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The device of magnetic processing of water for boiler greenhouse

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Abstract

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The most part of the heat power equipment in agriculture is maintained with infringement of requirements in rules of technical operation. The scum that does not leave from heating surfaces reduces copper efficiency and increases fuel consumption. Chemical ways of ecological water preparation are not safe and are expensive. Magnetic water preparation has a number of advantages in this way, one of which is the possibility not only to prevent scaling, but also to remove earlier scum. Existing devices of water magnetic processing has a basic deficiency – presence of narrow slot hole backlashes in which the processing is performed. Thus, the productivity of installation and its reliability decreases. Transition from water processing by the basic magnetic stream to dispersion streams eliminates this deficiency. Getting optimum parameters of processing water (the constructional module) is connected with a change of magnetic system design. The crystal-optic way is the most exact at definition of efficiency of processing water by magnetic field.

Keywords: scum; salt crystals; rigidity of water; heat supply; magnetic field

The greatest practical application in industrial vegetable growing is that of technical heating as it allows receiving production out of season. In local systems, the heat supply is carried out by the boiler-houses constructed specially for glass-house industrial complexes. Water heating is the most extended, as it allows applying the automated control systems in temperature of air and soil (Fig. 1). Water heating is subdivided into the system of water heating of a tent air space and the system of heating soil.

The heat-carrier temperature in the system of a heat supply of a tent from own boiler-house, no more than 130°C is accepted and the temperature of return water equals 70°C (Antonov, Ivashina 2009; Antonov, Atanov 2010; Antonov et al. 2014).

The soil temperature in root layer should be from 18°C to 25°C. Heat-carrier temperature in the inlet pipeline is 40–45°C, and in the return 30°C.

Sources of water supply of heating boiler houses can be surface waters of lakes, rivers and artificial

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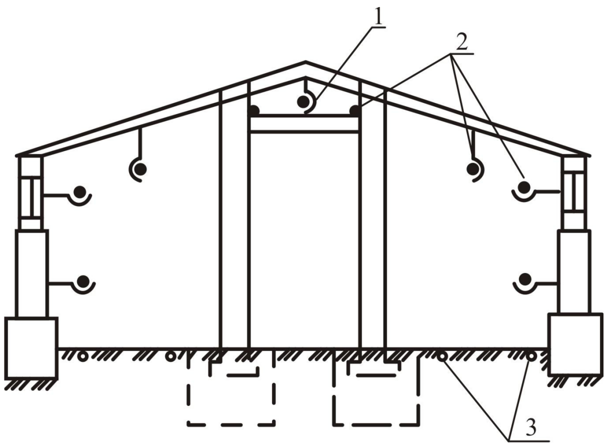

Fig. 1. Soil glass-house with water heating: 1 – main inlet pipeline; 2 – pipes of space heating; 3 – pipes of undersoil heating

water basins, and also underground waters can serve in constructions of the protected ground from artesian chinks. Surface water always contains dissolved substances and not dissolved mechanical impurity. Underground waters are usually transparent and almost do not contain mechanical impurities. Salt contained in underground waters is, as a rule, higher than superficial. For water supply for boiler installations surface water of rivers and lakes have the greatest value. Expense and quality of river water changes cyclically not only according to the season of the year, but also in a long-term period. Depending on the character of used water various consumers define also the indicators necessary for qualitative and quantitative characteristics of water. One of such indicators of water for its use in the water-heating equipment is hardness.

General hardness of water is defined by total concentration of ions of calcium and magnesium, expressed in mg-ekv/kg. In natural water, there is mainly calcium carbonate, sulphate of calcium and hydroxide and magnesium are much rarer.

The calcium carbonate in the nature has two crystal modifications – calcite and aragonite (Gurnitsky et al. 2001; Antonov, Atanov 2011; Antonov 2008). Calcite crystallizes in the shape of rhombohedrum; aragonite concerns rhombic system and can get various forms.

There are chemical and physical methods of the water preparation, the purpose of which is a decreased forming of scum on surfaces of heating and in the heat supply system. The most perspective and harmless method is magnetic water preparation.

The magnetic method of water processing is based on the phenomenon that water after being exposed to magnetic field do not build up scale on a heating surface at its subsequent heating in copper. Some compounds crystallize on a heating surface, forming a scum. The centres of such scum are roughness areas of the heating surface (Reddy 1965; Diamant 1969). As a result of magnetic processing of hardness salt, it drops out in a kind of slurry and should leave continuously from the bottom points of copper.

