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**RESEARCH OPERATIONAL SAFETY OF PROCESS EQUIPMENT AT
LOSS OF CALCIUM CARBONATE**

**BEZPIECZEŃSTWO UŻYTKOWANIA APARATURY
BADAWCZEJ W ZAKRESIE TECHNOLOGICZNEJ UTRATY
WĘGLANU WAPNIA**

**ДОСЛІДЖЕННЯ БЕЗПЕКИ ЕКСПЛУАТАЦІЇ
ТЕХНОЛОГІЧНОГО ОБЛАДНАННЯ ПРИ ВИПАДАННІ
КАРБОНАТУ КАЛЬЦІЮ**

Abstracts

The article describes the process of operation of water heating equipment, associated with water, which requires compliance with certain water regime. It is focused on the consequences and their elimination when using water heating equipment, and safe operation. The results of physical and chemical analyses of artesian water have been ordered..

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Keywords: water heating equipment, magnetic field, dispersion of sediment, the physico-chemical properties of water.

Streszczenie

W artykule opisano bezpieczeństwo użytkowania aparatury badawczej i sposób działania urządzeń ogrzewania wody, który wymaga przestrzegania określonego reżimu wodnego. Autor skupia się na konsekwencjach korzystania z urządzeń do ogrzewania wody oraz zasadach bezpiecznej pracy i procesu technologicznego utraty węgla wapnia. Scharakteryzowano wyniki fizycznej i chemicznej analizy wody artezyjskiej.

Słowa kluczowe: Sprzęt do ogrzewania wody, pole magnetyczne, dyspersja osadu, właściwości fizyko-chemiczne wody.

Анотація

В статті розглянуто процес експлуатації водонагрівального обладнання пов'язаного з водою, яке потребує дотримання певного водного режиму. Акцентується увага на наслідках та їх усуненні при використанні водогрійного пристрою та безпечної експлуатації. Приведені результати фізико-хімічних аналізів артезианської води.

Ключевые слова: водонагрівальне обладнання, магнітне поле, дисперсність осаду, фізико-хімічні властивості води.

Operation of any water heating equipment throughout the year is related to the water. Failure of an appropriate water regime can lead to salt deposits, primarily to hardness (calcium and magnesium), which are in the water in excessive quantities. These salts under high temperature are capable precipitate and form scale.

Salt deposit (deposit of calcium carbonate), in most cases, leads to overgrowth of hot-water installations and

pipelines supplying hot water (water boilers, heat exchangers, etc.), reducing of heat to enhance corrosion by trapping sediment metal parts of the equipment and to reduce the thickness of the metal; which in turn brings down processing equipment, and it leads to injury or accident workers.

To determine the corrosive properties of the source water were carried out experimental research of water stability index (Table 1).

Table 1. Results of physico and chemical analyzes of artesian water

№	Indicator	Unit of measurement	Well №1	Well № 2
1	pH	-	7.2	7.05
2	Alkalinity	mEq / L ³	6.08	6.2
3	Total hardness	mEq / L ³	7.4	7.0
4	Calcium	mg / dm ³	110.0	100.0
5	Magnesium	mg / dm ³	23.1	24.3
6	Iron (II)	mg / dm ³	1,015	.825
7	Iron (III)	mg / dm ³	0.06	0,225
8	Manganese	mg / dm ³	0.25	0.3

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9	chlorides	mg / dm ³	16,84	33.69
10	Sulfates	mg / dm ³	28.0	26.4
11	Ammonium	mg / dm ³	0.21	0.38
12	Nitrites	mg / dm ³	not q.	not q.
13	Nitrates	mg / dm ³	not q.	not q.
14	Eventual	mg / dm ³	378	458
15	Okysnist permanganate	NGO / dm ³	4.7	8.18
16	Hydrogen sulfide	mg / dm ³	0.9	0.5
17	Colour	hail. PKS	10	23
18	Sustainability Index (experiment).	-	1.03	1.04
19	Temperature	hail. WITH	8.0	9.8
20	Carbon Dioxide	mg / dm ³	is not defined.	27

According to water quality indexes for physico and chemical analysis stability index was positive and, therefore, the water even at low temperature source water (10 degrees) possible loss of calcium carbonate. At higher temperatures after heating phenomenon amplifies and calcium carbonate starts to settle (Figure 1).

