Energy Efficient Processing of Geothermal Water for Energy-Heating Objects of the Building Industry

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Abstract. Due to the energy crisis in Ukraine, the problem of significant increase in the efficiency of production, transportation and use of energy is of particular importance. Considering the significant role in energy supply of the country, the issues of efficient use of heat energy in all areas of these systems are solved: generation for heating water or for steam generation; transportation to the consumer, as well as when using it by the consumer. On the heat exchange surfaces of the systems, scale occurs, which leads to deterioration of heat and mass transfer processes and heat energy indices [6]. This affects the overall performance of the process. In this paper, the question of determining the parameters of an electromagnetic field in the process of treatment of pure water is solved and physical models of the change of the structure of pure water after treatment in the electromagnetic field and the change in the nature of its interaction with different surfaces are developed. To improve the efficiency of the system, perform preliminary cleaning and softening water before feeding it to the heat pump by the method of processing it in fields of constant current and in the field of permanent magnets. Next, filtration and water treatment in the field of electromagnets with certain parameters of high frequency of electric current and field induction are carried out. The scientific principles of changes in structural and thermophysical properties of water, ecological and technical technologies, which include the implementation of its basic principles, in which environmental and anthropogenic factors perform a functionally unifying role, are developed.

1. Introduction

In the European Commission’s biennial report, the European Union increases the share of renewable energy in the energy balance of the EU Member States. In 2013, the share of renewable energy in the entire EU energy cycle was 15%. A year later, it increased by 0.3%. Growth has occurred in all EU countries, it seeks to increase the share of sources of this type of energy up to 20% by 2020. At the same time, each country should implement an appropriate quota at its own expense. The European Union manages to achieve such indicators, first of all at the expense of Sweden, Denmark, Latvia, where the share of renewable energy sources is up to 42%, in the UK it is not more than 5%, and in Germany - 9.5%. In 2013, about 21% of the world's energy consumption was provided from renewable energy sources [1, 2].
In 2008, the installed capacity of power generating geothermal plants in the world amounted to about 11 million kW with a production of 55 billion kWh of electricity. The Energy Community supports the National Action Plan of Ukraine on Energy Efficiency until 2020. Due to the energy crisis in Ukraine, the problem of a significant increase in the efficiency of energy production, transportation and utilization systems is becoming increasingly important.

Given the significant role in the country's energy supply systems by water and steam supply systems, they are faced with the issue of the efficient use of thermal energy in all areas of these systems: generation for heating water or for steam generation; transportation to consumers, with the use of its consumers. All these stages in water heating systems water coolant passes in various sectors of the economy: the housing and communal sector, industry and agro-industrial complex, where changes in composition, structure and properties of water, heat exchange surfaces of systems, and the formation of scum on them can take place. This leads to a deterioration of heat exchange processes and thermal energy indicators, which affects the overall performance of the process, which greatly complicates its theoretical consideration and substantiation of the regime parameters. In all these areas, positive results of water treatment in magnetic fields have been achieved. Existing problems are greatly simplified when pre-cleaning water. It is shown, as a result of research, that for obtaining clean water, it is necessary to determine the necessary parameters of system processing.

As a result of theoretical and experimental studies, parameters of the electromagnetic fields have been established, which allow to have the greatest influence on the change of water structure, its characteristics, that is, allows to achieve the required water quality, most distinguishes the conditions of interaction between bodies and their surfaces, which ensures the possibility of reducing the temperature of water in the process handling and interacting with these materials. These parameters were developed on the basis of the kinetic theory of the liquid Y.G. Frenkel, the frequencies of the electromagnetic field were determined, which resulted in the destruction of water clusters at temperatures and energy costs significantly lower than in the existing thermal methods, that is, the non-reagent water treatment method [3, 4].

