PLASMA STERILIZER WITH ULTRASONIC CAVITATION

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A sterilizer consists of ozone generator based on a barrier glow discharge with the flat electrodes covered with dielectric with a high-voltage pulsed power supply of up to 250 W [1]. The sterilization camera is equipped with ultrasonic source with the power of 100 W. The experiments on the inactivation of bacteria of the Bacillus Cereus type were carried out in the distilled water saturated by ozone. Ozone concentration in the aqueous solution was 6 mg/liter with ozone concentration at the output of ozone generator 30 mg/liter. The complete inactivation of spores took 15 min.
PACS: 52.77.-j; 42.62.Be

1. INTRODUCTION

Plasma methods are widely applied in different technological areas. For instance, in medicine they can be utilized for sterilization of medical instruments. In contrast to the traditional methods of sterilization (steam, boiling, radiation, gaseous with the application of ethylene and many others), plasma methods possess the new properties, which make it possible to avoid the temperature heating of the workable objects and toxic ingredients. One of the important factors is lower power consumption for sterilization procedures. Taking into account several research works on sterilization in microbiological media [2], it is possible to note that the barrier surface discharge under atmospheric pressure used for ozone generation turned to be a rather effective action which can influence on the row of microorganisms. As one of disadvantages it is possible to note the problems with the insufficient cooling of the electrodes of reactor. We should point out to industrial ozone sterilizer CO -01-P6 (Russia) on the basis of lamellar reactor with the vacuum working chamber. In ref. [3] the dependences of the inactivation of spores Bacillus cereus in ozone by the concentration of 3 mg/l with the relative humidity from 50% to 95% were investigated. In this case, the effectiveness of inactivation grows with an increase in the humidity. But even with 95% of humidity it does not achieve complete destruction. In this case the cycle time of sterilization is measured by hours. In the present work experimental studies on the inactivation of spores Basillus in the water with different concentration of ozone-air flow are carried out. From the literature, the solubility of ozone in the aqueous solutions depends on the specific conditions of conducting the experiment: from the quality of water, its temperature, concentration of the forced ozone-air mixture. In our case the distilled water at room temperature was used. The process of sterilization by ozone is determined by its oxidizing properties and the operation with contaminated medical instrument is rather time-consuming. On the other hand, the methods of ultrasonic cleaning and sterilization of tools also take place. However, in order to obtain the effect of sterilization it is necessary to add into water chemical active additives. In our case, we attempted to combine generation of ozone in the aqueous medium with the ultrasonic cavitations. Thus, it is possible to carry out rough low-temperature cleaning of the surface of medical instrument with the ozone sterilization.

2. EXPERIMENTAL

The functional diagram of sterilizer is presented in Fig.1. Airflow from the compressor was cleaned from the moisture through the filter and get into the ozone reactor. Ozone-air mixture enters mixer (1) where ozone mixes with the water entering from sterilization camera (4) with the help of the specially developed anticorrosive electromagnetic pump. The pressurized water mixed with ozone enters sterilization camera. Worked out ozone is moved away from the camera through destructor (activated carbon) into the atmosphere. Sterilization camera is supplied (5) with ultrasonic generator. The reactor is constructed in the form of flat parallel plates with the dielectric coatings with the pulsed power supply [1].

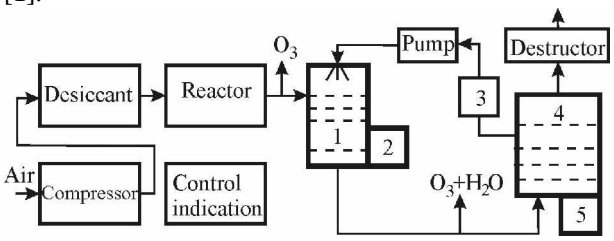

Fig.1. The block diagram of the sterilizer: 1 - mixer, 2 - thermoelectric module, 3 - UV indicator ozone, 4 - sterilization camera, 5 - ultrasonic generator

The basic characteristics of the reactor are presented in Fig.2.