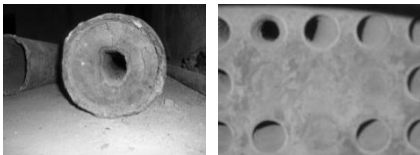
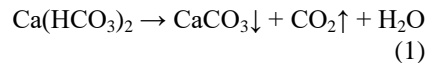


Fig. 1. General view of pipes and heat exchangers as a result of overgrowth of calcium carbonate

Frequently holes in pipelines overgrow and where is the process of hot water pumping. In one year living section of steel pipe with a diameter of 150 mm can be reduced to a diameter of 60 mm.

Analysis of the deposits on the surface of pipelines and equipment of artesian water (Table. 1) showed that about 70% of compounds are represented by deposits of calcium carbonate, 20% - iron, 3% - magnesium.

The main reason for the formation of carbonate deposits is due to the violation carbon dioxide balance due to waterheating . Particularly intense formation of deposits in pipes and drainage of hot water in the equipment where there is contact with water heated atmospheric air, and removed much of free carbon dioxide from the water. As a result of conversion of bicarbonate to carbonate falls crystalline precipitate



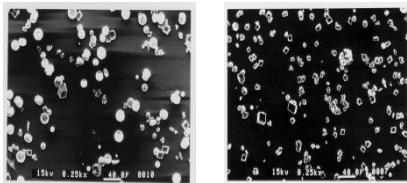
To maintain the concentration of bicarbonate ions must maintain the required amount of free carbon dioxide. With an excess of CO₂ is dissolving carbonate, the shortage of CO₂ is calcium carbonate precipitation followed by binding carbon dioxide ions Ca²⁺.

One way to fight with the loss of calcium carbonate can be used for water treatment magnetic field, which refers to physical methods of prevention salt deposits. At the end of the last century there were a number of scientific works that were devoted to the influence of

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magnetic field on the structure of the sediment in aqueous solutions. Under the influence of the magnetic field changes the physical and chemical properties of aqueous solutions. Impurities, which form a scum lose their ability to precipitate in the form of thick stone and crystallized in the form of fine, loose suspension, which is made water flow out of the system without being besieged the walls of the pipes. When contacting the water that was magnetic processing of salts are selected, they undergo partial dissolution and destruction of the state of fine sludge that is easily removed, and is caught by standard cleaning of the filters impurities.

The magnetic field influences the crystallization form of calcium carbonate (CaCO_3), which crystallizes in three different forms: calcite, aragonite and vaterite. Calcite is a dense type of hard



scale, while aragonite and vaterite form a soft, loose scale that is easily washed off. Vaterite is a metastable modification of calcium carbonate, often precipitate first, but usually quickly turns into calcite.

Dispersion of sediment formed in water without and after magnetic treatment is different (Fig. 2).

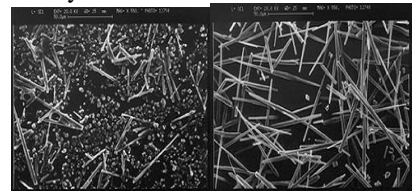
a) b)
 Fig. 2. Picture of precipitation CaCO_3 obtained from a supersaturated solution of highly purified suspension
 a) without the magnetic field; b) passed through a magnetic field 8000 E.

In the presence of the magnetic field observed irregular particles, the spherical

shape of about 1 micron, consisting of calcite crystals smaller too irregular.

According to [1] in the water after magnetic treatment, formed mainly aragonite, unlike calcite that is most sediment in untreated water. Aragonite crystals (Fig. 3) have a needle shape [1].

