wastewater is the most polluted. Its composition includes protein substances, fat parts, lactose, detergents, oil products, which can be brought from maintenance stations. Application of new dye-stuffs, preservation substances, thickeners, flavours and new synthetic detergents results in appearance of new pollution substances in the sewage composition. Appearance of buttermilk is of special danger, as it causes the destruction of useful microflora, increase of nitrogen and phosphorus, which causes sharp growth of harmful microflora, which results in the destruction of active silt at the stage of biological purification.

Mechanical, physical-chemical and biological methods are conventional for disinfection of such wastewater. Technological disinfection scheme includes sediment installations, «averaging» tank, fat catcher, aerators and areas with active silt [1]. Chemical methods, improved by coagulators and floculators, make possible to eliminate small-dispersion and suspended substances from wastewater. But the effectiveness of such purification depends on the kind of colloid particles, their concentration and dispersion, availability of other contamination. The cost of reagents and operation expenditures are worth being taken into account too. Application of technology for biological purification of untreated or partially treated sewages does not always provide sufficient level of purification. The method takes much time and great space for the silt areas. The measures presented above are often the source of the streptococci and

intestine bacilli in particular, that is why among the problems of sewage purification special attention must be paid to the disinfection of them.

Promising methods of treatment milk-processing industry wastewater are those of electrocoagulation with the further sediment or electroflotation, physical-chemical and bio-chemical methods. Ultrafiltration is of special attention. Application of filtration finish purification and ultra-violet treatment provide standard data. At the same time application of the presented methods is favorable from the economic point of view that is why the need to look for new technologies of purification and improvement of the available ones is up-to-date.

It is known that after bio-chemical and chemical purification adsorption methods are used, which make possible to eliminate substances, which are toxic or are not subject to biological decomposition. The advantages are their high effectiveness and possibility of wastewater disinfection from some substances simultaneously. To provide disinfection different artificial and natural porous materials are used: silico-gels, aluminum-gels, clay, ash, slag, wood-wastes, peat, etc. The most effective among them is activated charcoal.

Application of the hydrodynamic cavitation treatment of wastewater at the stage of finish disinfection is promising from the point of view of this technology improvement. During cavitation treatment intense water molecule dissociation in highly active Y+ and OH- with their further recombination is observed in the working areas, hydrogen peroxide and active oxygen being formed [2]. The experiments testified the disinfection action of the cavitation effects [3].

Water being treated by cavitation is thought to be chemically processed by the substantial number of monomeric molecules, free radicals – atoms and atom groups with unpaired electron. Such active particles are attracted to the positive pole of the hydrogen dipole moment. It results in the increase of its activity with the further break of so-called hydrogen bonds (the later appear between opposite poles of neighboring dipoles and thanks to it associations of water molecules are formed, they are likely “to sew together”). Thus, water treated by cavitation looses its space structure, its dipoles being free and more active.

It had been investigated, that during cavitation treatment of water its principle physical-chemical properties change: electroconductivity, viscosity, surface tension [4]. When the viscosity decreases, the coefficients of the inside diffusion increase, and the change of the liquid structure (clusters and hydrogen bonds breaking) improves the mobility of the diluent elements near the surface of the solid phase and inside its pores. It is of great importance for such processes as extraction, solution, sorption, because their kinetics depends not only on the hydrodynamic situation in the system, but on the physical-chemical properties of the liquid phase, on its “activity” in particular. In the treatment water the solution of gases increased greatly [5].

Thus, cavitation treatment of water solutions can not help affecting the adsorption process of the contamination substances both organic and inorganic. In the papers [6] the authors stress, that the active water molecules wrap the microelements ions and molecules of other soluble substances and transfer them better, the adsorbent itself causing increase of its activity. It is testified by the previous results obtained thanks to the preliminary treatment of the water solution $Ni(NO_3)_2$ in the hydrodynamic cavitation installation and further adsorption purification through the zeolite layer. Increase of the nickel ions elimination more than by 14% as compared with the untreated solution has been investigated [7].

Reasonability of the preliminary cavitation treatment of wastewater was estimated according to COD factor, which is the characteristic of the milk-processing industry. This factor specified the amount of oxygen used while chemical oxidation of the organic substances, which are in water before inorganic products under the action of strong oxidants. Such oxidants include chlorine, dioxide chloride, ozone, etc. But sufficient disadvantages of such measures are their high cost and possibility to obtain harmful recombination products (chlorine-picryn, dioxin). Application of the cavitation treatment of water in order to investigate COD change is reasonable.