The analysis of the saved up scientific knowledge gives an ambiguous answer to a question on influence of magnetic field on the physical and chemical processes occurring in water solutions. However, it has been proven that the magnetic field has a certain impact on crystallization kinetics, causing an increase in concentration of the centres of crystallization, as instead of scum a suspension (pulp) is formed (Rubin 1975; Kuivinen, David 1975; Alleman 1985).

The processes in water exposed to magnetic field may be presented as follows. At water passage through a zone of the magnetic field and presence of ferromagnetic substances in supersaturated solution forming scum, (water) germs of the centres of crystallization are formed (Antonov, Atanov 2010).

Results of studies on magnetic field influence on a firm phase of carbonate calcium from the instable environment (at t = 20°C and t = 100°C) have shown that the size and quantity of crystals change, whereas the characteristics of phases does not.

Magnetic field influences only the geometrical size of crystals. With an increase in magnetic induction, the firm phase becomes smaller, and the quantity of particles (the crystallization centres) increases.

There exist more than hundred designs of water magnetic processing devices (Rippie 1965). Existing devices have a basic deficiency – presence of narrow hole backlash with water in it, in which the processing is performed. Refusal of water processing by the basic magnetic stream and transition to processing by "dispersion" field would allow eliminating this deficiency.

Analysing the above mentioned theses, the assumption that for effective magnetic processing of water it is possible to use not only the basic magnetic stream, but dispersion stream (bulging) is put forward. The use of those streams will allow raising productivity of devices, without reducing characteristics of an electromagnetic field.

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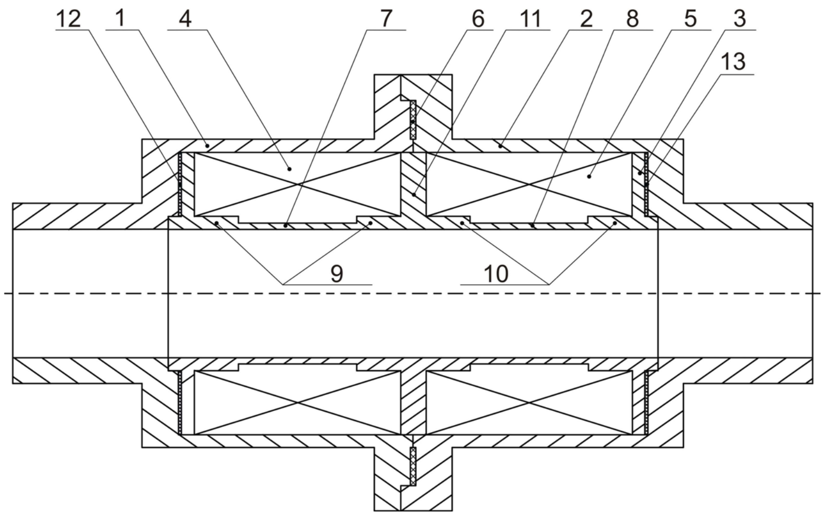

Fig. 2. Construction of the magnetic water-processing device

1, 2 – magnetic case; 3 – magnetic carcass of the coil; 4, 5 – magnetizing coils; 6 – rubber lining; 7, 8 – thin walls; 9, 10 – thickenings; 11 – magnetic wire; 12, 13 – rubber linings

For hypothesis check, it is necessary to solve the following problems:

– To optimize a design of magnetic system of the device;
– To make experiment to define magnetic processing efficiency;
– Subject of researches is water processed in a magnetic field.

For the decision of tasks in view, the following design of the device of water magnetic processing is offered (Fig. 2) which contains: two halves of magnetic case 1 and 2, between them hermetic sealing of a magnetic carcass of the coil (3) and magnetizing coils (4, 5), rubber lining (6) is provided. The magnetic carcass of the coil (3) has thin walls (7, 8) and thickenings (9, 10); and also magnetic wire (11) which separates coils 4 and 5 from each other. For protection against moisture, the magnetic carcass of the coil 3 is separated from halves of the magnetic case 1 and 2 by means of rubber linings 12, 13.

