УДК 628.162

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CARBON STEELS CORROSION RESISTANCE TO DISINFECTANTS

The paper presents comparative analysis of the corrosion activity of chlorine bleach and a saturated solution of ozone in water to carbon steels by gravimetric method. Studies were carried out on low carbon steel St37-3 and Ct20 brands. Established that the most corrosion activity of test solutions has saturated solution of ozone in water among chlorine disinfectants – sodium hypochlorite.

Introduction. To reinforce the wellbore walls against cave-in the tubing is made using casing pipes. For this purpose and depending on parameters and function of the wellbore the metallic (galvanized, stainless, enameled), asbestos-cement or polymer (PVC, LPPE) casing pipes are used. These products are subdivided into technical and drinking ones. The casing pipes of PVC are mostly used today when boring water-supply wells. In some situations as alternative it is possible to install the plastic casing pipe inside the metallic one. However today the absolute majority of casing pipes is made of steel. Ct20 GOST 8732-78 steel seamless pipes having the wall thickness of 6 mm are often used as casing ones for individual water supply. However, drilling companies sometimes use the pipes with wall thickness of 4.5 mm of St37-3 (GOST 10704-91) in order to keep up the competitive price and to reduce costs.

The number of water-supply wells in the Republic of Belarus makes about 35,000 and the new 500–600 wells are drilled every year.

At present the disinfection of wellbores and wells as well as that of piping of drinking water supply is carried out by treating with chlorine-containing reagents [1], application of which has some disadvantages [2].

To solve the problems and to eliminate disadvantages of the methods applied today for disinfection of above mentioned piping, it is possible to use ozone as a disinfectant [2].

According to the results of many experiments represented in publications, the ozone excels all the chlorine-containing disinfectant solutions. Under its bactericidal action the ozone is 3–6 times stronger than the ultraviolet radiation and 400–600 times stronger than chlorine.

The present work is aimed at making comparative analysis of the corrosion stability of carbon steels to the chlorine disinfectant solutions and to saturated solution of ozone in water.

Main part. To develop the technology for water wells disinfection using ozone it is necessary to accomplish four important tasks as follows:

to define the ozone solubility under the height of liquid column;

to make the comparative analysis of the corrosion activity of disinfectant solutions;

to compare the inactivation efficiency of different disinfectant solutions;

to provide the feasibility study of the offered technology use.

Today we have the results of many researches for detection of corrosion of chlorine acid media to metallic surfaces however the same information for ozone solution in the water is practically missing. Therefore the comparative analysis of the corrosion stability of metallic parts to these solutions is very actual task. So the very important question at applying the ozone as the disinfectant is the comparison of its corrosion activity with solutions of chlorine disinfectants. The following reagents have been used to detect the corrosion activity: calcium hypochlorite, sodium hypochlorite, chlorite of lime, water ozone saturated solution. Tested concentrations of chlorine disinfectant solutions are the following: 50, 100 and 150 mg/l of available chlorine. The cascade turboozonator of company "Rovalant-SpetsService" Ltd. was used to get the ozone saturated solution in water; the volume of the treated water was 200 ml, ozone concentration in gas mixture was 2.7 g/m^3, gas mixture consumption was 13.2 l/min, saturation time was 30 min. During this analysis, the ozone-containing gas medium was fed continuously. For corrosion tests we used the plates of carbon steel, grade St37-3 and Ct20. The tests were carried out by gravimetric method.

As you can see from the results shown on Fig. 1 and on Fig. 2, the reduction of plate weight in tested disinfectant solutions proceeds evenly however we can observe a sharp decrease of plate weight in the ozone saturated solution for steel grade Ct20 after 2 hours of its staying in solution. At that the weight loss after 8 and 16 hours of treatment makes 248 and 556 mg.

To determine the metal resistance class with respect to disinfectant solutions we calculated the weight (K_m, g/m^2 · h) and depth ($K_г$, mm/year) corrosion indexes, which correspond to the diminution of metal thickness due to corrosion. The class and number of metals resistance in this corrosive medium were determined under the value of depth corrosion index.