To carry out investigations the model solution of water and milk was used. Experiments were conducted on the static-type stand, which is of circular profile and includes the centrifugal pump, hydrodynamic cavitation module, capacity pipeline fitting, measuring devices [8]. Cavitation module is made as the Venturi-type tube, on the inlet of which movable obstacle is mounted in the form of truncated

cone, which can move in counter-progressive direction. In the outlet areas of the module flow equalizer is mounted. The module is made of fluorine plastic and organic glass, which make possible to watch the process in the working area. COD analyses was carried out according to the conventional method [9].
Results of investigations on the treatment of model solutions of water and milk are presented in Fig.1.

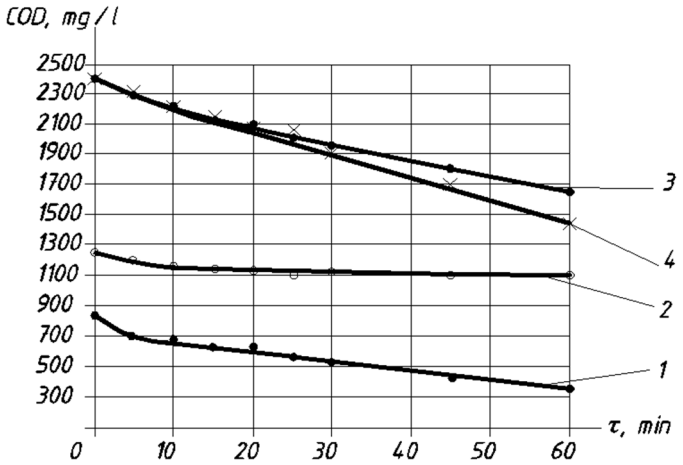

Fig.1. Change of COD model solution water + milk: 1 – COD_0=815 mg/l, gap value between the cone and body δ=1 mm, pressure in inlet p=0,3 MPa; 2 – COD_0=1250 mg/l, gap value between the cone and body δ=1 mm, pressure in inlet p=0,3MPa; 3 – COD_0=2400 mg/l, gap value between the cone and body δ=2 mm, pressure in inlet p=0,3 MPa; 4 – COD_0=2400 mg/l, gap value between the cone and body δ=2 mm, pressure in inlet p=0,4 MPa

As it is seen from Fig.1, COD decreases, which testified the initiation of oxidation processes by physical-chemical cavitation effects. To compare the process kinetics during the treatment of the model solution with the other methods similar to the equations of the chemical reactions kinetics the sequence of the oxidation reaction and the speed constant were found. The conventional method is based on the results of the equation integration $r = \frac{\partial C}{\partial \tau} = -kC^n$. Provided *n=1:* $C = C_0 \cdot e^{-kt}$,

here C_0– initial concentration, mg/l; C – current concentration, mg/l; τ – time, sec; k – oxidation rate constant, n – reaction sequence; r – reaction rate, mg/l.

Results of calculation are presented in Fig.2.

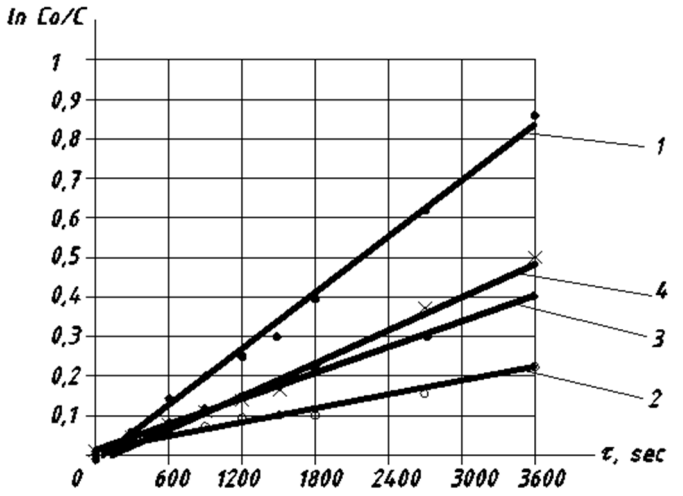

Fig.2. Determination of the reaction sequence and oxidation reaction rate constants of the organic contaminations under different conditions of cavitation treatment: 1 – COD_0=815 mg/l, gap value between the cone and body δ=1 mm, pressure in inlet p=0,3 MPa; 2 – COD_0=1250 mg/l, gap value between the cone and body δ=1 mm, pressure in inlet p=0,3MPa; 3 – COD_0=2400 mg/l, gap value between the cone and body δ=2 mm, pressure in inlet p=0,3 MPa; 4 – COD_0=2400 mg/l, gap value between the cone and body δ=2 mm, pressure in inlet p=0,4 MPa.