The device of magnetic processing of water works as follows (Fig. 3): at giving constant or alternating current on magnetizing coils 4, 5, magnetic flux Φ_1 and Φ_2 are formed: for magnetic flux Φ_1: half of the magnetic case 1 – magnetic carcass 11 – magnetic carcass of the coil 3; for magnetic flux Φ_2: half of the magnetic carcass 2 – magnetic wire 11 – magnetic carcass of the coil 3.

Thin walls 7, 8 represent considerable magnetic resistance for magnetic fluxes Φ_1 and Φ_2. As a result flux Φ_1 is divided into flux: $\Phi_{1.1}$ – magnetic which is becoming isolated on thin wall 7, flux $\Phi_{1.2}$ – magnetic flux in volume of the magnetizing coil 4, flux $\Phi_{1.3}$ – magnetic flux, going towards the processed substance. Flux Φ_2 is divided into fluxs: $\Phi_{2.1}$ – magnetic flux which is becoming isolated on thin wall 8, flux $\Phi_{1.2}$ – magnetic flux in volume of the magnetizing coil 5, flux $\Phi_{1.3}$ – magnetic flux, bulging towards the processed substance. Moving water with any speed repeatedly crosses power

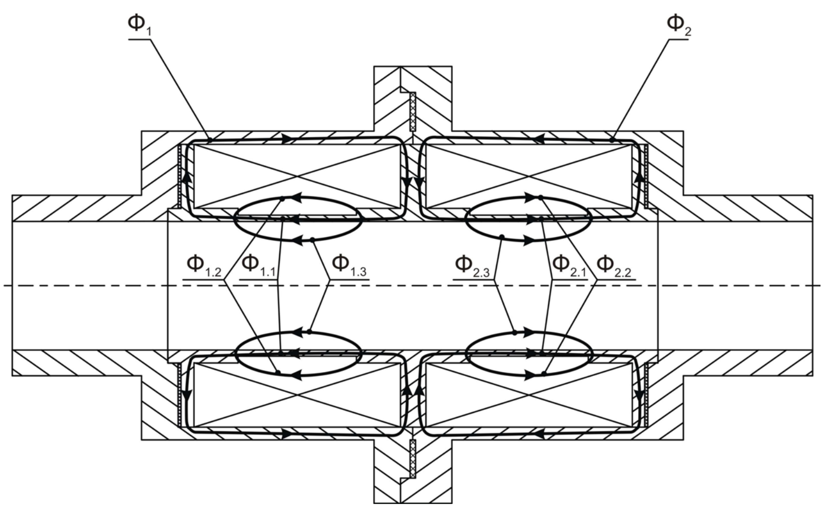

Fig. 3. Principle of the device work

Φ_1 – magnetic flux; $\Phi_{1.1}$ – magnetic flux which is becoming isolated on thin wall 7; $\Phi_{1.2}$ – magnetic flux in volume of the magnetizing coil 4; $\Phi_{1.3}$ – magnetic flux, going towards the processed substance; Φ_2 – magnetic flux; $\Phi_{2.1}$ – magnetic flux which is becoming isolated on thin wall 8; $\Phi_{2.2}$ – magnetic flux in volume of magnetizing coil 5; $\Phi_{2.3}$ – magnetic flux is exposed to physical influence

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lines of magnetic fluxes $\Phi_{1.3}$ and $\Phi_{2.3}$ and is exposed to physical influence.

To control the conditions of isolation magnetizing coils it is planned to use the microcontroller device for diagnostics of isolation (Vostrukhin et al. 2013a,b).

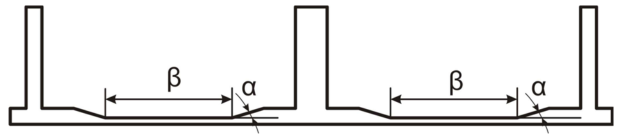

Fig. 4. Form of magnetic system poles

1 – scope poles; 2 – thin walls

MATERIAL AND METHODS

The basic criterion of the optimum device is maintenance in a zone of processing of certain value of the constructional module (*M*). This indicator represents a product of magnetic induction of the device (B_{av}), speed of crossing by magnetic field water (υ) and time of water being in a processing zone (t).

$$M = B_{av} \times \upsilon \times t \quad (1)$$

where: *M* – the constructional module (T·m); B_{av} – average magnetic induction (T); υ – speed of a stream of liquid (m/s); *t* – time of presence of liquid in magnetic field (s)

For those systems where speed of a stream of liquid is not known, it is possible to accept a constant equation in a form:

$$M = B_{av} \times L_0 \quad (2)$$

where: L_0 – water way to the processing zone (m)

For optimization of magnetic system of the water magnetic processing device, two factors were used (Fig. 4):

The first: α – the corner of scope poles (X1), influences value of magnetic induction *B*.