The calculation results are given in Tables 1 and 2.

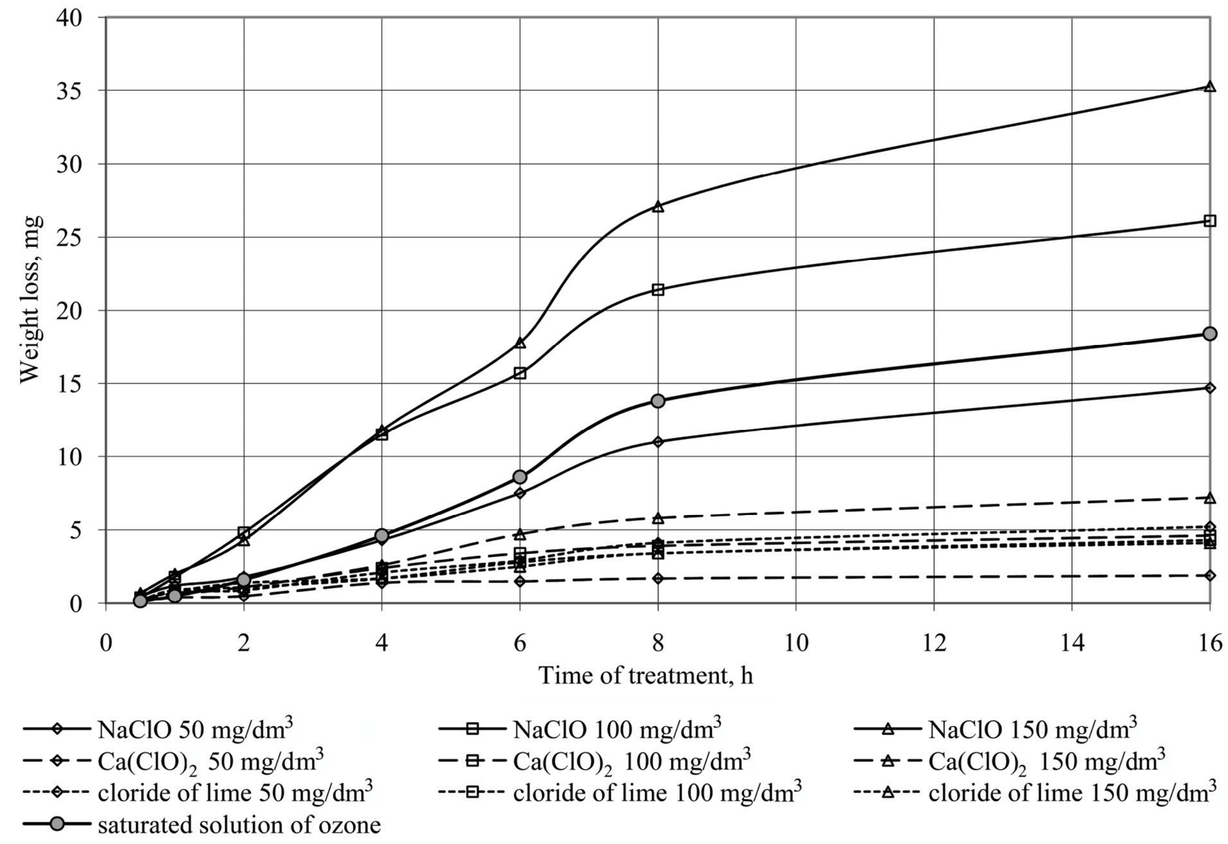

Fig. 1. Weight loss of St37-3 steel metallic plate due to time of disinfectant solution influence