The research by Horobets U. I. etc. [2] are steady flow of metal elements highly gradient magnetic nozzles (HGMN) in fixed electrolytes under the influence of a constant magnetic field. We used iron balls and cylinders (from tens of microns to several millimeters in diameter), which are fixed on the non-magnetic, chemically inert holder that does not conduct electricity. In the



a) b)
 Fig. 3. Crystals precipitation (calcite and aragonite)
 a) no magnetic treatment; b) after magnetic water treatment.

magnetic field of the cell inserted model solution. In the absence of an external magnetic field motion model solution is practically not observed for most salt solutions and has been very slow to acid solutions. When you switch on the constant magnetic field observed movement of salt solutions, speed of acid solutions has grown several times in order or depending on the size of the external magnetic field, the surface area of metal elements and parameters of electrolyte. In addition, depending on the model electrolyte around iron cylinder were observed two mutually opposite rotational

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movements in the direction of the model solution (Fig. 4).

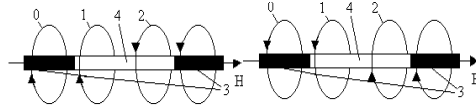


Figure 4. Vortex structure of a water solution of nitric acid

0),1),2) vortices;3) isolated area of the cylinder;4) cylinder.

Number of vortices were at least two. Changing the sign of the field to the opposite, involved a change in the direction of the electrolyte in all vortices, that there is an odd effect. Replacing electrolytes distilled water showed that the presence of a magnetic field and without vortices did not appear.

Then the surface of the iron balls or cylinder was covered with a thin layer of electrical insulator (about 2 mm) varnish or glue. Movement model solution was not without a magnetic field, and when it is switched on. That is, the constant external magnetic field leads to a convective mass transfer on surfaces of metallic elements in electrolytes.

The study of [4,5] in the gap magnetic laboratory apparatus aqueous solution oversaturated by calcium carbonate showed that the magnetic field itself does not affect the intensity of selection of calcium carbonate in the gap system in the presence of a magnetic field and without it. Overlay on water flow magnetic field ($H = 220 \text{ kA / m}$) does not affect the nature of the sediment CaCO_3 in the control region of heat transfer in the absence of a magnetic field. Scum-like residue in the control region had dense structure and an increase in the flow rate to $0.8\text{-}1.0 \text{ m / s}$ watered out only $10\text{-}20\%$ of

the deposited amount if the gap were accumulated magnetic device or a layer made of ferromagnetic impurities, there was intense crystallization of calcium carbonate on the surface of the detainees in the gap ferromagnetic particles. Chemical analysis and mass ferromagnetic particles from the magnetic gap device showed that they contain up to $20 \dots 30\%$ CaCO_3 by weight. Microscopic examination revealed that the crystals CaCO_3 (crystalline structure - aragonite) growing on magnetite substrate in a bifurcated dendrites, resulting proportion of magnetite that was detained magnetic field in saturated stream covered with loose layer of long crystals CaCO_3 , the number of which grows perpendicular magnetite substrate. Adding the gap magnetic storage device and magnetite him there to the value of G changed the nature of scale formation in heat control region through intensive phase transformations in the gap. The precipitate heat in the control region at 3rd regime was loose and water out $60\text{-}80\%$ by increasing the flow rate to $0.8\text{-}1.0 \text{ m / s}$. Magnetic devices can generate crystals scale formation, which changes the nature of the sediment on heat transfer surfaces. However, the mechanism of the process of generating solid phase of accumulate gap in the magnetic device is not fully clarified.

When magnetic water treatment is a hypothesis, the authors have suggested the possibility of changing many parameters comparing with pure water (conductivity, viscosity, density, solubility and activity of impurities, optical density, dielectric and magnetic permeability, etc.). At the same time, a number of experimental and theoretical work is not confirmed. Magnetic devices can change this setting water system, the concentration of

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ferromagnetic impurities [4,5]. "Magnitization" water can differ from the original first content of impurities. That is the apparatus for magnetic water treatment exchanger, the number of detainees in the magnet gap G impurities will continuously increase and reach the limit after a certain period of time.