The second: β – the length of thin wall (X2), influences a zone of processing water L_0.

The method essence consists in the following. Factor X2 was fixed and movement began from a corner 10° to 90° with step 10°. Factor X1 was fixed, changing length of thin wall from 0 to 80 mm with step of 10 mm for one coil. It will change in parallel length of thin wall 0 to 80 mm with step of 10 mm and for the second coil. Thus, the total length of a thin insert will be twice higher.

As a result, research matrix is presented in Table 1. From the received matrix it follows that is necessary to settle eight–ten one designs of magnetic system.

Calculation of magnetic system is made by means of program complex ELCUT (TOR, St. Petersburg, Russia).

Definition of efficiency of magnetic processing (Fig. 5) which represents imitation of both opened and the closed system of heat supply and works as follows: the water arriving from the pipeline of the central water supply or forced by the circulating pump (4) from capacity, passes the device of magnetic processing of water (5) (Antonov 2008; Antonov, Atanov 2011). Then it arrives in a heating tank (1). Speed of movement of water changes the gate (12) or change of frequency of rotation of the circulating pump. Passing a heating element, water heats up to temperature equal to 80– 90ºC. Water heated to the necessary temperature arrives in keeper (7), and then through the heating device (2) and an investigated element (8), further in the pipeline in the central water drain. The scum which was formed after water heating settles on glass subject established in the bottom part of keeper.

Table 1. Research matrix (T·m)

α \ β × 2	10	20	30	40	50	60	70	80	90
0	7.0610	6.8794	6.7770	6.7208	6.7006	6.6668	6.6298	6.6226	6.8058
10	7.3590	7.3228	7.1782	7.1854	7.1648	7.1534	7.2304	7.1726	7.1614
20	7.4738	7.4880	7.4114	7.4794	7.3848	7.4112	7.3728	7.4646	7.4418
30	7.5278	7.5378	7.5228	7.5024	7.4970	7.5124	7.4952	7.5024	7.4818
40	7.5480	7.5592	7.5684	7.5718	7.5740	7.5782	7.5782	7.5696	7.5724
50	7.5380	7.5278	7.5346	7.5488	7.5414	7.5534	7.5484	7.5558	7.5578
60	7.5292	7.5020	7.4856	7.4836	7.4882	7.4990	7.4896	7.4870	7.4888
70	7.4826	7.5396	7.4792	7.5088	7.4970	7.5070	7.5078	7.5098	7.5106
80	7.4882	7.4978	7.5148	7.5286	7.5060	7.4602	7.5034	7.5244	7.5120

α – corner of scope poles (X1); β – length of thin wall (X2);

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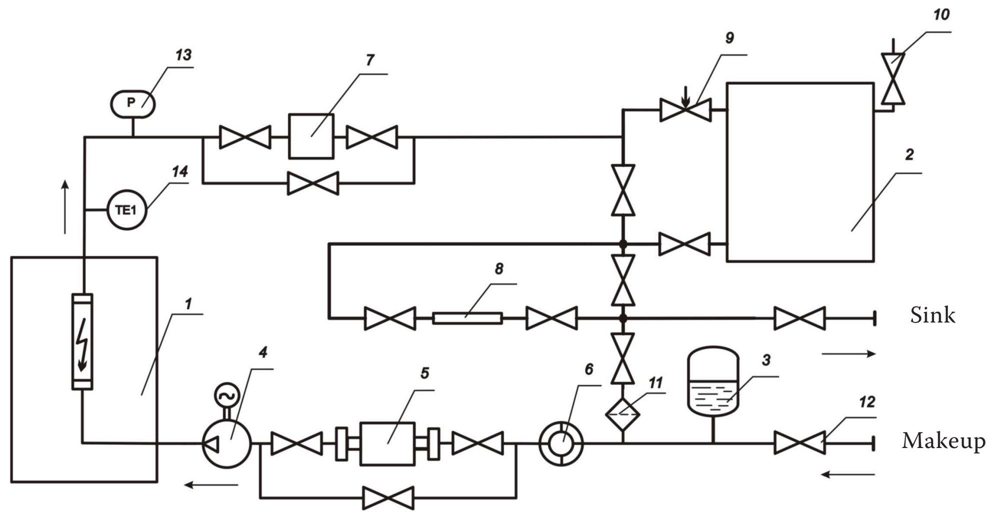

