

Creation Of A Highly Efficient Technology For Mixing Ozone With Water For The Preparation Of Drinking Water From A Reservoir

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Abstract

The article discusses the features of mixing ozone with treated water, directly in the technological pipeline. In connection with the significant volumes of water consumption in the interests of economic activity, the issue of disinfection of drinking water is acute. Along with traditional methods of disinfection, considerable attention of modern researchers is focused on the development of innovative technologies for this process. These include the technology of mixing the ozone-air mixture with treated water directly in the technological pipeline. The features of the formation and qualitative composition of the water of the Charvak reservoir were studied with an analysis of the reliability of the existing technology for the preparation of drinking water. The effect of ozone on the physical and chemical parameters of water taken from the reservoir was studied.

The article discusses the process of disinfection of drinking water with ozone directly in the technological pipeline. A description is given of a model plant for disinfecting drinking water with ozone directly in the technological pipeline. The results of experimental studies on identifying the dependence of the degree of liquid disinfection with the help of ozone are presented.

It has been established that the intensification of the process of ozone dissolution in water due to swirling flow is considered as the most economical and promising way to achieve 95-99% percent of ozone use.

As a result of the study, a processing mode was determined that provides the smallest amount of ozone with maximum disinfection efficiency.

Key words: ozonation, mixing, reservoir, the mode of treatment, disinfection efficiency, technological pipeline, swirling flow.

Introduction. In recent years, in our country and abroad, research has been carried out to study and implement the dispersion of the ozone-air mixture directly in the technological pipeline using static mixers [1-3-26-27-28]. Static mixers are compact and have high mass transfer coefficients. Gas-liquid mixing is carried out by creating an intense swirl of the liquid and gas flow by using the kinetic energy of the liquid. Intensive swirling of the flow in static mixers is associated with the creation of a rotational movement of the liquid in certain sections of the pipeline located behind the mixer. The action of such devices is based on the use of the energy of the flow of mixed media to create high local shear stresses.

The intensification of the process of ozone dissolution in water due to swirling flow is considered as the most economical and promising way to achieve 95-99 percent of ozone use.

The preference for one or another method of mixing ozone with water is justified in each specific case by economic calculations, and also depends on the purpose of ozonation. For example, to promote the process of coagulation or disinfection, it is known that different doses of ozone and the duration of contact of the ozone-air mixture with water are required, which determines the choice of one or another mixing method.

Currently, in the vast majority of cases, purification and disinfection of drinking water is carried out using coagulation, chlorination at the initial and final stages of purification. However, wastewater discharges from cities

and industrial enterprises have led to serious changes in the qualitative composition of water in water supply sources. The appearance in its composition of products, surface-active substances (surfactants), oil products, phenols, ions, heavy metals, etc. does not allow the existing treatment facilities to perform a barrier role in their removal. In addition, as a result of treatment of water from surface sources with chlorine, volatile halogen-containing compounds (VHCs) are usually formed and trihalomethanes (THMs) in their composition, which are toxic and carcinogenic substances.

In this regard, the scientific and technical task of developing a technology for obtaining high-quality drinking water is of great national economic importance.

In recent years, many research institutes working in the field of water treatment have developed new technological processes and methods for treating drinking water, providing water with a high degree of sanitary reliability. One of the methods to improve the quality of water treatment at waterworks is water ozonation.

The first pilot plant for water ozonation was built at the end of the last century in Paris. In Russia, in 1911, the world's largest industrial ozonation plant was put into operation at a filter station in St. Petersburg with a capacity of 44.5 thousand m³/day. Subsequently, water ozonation became widespread in France, the USA and a number of other countries.

The improvement and modernization of existing ozonizers in order to increase the reliability of their work, as well as the development of high-capacity ozonator equipment, is being carried out by the Dzerzhinsky branch of LenNIIkhim mash and Kurganarmkhim mash Product Association.

In recent years, the Dzerzhinsky branch of LenNIIkhim mash has modernized the following equipment: since 1989, the ozonator OP I2I has been replaced by a monoblock sample V24-25-IL-0I. Technical performance indicators have been significantly improved, including - specific energy consumption has been reduced from 22.5 kW to 15.6 kW per 1 kg of ozone; water consumption reduced by 2 m³/h; the pressure of the ozone-air mixture was increased to 1.6 kgf/cm². The PT 510 ozonator is supposed to be replaced by the V-175-165-OIL-O1 type from 1991. The Ozon-2M ozonizer has been replaced since 1989 by a new model V-085-08-1L-01. These types of ozonizers operate at industrial frequency.

The development of ozonation modules for 15 and 30 kg of ozone per hour, operating at higher frequencies (up to 1000 Hz), is at the final stage.