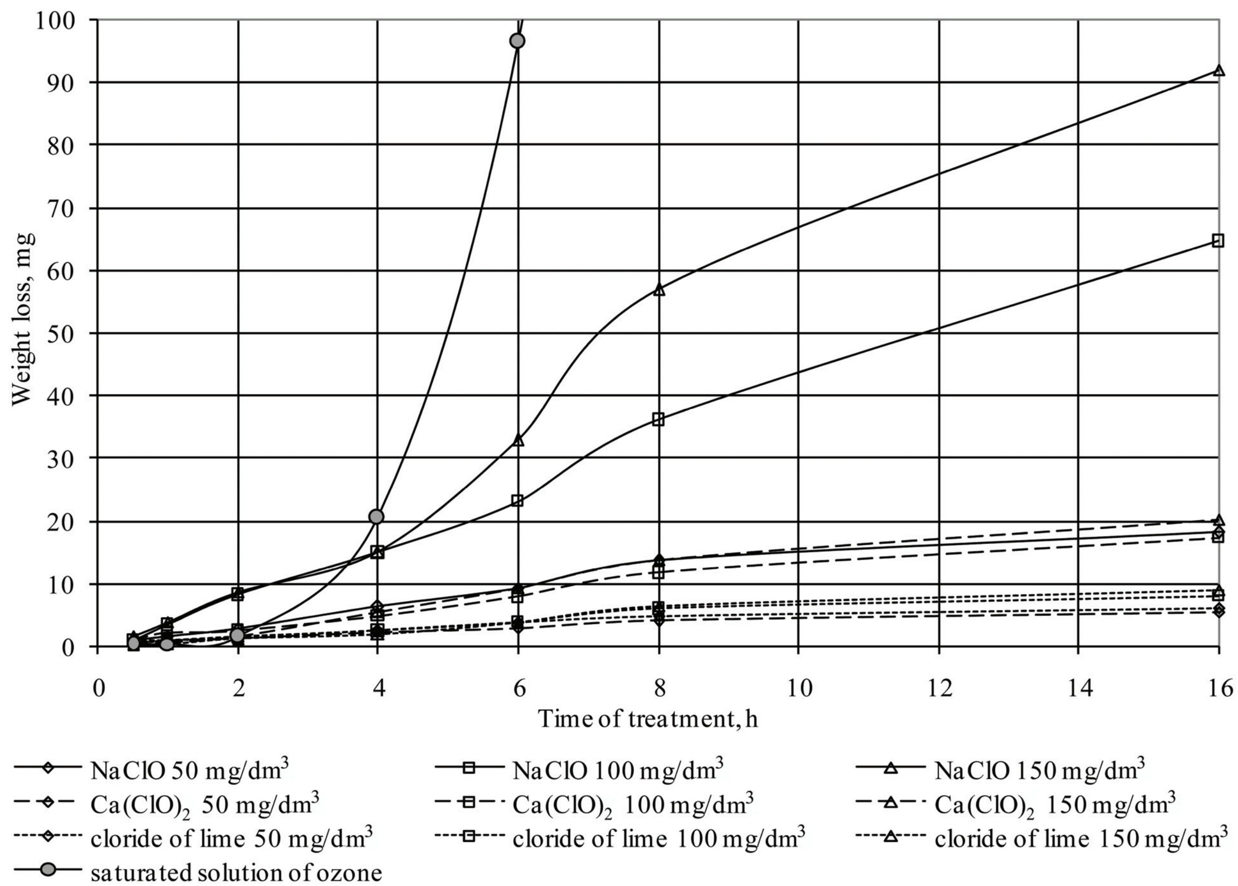

Fig. 2. Weight loss of Ct20 steel metallic plate due to time of disinfectant solution influence

Table 1

Weight and depth corrosion index of carbon steel grade St37-3 in disinfecting solutions