Fig. 5. Circuit diagram of experimental installation for definition of efficiency of magnetic water-processing devices

1 – heating element; 2 – heating device; 3 – broad tank; 4 – circulating pump; 5 – device of magnetic processing; 6 flowmeter counter; 7 – slug catcher; 8 – investigated element; 9 – expense regulator; 10 – "Maevsky" crane; 11 – filter; 12 – crane valve; 13 – manometer; 14 – temperature gauge

RESULTS

Calculation of magnetic system is done by the method of final differences applied in program ELCUT. The given program allows calculating magnetic field for axisymmetric and flat objects.

The results of calculation of the constructional module of the device are presented in Fig. 6.

Control over water magnetic processing by magnetic field consists in comparison of indicators of quality of water or characteristics of an allocated firm phase before its processing. These indicators can serve to determine changes. Indication makes an integral part of water processing with magnetic field application.

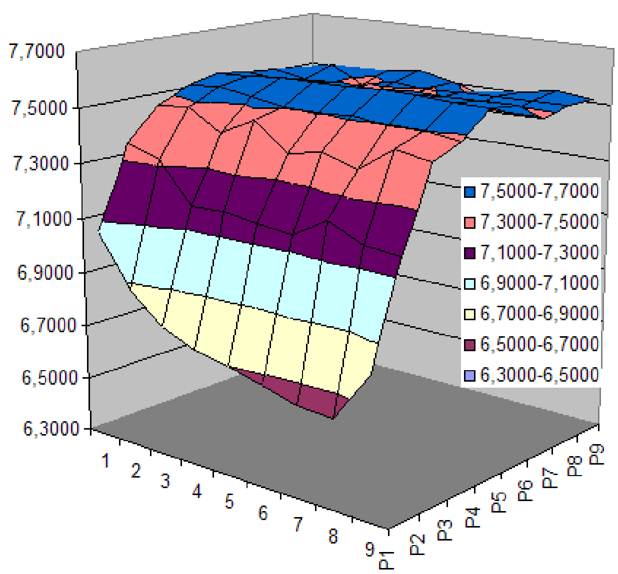

Fig. 6. Surface of the constructional module, in function

1–9 – corner of scope poles (α); P1–P9 – length of thin shunting wall (β)

For an estimation of efficiency of water processing with magnetic field, a technique recommended by the Kharkov engineering-economic institute was used (Alleman 1985; Antonov, Atanov 2010). The results of photos of crystals of salt dropped out in a deposit are examined by means of a microscope.

Results of crystal-optic way for water processed by a magnetic field for corner scope poles 500 are presented in Figs 7 and 8.

DISCUSSION AND CONCLUSION

Analysing the results of optimization of magnetic system water-processing device, it is possible to conclude that the changes of the constructional module such as length of a thin insert have exponential dependence. Hence, efficiency of magnetic system of the device reaches the maximum values at a length of a thin insert more than 50 mm, and does not depend on such parameter as corner slope poles.

As to the efficiency of magnetic processing, the carried out experiments have shown that water exposed to magnetic processing dropped out more than salt compared to raw water. It means that salt

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(a) (b) (c)