The mechanism of action of magnetic water treatment process to fight with scale formation:

- magnetic device holds in his gap ferromagnetic impurities;
- after a period of time in the gap formed porous layer of well-developed surface;
- component in which supersaturated water (gas, salt), adsorbed on surface ferromagnetic particles lower effect magnetic field;

According to [8] magnetic accumulator can be installed in the pipeline or on the outer surface of the pipe. In the first case, the surface can settle magnetic accumulator calcium carbonate, the second is a weakened magnetic field. Illiterate use of magnetic transducers can lead to clogging sludge system. In addition, the magnetic treatment of water produced carbon dioxide which affects the corrosion properties of metal equipment, metal pipes and so on.

According to [7] magnetic water treatment for boilers can be carried out at a concentration of 0.3 mg of iron to / dm³, oxygen - 3 mg / dm³, chlorides and sulfates - 50 mg / dm³, carbonate hardness - no more than 9 mmol / L³, and the temperature should not exceed 95 degrees. According to [3] water can "get used" to the magnetic treatment and stabilization effect may decrease. In addition, the amount of chlorides and sulfates in some periods exceed 50 mg / dm³.

is essentially a magnetic filter. When installing a magnetic device to deal with scum on the line, providing a heat

- the magnetic field can increase corrosion of metal surfaces if the electrolyte is an aqueous solution;
- Products sorption flow of water washed away from the surface of ferromagnetic particles held in the gap magnetic field;
- themselves is ferromagnetic particles by score extended stay in saturated stream change of surface properties covered bed carbonate calcium and begin perform features centers crystallization.

Activator(Fig. 5) is a pipe casing with flanges, which have one or more magnetic modules. The magnetic module has thou shalt cylinder 7 which is made of diamagnetic material (poliamydu, polyethylene) with its walls drenched in permanent magnets 8. All pairs of magnets are shifted relative

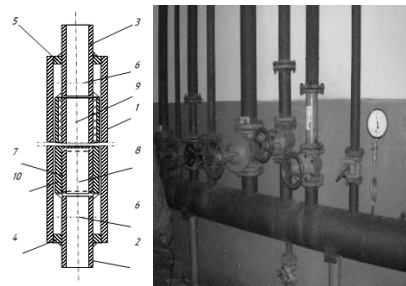


Fig. 5. Magnetic camera "KM - 1,2,3" 1) steel case; 2), 3) pipes; 4),5) plugs; 6) hole; 7) thou shalt cylinder module; 8) permanent magnet; 9) hydraulic channel; 10) working gap

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to each other by 90^0 . In the case the water flow is divided into two streams, one passing through the module (channel 9), and the second - between the body and the module (through holes 6 and the working gap 10). In both flows affect the magnetic field, which is directed perpendicular to

the motion of water. Magnets installed in the walls of the modules in pairs against each other. Thus formed two magnetic circuits in one inside the module, and the second - between the module and the casing. After passing the streams connected modules.

The results of the annual operating magnetic cameras showed that nearly vanished effects overgrowth pipe and reflux calcium carbonate. However, in this case, magnetic water treatment lodged with high content of iron, and with increased in certain periods, the amount of chlorides and sulfates was opposite [7].

The water circulates in the cooling system, changed its physical and chemical properties are very slightly (Table. 2).

So one of the ways of fighting with carbonaceous deposits can be used magnetic water treatment, which has a number of significant advantages over other technologies does not affect the chemical composition of water; ease of use; do not need additional equipment and not energy consumed. Research of using magnetic water treatment indicate its feasibility and advisability of further deep researches

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Table 2 Physical and chemical properties of water to a magnetic field treatment and after treatment

Indexes	Unit of measurement	value		
		sv.1	Submission to reflux	After reflux
pH	Ed.	7.1	7.05	7.5
total Hardness	mmol / dm ³	7.0	6.7	6.8
total alkalinity	mmol / dm ³	6.4	5.8	6.0
Eventual	mg / dm ³	325	375	375
Cl ⁻	mg / dm ³	25.9	37.7	28.3
SO ₄ ²⁻	mg / dm ³	29.4	22.4	30.0
total Fe	mg / dm ³	2.25	2.70	2.25
fe ²⁺	mg / dm ³	1.91	2.35	1,875
CO ₂	mg / dm ³	33.11	47.2	-

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