At present, in Russia, ozone is used in the technology of natural water purification at large water treatment plants in Moscow, St. Petersburg, Nizhny Novgorod, Novosibirsk and other cities.

Abroad, a large number of ozonator installations are available in France, Russia, the USA, Japan, Switzerland, Germany, England, etc.

In various literary sources [1-3-29-37], water ozonation is often considered only as one of the methods of disinfection that does not have the disadvantages inherent in other methods of water disinfection. In accordance with this point of view, the intended purpose of ozonation is limited only by its abiotic effect. Meanwhile, ozone, due to its oxidizing ability, guarantees not only fast and reliable sterilization, but also provides effective oxidation of organic substances, improving the organoleptic properties of water. In Uzbekistan, ozonized drinking water has not yet been adopted to provide large settlements. Used in some holiday homes and children's health and sports camps

Ozone is known to be one of the strongest oxidizers [3]. In terms of its oxidizing power, ozone is second only to fluorine [2-31].

From an economic point of view, the introduction of ozone as a reagent for water treatment is also profitable [7-12-30]. So, at doses of ozone of 4-6 mg/l, ozonation is advisable not only from the point of obtaining a high effect of water treatment, but also in technical and economic terms.

An analysis of the available materials shows that at present there are no clearly developed recommendations on the use of ozone in water treatment processes. However, the enormous possibilities of ozone in water purification processes and its great impact on the aquatic environment are increasingly attracting specialists to new research and searches for reliable methods of natural water treatment.

It is known that phyto- and zooplankton contained in natural water significantly affect the operation of water treatment facilities.

Literature data show that fouling biocenoses can be used as an additional structure for preliminary water treatment [6-8]. On the active surfaces of this structure, finer dispersed particles, substances dissolved in water and microorganisms are captured. The latter, which have begun to develop in fouling, will, in turn, retain substances dissolved in water, using them for their exchange.

The mixing of the ozone-air mixture with water plays an important role in the ozonation process [9-11-32-33]. In the practice of ozonation, there is a wide variety of methods for mixing ozone with water [9-26-34]. At large water supply and sewerage stations, bubbling and emulsifying mixing methods are widely used [11-13].

As a result of considering the existing methods for introducing ozone into treated water, the designs of apparatus for mixing ozone with water, a direction was identified that turned out to be promising, especially for stations of low and medium productivity. Such a direction is the treatment of water with ozone in a technological pipeline [23,24,26-35-36].

This article discusses a new technology for water purification using the storage capacity of natural biocenosis, microfiltration and ozonation.

The purpose of the work is to create a highly efficient technology for mixing ozone with water to prepare drinking water from a reservoir.

To achieve this goal, the following tasks were solved:

- the features of the formation and qualitative composition of the water of the Charvak reservoir were studied with an analysis of the reliability of the existing technology for the preparation of drinking water;
- the effect of ozone on the physical and chemical parameters of water taken from the reservoir was studied;
- the mode of water treatment and the minimum dose of coagulant ozone were determined to achieve the standard level of drinking water parameters;
- created and investigated a new design of the apparatus for mixing ozone with water, with the development of a method for its calculation;
- developed and tested in the laboratory various methods for preparing drinking water from the reservoir.

Scientific novelty of the work: - developed a highly efficient technology for the treatment of medium-turbid, low-color natural waters by natural biocenosis, microfiltration, ozonation and filtration, providing drinking water with parameters corresponding to GOST UzDST 950-2011 "Drinking Water";

- a new design of the apparatus for mixing ozone and treated water in the technological pipeline was developed [3];

-theoretical foundations for the calculation of gas-liquid devices built into a technological pipeline have been developed. The optimal parameters of the process of mixing ozone with water - the swirl angle and the length of the mixing path - are experimentally revealed.

Substantiation of the object, subject, tasks and methods of research. This article discusses the design of the apparatus for mixing liquid and gas [3]. The principle of operation of the apparatus is based on the creation of swirl of the flow liquid in order to mix the water and gaseous media during the treatment of natural waters with ozone.