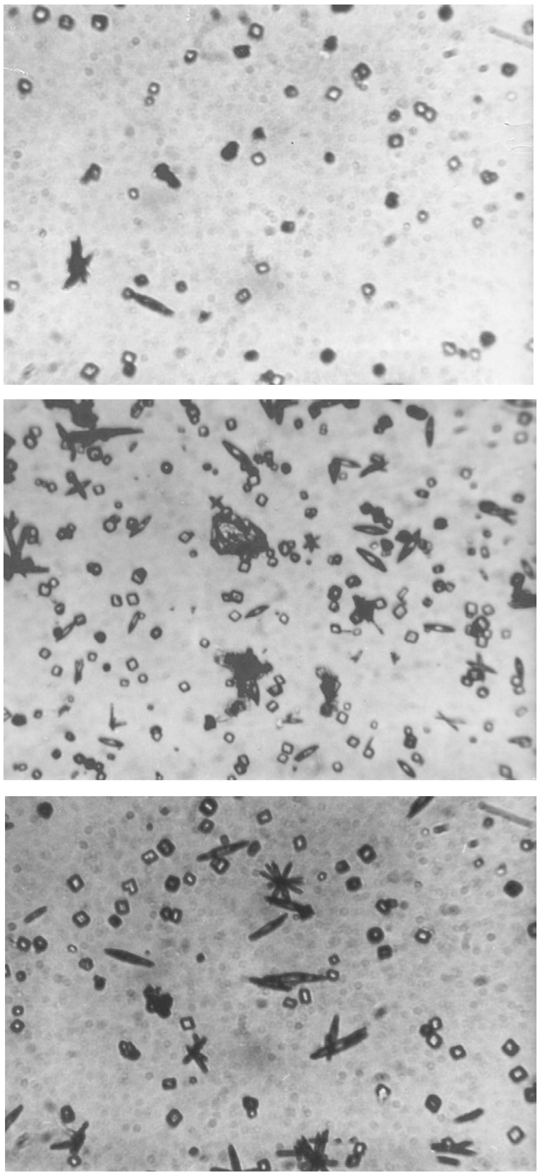

Fig. 7. Salt crystals in raw water (a) and processed water by the device with a length of thin wall: 0 (b) and 20 mm (c)

(a) (b) (c)

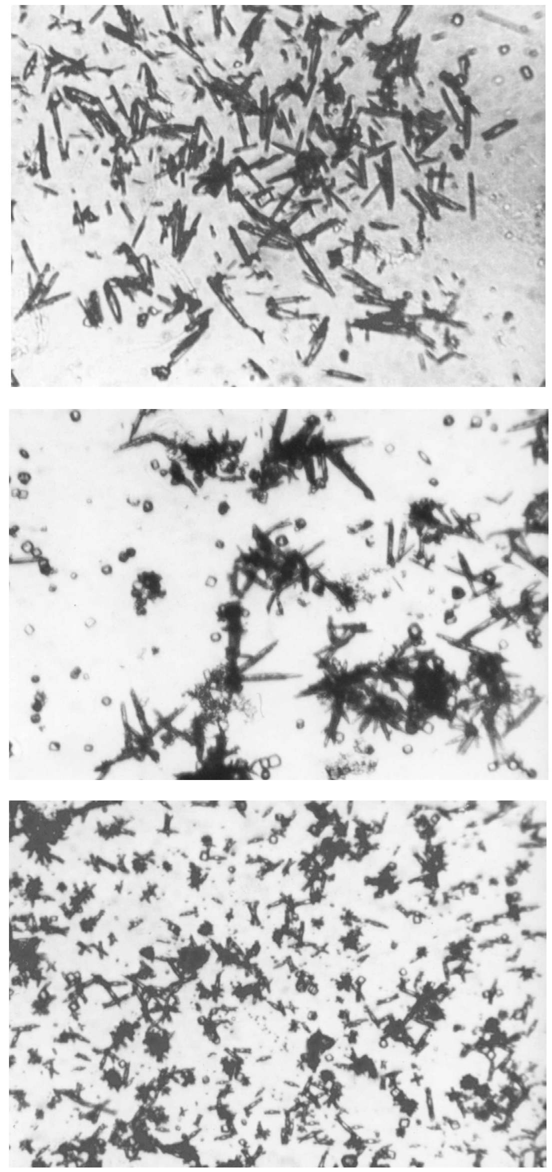

Fig. 8. Salt crystals at processed water by the device with length of thin wall: 40 (a) and 60 mm (b) and 80 mm (c)

is allocated in all volume of water, and not just near the heating surface. Formation of the centres of salts crystallization promotes an increase in weight of salts and by that they pass at heating from the dissolved condition in the weighed. A special criterion at definition of efficiency of magnetic processing is a decrease in the linear sizes of crystals dropped out in a deposit. The factor of estimation of processing efficiency of devices decreases in process of adjournment of a scum on surfaces of heating and in heat supply systems.

Analysing the results of crystal-optic way and of control with respect to efficiency of the processing, the optimal design is the device with length of thin wall 80 mm. It is connected with increase in quantity of the formed centres of crystallization and three-times reduction of the linear sizes of crystals.

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