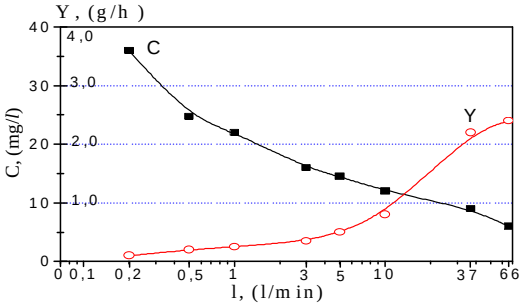

Fig.2. Characteristics of ozone generator with glass enamel dielectric: C –ozone concentration, Y – yield rate, l – air flow rate

When conducting an operating cycle in the sterilization camera it is necessary to obtain concentration in the water not less than 5 mg/l. Taking into account the

volume of sterilization camera, obtaining this concentration is possible with the appropriate output concentration from the output of reactor or with a decrease of the water temperature in the camera. In Fig.3 the results of the solubility of ozone in the distilled water with a volume of 1.5 liters depending on the time of injection and constant (30 mg/l) concentration at the output of reactor are represented.

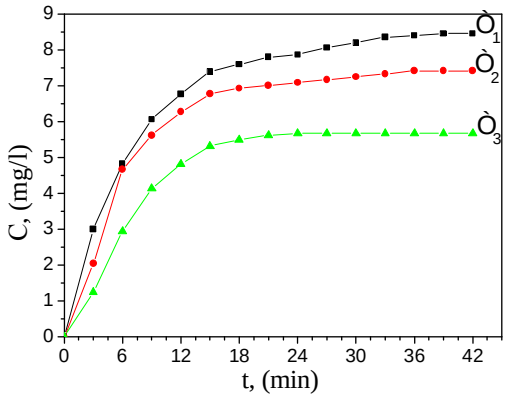

Fig. 3. Solubility of ozone in the distilled water depending on the time; water temperature: 1 - 13º C, 2 - 17.5º C, 3- 24 º C; concentration of ozone-air mixture is constant (30 mg/l)

It is evident from the graph that the water temperature has a great influence on ozone solubility and allows to reach higher ozone concentration at lower temperatures. The similar conclusions can be drawn from the analysis of Fig.4, where it is shown that ozone concentration in the water decreases under a slow increase of the water temperature from 20 to 25° C.

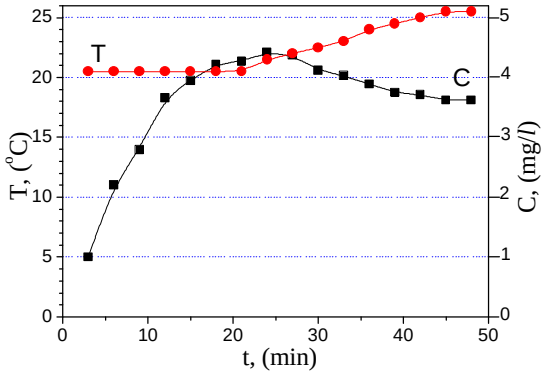

Fig. 4. Dynamics of a change of ozone concentration in the dependence on the water temperature, P = 0,07 atm, U = 300 V, λ = 0,3 l/min

The solubility of ozone in the water depends on the output concentration of reactor (Fig. 5).

In the sterilizer the water-cooling took place in a special mixer. A mixer is 0.5 l - vessel made of the stainless steel, that consists of water sprayer and ozone disperser. For the purpose of the stabilization of the sterilization process and obtaining the necessary water temperature, the mixer is equipped with thermoelectric module. The result of the solubility of ozone in the water with the periodic start of ultrasonic generator and the work of thermoelectric module are shown in Fig. 6.

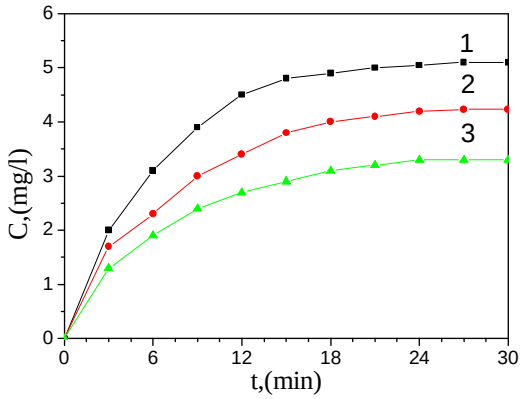

Fig. 5. Solubility of ozone in the distilled water depending on time, with different concentration of ozone at the output of the reactor: 1 – 30 mg/l, 2 – 25 mg/l, 3 – 20 mg/l

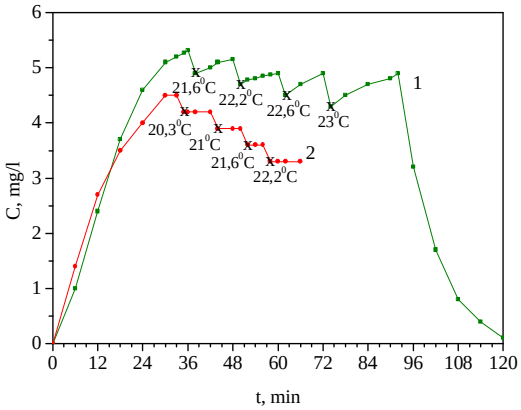

Fig.6. Solubility of ozone in the water with the periodic start of ultrasonic generator. Sterilizations of leaves

3. RESULTS

The table presents the results of the inactivation of spores Bacillus Cereus in the ozonized water with different concentration of ozone at the output of reactor.