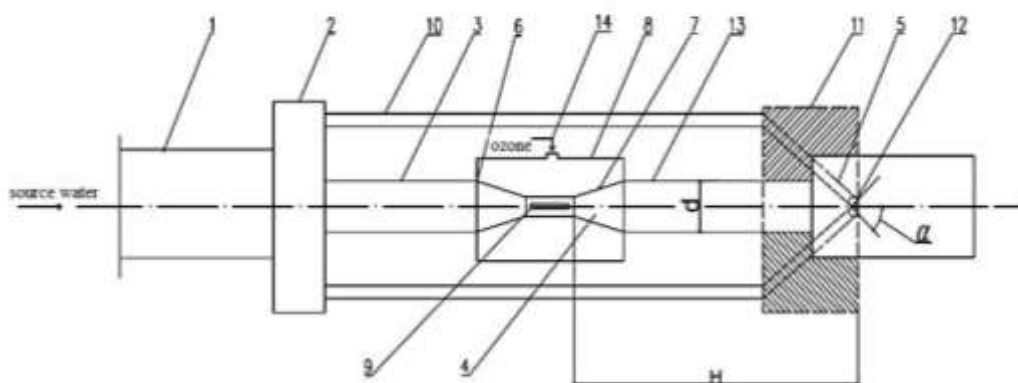


Fig.1. Apparatus for mixing liquids and gases.

1 - pipe $\varnothing 50$ mm; 2 - liquid distributor; 3 - pipe $\varnothing 32$ mm; 4 - I-stage mixing chamber; 5 - mixing chamber II-stage; 6 - confuser; 7 - diffuser; 8 - gas inlet chamber; 9 - slot $\varnothing 2$ mm; 10 - supply pipe $\varnothing 5$ mm; 11 - channel $\varnothing 5$ mm; 12 - holes $\varnothing 5$ mm; 13 - pipe $\varnothing 32$ mm; 14 - branch pipe.

The apparatus, Fig. 1, contains a liquid supply pipeline 1, a liquid distributor 2, a pipeline 3 installed in series on the same axis of the mixing chambers 4.5, the first and second stages, respectively. The chamber 4 of the first stage includes a confuser 6 with a diffuser 7 connected by a branch pipe with slots 9 and surrounded by a gas inlet chamber 8.

The mixing chamber 5 of the second stage is connected by supply pipes 10 to the flow distributor 2. Channels 11 are made in the walls of the mixing chamber 5, connected to the supply pipes 10 and are made along a helical line at an angle of 60-75 degrees to the chamber axis. At the same time, the outlet openings 12 of the channels 11 are located from the inlet opening 13 of the mixing chamber of the first stage at a distance H equal to 2.5-4 of the diameter of the mixing chamber of the first stage. The chamber 8 is equipped with a gas branch pipe 14.

The device works as follows. The liquid is supplied through the pipeline 1 to the distribution flow 2, from where part of it through the supply pipe 10 enters the mixing chamber 5 of the second stage. The main flow of liquid is fed through the pipeline 3 into the chamber 4 of the first stage of mixing. Entering the confuser 6, the liquid through the holes 6 captures the gas coming from the branch pipe 14. In the diffuser 7, the mixture expands, after which the mixture enters the mixing chamber 5 of the second stage, where it is supplied from the liquid distributor 2 through pipes 10 and channels 11. Due to the helical direction channels 11 located at an angle of 60-75 degrees to the axis of the chamber, the flows of the added liquid move into the chamber 5 along a helical path and mix with the gas-water mixture coming from the mixing chamber 4 of the first stage.

The efficiency of an experimental study of swirling flow in pipes depends to a large extent on the choice of the technique for setting up and processing the experiment itself, as well as on the design of the stand. A number of properties of swirling flows manifest themselves in various forms depending on the constructive use of the hydraulic circuit of the experimental setup. Therefore, in order to obtain reliable experimental data, such influences were excluded.

The specific features of the swirling flow of gas-liquid mixtures in pipes, the strong anisotropy of the medium under study, the complexity and variety of flow forms, the large difference in the physical properties of ozone and the water under study, impose certain conditions on the design of the experimental setup.

A specific feature of swirling flows is also the occurrence of flow regions with the active influence of centrifugal body forces on the flow structure, in which the field of body forces contributes to the development of random perturbations or suppresses them.

Thus, the swirling flow is characterized by the presence of flow regions with opposite longitudinal static pressure gradients, negative in the peripheral and positive in the axial zone of the pipe. In this case, in contrast to axial flows, the signs of the velocity and pressure gradients coincide with each other.

Findings. As a result of considering the existing designs of devices for mixing ozone with water, a direction was identified that turned out to be promising, especially for a treatment plant of small and medium productivity. Such direction is the treatment of water with ozone in the technological pipeline. In this regard, a new highly efficient design of an apparatus for mixing an ozone-air mixture with water in a technological pipeline has been developed. Gas-liquid mixing in the developed apparatus is carried out by creating an intense swirl of the liquid and gas flow by using the kinetic energy of the liquid.

The intensification of the process of ozone dissolution in water due to the swirling flow makes it possible to achieve 95-99% percent of ozone use.

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