As it is seen from Fig.2 experimental points lay on the straight line. It testified the first order of the organic oxidation reaction during the cavitation treatment of the solution. The value of the process rate constants was found according to the straight line inclination angle tangent.

Table 1

Oxidation rate constants

Treatment conditions	Constant value, *k*, sec^{-1}	Equation appearance
COD_0=815 mg/l, gap value between the cone and body δ=1 mm, pressure in inlet p=0,3 MPa	$k=2{,}33*10^{-4}$	$C = C_0 \cdot e^{-0.000233t}$
COD_0=1250 mg/l, gap value between the cone and body δ=1 mm, pressure in inlet p=0,3MPa	$k=5*10^{-4}$	$C = C_0 \cdot e^{-0.0005t}$
COD_0=2400 mg/l, gap value between the cone and body δ=2 mm, pressure in inlet p=0,3 MPa	$k= 1*10^{-4}$	$C = C_0 \cdot e^{-0.0001t}$
COD_0=2400 mg/l, gap value between the cone and body δ=2 mm, pressure in inlet p=0,4 MPa	$k=1{,}33*10^{-4}$	$C = C_0 \cdot e^{-0.000133t}$

The next stage of investigations was the comparison of kinetics of the organic compounds elimination from the solutions by adsorption and comparison of results after using their preliminary cavitation treatment and without it.

On Table 2 results of COD change in the model solutions after their adsorption finish purification under usual conditions and under preliminary treatment in the hydrodynamic cavitation module are presented.

Table 2

Results of COD change in the model solution during adsorption finish purification.

τ, min	0	30	60	120	180
COD, mg/l	380	316	232	164	122
COD*, mg/l	386	300	204	144	104

* – solution is preliminary treated in the hydrodynamic cavitation module

As the analysis of results presented on Table 2 testified, the hydrodynamic cavitation treatment of water solutions at the preliminary stage of their adsorption finish purification is worthy being treated as reasonable from the point of view of the process effectiveness increase, because COD value are less as compared with similar ones according to the determined treatment time.

Thus, the carried out experimental investigations testified the initiation of the oxidation process of organic substances in solutions under the influence of cavitation effects, which is testified by the COD decrease in time o their treatment in the circular profile of hydrodynamic type. Mathematic summarizing of this data make possible to calculate the organic compounds oxidation rate constants in the model solution (water + milk). At the same time preliminary positive kinetics data on elimination of organic compounds from the solution, taking advantage of adsorbent needs further sufficient investigation.

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COMBINED SOLAR COLLECTOR

In this article was analyzing the efficiency of the combined solar collector for heating buildings. This enhances the efficiency of solar system by increasing the area of the absorption of solar energy. There are describes the results of the research on solar radiation input on a combined solar collector.

Key words: combined solar collector, solar radiation, solar heating supply.

Проаналізовано ефективність використання комбінованого сонячного колектора для теплопостачання будівель. Він забезпечує підвищення ефективності геліосистеми за рахунок збільшення площі поглинання сонячної енергії. Описано результати досліджень надходження сонячного випромінювання на комбінований сонячний колектор.

Ключові слова: комбінований сонячний колектор, сонячне випромінювання, геліосистема.

Introduction

The issues related to the future ways of energy development escalate more and more every year. On the one hand, the population growth, the desire to improve the living standards of people dictate the expediency of accumulation of energy capacity, moreover, on gigantic rates, on the other hand, the environmental problems arising, exhaustion of natural sources of raw materials, and, above all, oil and gas, require more economic and efficient use of the energy obtained. Fuel and energy resources become more expensive every year both for the industry, and for the population.

Therefore there is a need to implement complex measures on the use of new alternative energy sources. The solution of this problem requires significant changes in the global energy balance. An alternative in this field is the use energy of the sun. It is completely free for the mankind and given to us in virtually unlimited quantities.

Formulation of the problem

Using solar energy is sufficiently promising to improve the environmental situation, reducing costs of fossil fuels, and for domestic and process needs. The annual amount of solar energy by almost 15 000 times higher than the needs of the world's population. To date, it is important to improve and develop new