№ p/p	C(O3), mg/l reactor	C(O3), mg/l water	Exposure t, min	T°,C water	T°,C air	Method	Result
1	0		30	26	23	US, P=220 Wt	-
2	10	1.5	30	22	23	Ozone +US,P=220 Wt	-
3	11	2	60	20	23	Ozone +US,P=220 Wt	-
4	30	2.3	60	20	18	Ozone +US, P=100 Wt	+
5	30	6.2	180	18	18	Ozone +US, P=15 Wt	+
6	10	2	60	20	23	Ozone	-
7	30	6	20	25	22	Ozone	+
8	30	6	15	25	17,5	Ozone	+
9	25	4.3	30	22	17,5	Ozone	+
10	25	4.3	30	25	22	Ozone	+
11	20	3.8	30	25	17,5	Ozone	+
12	20	3.8	30	25	22	Ozone	+
13	20	3.8	25	25	22	Ozone	+
14	15	3	30	25	17,5	Ozone	+
15	15	3	20	25	22	Ozone	+

The effect of the complete destruction of spores is observed with ozone concentration in the water not less than 3 mg/l. Steady sterilization occurs with the concentration not less than 5 mg/l.

4. CONCLUSIONS

The atmospheric pressure barrier glow discharge with pulse power was adapted for ozone production. Ozone reactor with the flat electrodes and the dielectric coatings from the glass enamel had a value of the output ozone concentration on the order of 30 mg/l with the air flow 0,5 l/min. Sterilization was achieved in the distilled water. Ozone concentration in water is of the order of 6 mg/l. The control of aqueous sterilization was conducted on the cryptogamous Bacillus Cereus. Minimum time for the complete inactivation of spores was 20 min. The process of sterilization was combined with the ultrasonic cavitation - cleaning. Influence on the process of cleaning and sterilization US emitters with power from 10 to 250 W is investigated.

As a result of applying the developed sterilizer the process of the sterilization of medical instrument will obtain the following new preferred properties:

- combination of cleaning and sterilization of the tools;
- sterilization at a low temperature;
- exception of unnecessary chemical compounds;
- improvement in the quality of the sterilization of tool due to the tight control and the stabilization of technological process;
- lightening and convenience in the service personnel;
- reduction of prices of the sterilization process;
- realization of sterilizer on the basis of ultrasonic washing.

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ПЛАЗМЕННЫЙ СТЕРИЛИЗАТОР С УЛЬТРАЗВУКОВОЙ КАВИТАЦИЕЙ

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Разработан озонный генератор на основе барьерного тлеющего разряда с плоскими электродами, покрытыми диэлектриком, с высоковольтным импульсным питанием, мощностью до 250 Вт [1]. Стерилизационная камера оснащена ультразвуковым источником мощностью 100 Вт. Проведены исследования инактивации спор Bacillus Cereus в дистиллированной воде насыщенной озоном. Концентрация озона в водном растворе была 6 мг/л при концентрации озона на выходе озонного генератора 30 мг/л. Полная инактивация спор происходила за время порядка 15 мин.

ПЛАЗМОВИЙ СТЕРИЛІЗАТОР З УЛЬТРАЗВУКОВОЮ КАВІТАЦІЄЮ

В.В. Красний, А.В. Клосовський, Т.А. Панаско, О.М. Швець, О.Т. Семенова, В.С. Таран, В.І. Терешин

Розроблено озонний генератор на основі бар'єрного тліючого розряду з плоскими електродами, покритими діелектриком, з високовольтним імпульсним живленням, потужністю до 250 Вт [1]. Камера стерилізації оснащена ультразвуковим джерелом потужністю 100 Вт. Проведені дослідження інактивації спор Bacillus Cereus у дистильованій воді, насиченій озоном. Концентрація озону у водному розчині була 6 мг/л при концентрації озону на виході озонного генератора 30 мг/л. Повна інактивація спор відбувалась приблизно за 15 хв.