Solution denomination		K_{m}, g/(m^2 · h)	K_r, mm/year	Class of resistance	Number of resistance
Solution of NaClO	50 mg/dm^3	0.67	0.743	Reduced resistance	7
	100 mg/dm^3	1.26	1.403	Low resistance	8
	150 mg/dm^3	1.46	1.630	Low resistance	8
Solution of $Ca(ClO)_2$	50 mg/dm^3	0.15	0.169	Reduced resistance	6
	100 mg/dm^3	0.30	0.332	Reduced resistance	6
	150 mg/dm^3	0.38	0.426	Reduced resistance	6
Solution of lime chloride	50 mg/dm^3	0.31	0.348	Reduced resistance	6
	100 mg/dm^3	0.30	0.332	Reduced resistance	6
	150 mg/dm^3	0.298	0.335	Reduced resistance	6
Saturated solution of ozone		0.61	0.68	Reduced resistance	7

Table 2

Weight and depth corrosion index of carbon steel grade Ct20 in disinfecting solutions

Solution denomination		K_{m}, g/(m^2 · h)	K_r, mm/year	Class of resistance	Number of resistance
Solution of NaClO	50 mg/dm^3	0.89	1.0	Reduced resistance	7
	100 mg/dm^3	2.09	2.329	Low resistance	8
	150 mg/dm^3	2.76	3.081	Low resistance	8
Solution of $Ca(ClO)_2$	50 mg/dm^3	0.32	0.35	Reduced resistance	6
	100 mg/dm^3	0.81	0.898	Reduced resistance	7
	150 mg/dm^3	0.61	0.678	Reduced resistance	7
Solution of lime chloride	50 mg/dm^3	0.34	0.38	Reduced resistance	6
	100 mg/dm^3	0.44	0.489	Reduced resistance	6
	150 mg/dm^3	0.28	0.314	Reduced resistance	6
Saturated solution of ozone		8.8	9.8	Low resistance	9

As you can see from Tables 1 and 2 the depth and weight corrosion indexes in ozone saturated solution are 14.4 times lower for steel St37-3 than for steel Ct20. The solutions of sodium hypochlorite are the most corrosive among the chlorine disinfectant solutions. Depth corrosion index is up to 9.6 and 4.9 times higher (for steel St37-3) and up to 8.8 and 9.8 times higher (for steel Ct20) than the solutions of calcium hypochlorite and chloride of lime accordingly. In some experiments we can see the metal passivation effect when increasing the available chlorine concentration in solution. Passage to metal passive state is followed by corrosion velocity slowing with increasing of active material concentration in solution.

Based on given results it is clear that the figures of the weight and depth corrosion index for the steel grade St37-3 are significantly lower than those for the steel grade Ct20. With increasing the carbon content in steel we have the acceleration of its corrosion because the process of corrosion in acid medium is usually controlled by the hydrogen depolarization process, velocity of which grows with increasing of cathode area on metal surface.

The weight and depth corrosion indexes of ozone saturated solution for steel grade Ct20 exceed the values in chlorine disinfectant solutions up to 31.4 and 31.2 times. The weight corrosion index of ozone saturated solution for St37-3 steel grade exceeds almost twice the values for calcium hypochlorite solution and chloride of lime and is up to 2.5 times lower than the values for sodium hypochlorite solution.

It is to be mentioned that the time for constructions and piping treatment using the ozone does not exceed 15–20 min, at that the weight corrosion index for Ct20 steel grade makes 2.2 g/m^2, and the disinfection with chlorine solutions can last from 8 to 24 hours and at the same time the weight corrosion index will be equal to 10.6 g/m^2 for solution of chloride of lime with concentration of available chlorine of 100 mg/dm^3.

Thus it is possible to conclude that during one stage of disinfection the materials of constructions will be corroded less when using the ozone saturated solution than with chlorine disinfectant solutions.

Conclusion. Based on the performed comparative analysis of carbon steel corrosion resistance to the disinfectant solutions it is possible to conclude that the use of dissolved ozone will cause both reduced corrosion of the materials used for water-supply wells and much better disinfection.

Economic calculations for creating the mobile disinfection plant for water wells and drinking water supply piping have shown that taking into account the costs for Research and Development the payback period will be about 1.5 years if compared with the chlorine disinfectant solutions applied today.

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Received 06.03.2014