Changes in the properties of water through non-reagent treatment in magnetic fields began to engage in the middle of the XX century, initially in fields of permanent magnets. Then they began to apply fields of DC electromagnets to low-frequency current up to 50 Hz. But despite the achievements in the use of water treatment in magnetic fields in some processes, the development of practical application of water treatment in magnetic fields in heat supply systems and various technological processes has not reached widespread. This is due to the inadequate level of theoretical studies in water physics. All the results are based mainly on empirical data that can’t justify a coherent picture of the structure of water, and the kinetics of changing this structure under the influence of various energy influences. Exceptions were made by Y. G. Dorfman, Y. G. Frenkel and V. I. Classen. On the basis of Y.G. Dorfman, "Magnetic Properties and Structure of a Substance", based on the data obtained in the above monograph, which shows that the oxygen atoms in water are paramagnetic, that is, they depend on the voltage or induction of the body. Increased frequency of oscillations leads to the destruction of clusters, according to Y. G. Frenkel "Kinetic Theory of Fluid", V. I. Classen "The enrichment of water systems" [3, 4].

2. Formulation of the problem
The investigations carried out at the laboratory stand of the Institute of Technical Thermo-physics allowed us to substantiate the technology of combating scale, to intensify various technological processes that affect the energy efficiency of the heating systems and their ecological indicators with insignificant material and energy costs, to decide the feasibility of using the methods of mitigation and water purification electric and magnetic fields [5].
Water treatment in the electric field is carried out to achieve different results: purification of wastewater with return of part of the purified water to the production cycle, provision of the necessary pH of the water for the technological processes, reduction of the salts of rigidity in the feed water, its purification, etc. [5].

Depending on the purpose, there are different methods of water treatment in the electric field: for purification of wastewater. In order to provide the necessary pH of the process water, the method of electrically activating water with electrolysis by its division is predominantly used; to reduce the amount of hardness salts in nutritious water.

To clean the more promising seems less cost-effective method, based on electrophoretic transfer of ions and particles to an oppositely charged electrode without water electrolysis. A variant of this method is the method of electrocoagulation: when passing the electric current into the water, coagulating active positively charged ions, for example, Fe ++ and Fe ++++, with coagulation complexes falling in the precipitate present in water negatively charged ions are isolated in the water.

The next promising method of water preparation is its consistent processing in electric, and then magnetic fields. Actually the magnetic field does not result in the purification or softening of water, but it affects the proton back of its molecules. This leads to the formation of a temporary non-equilibrium water form, which is characterized by a reduced energy bond between the molecules, which in turn leads to a decrease in the specific heat of vapor formation and an increase in the surface tension of water. The latter position contributes to the intense penetration of the magnetized water in the micro capillaries and cracks, which leads to the destruction of scum.

The aim of the study is determination of the necessary structural parameters of the equipment, the magnitude of the distance between the electrodes, the free cross-sectional area, the contact surface length and the technological modes of water treatment (voltage of electric current, processing time, electric current).

3. Method of experimental studies
For research it is necessary to confirm: parameters of the system to be measured: costs, speed, stiffness, chemical composition, temperature and dry water balance before and after treatment, and also distillate of this water; the electric field strength between the electrodes, the voltage on the electrodes, the electric current; magnetic field strength; degree of coagulation.

In the experimental study, water treatment was carried out in the field of constant electric current. Subsequent experiments were carried out with artesian highly mineralized fluid in the apparatus jointly with the laboratory of the Desniansk pipeline. Electro-coagulation method of treatment of mineralized water with further processing in a magnetic field was investigated [5].

Under the influence of electric current, positively charged ions (Fe ++, Fe ++++) are isolated from the cathode coating, which form coagulation complexes with negatively charged ions present in water. Coagulation complexes fall into the precipitate. In the installation with a dispersed nozzle, the precipitate is removed from the installation. The presence of a disperse nozzle intensifies massion-exchange processes in the apparatus.

Efficiency of water treatment in the field of constant current: the voltage between the electrodes is not more than 3 V, the electric field intensity 300 ÷ 500 V/m, the processing time is about 60 ÷ 70 s.

Results of electro-coagulation treatment of water in the field of constant current:
- electrodes: anode, steel 10X18HT, cathode - steel 10X18HT,
- potential difference between electrodes U = 3 B;
- distance between electrodes $d = 10$ mm;
- field strength $E = 300$ V/m followed by heating the water to $t = 30$ °C and its filtration.

Results of electrophoretic sequential treatment of water in the field of constant electric current followed by processing in a magnetic field:
- electrodes: anode - steel 10X6HT (nickel less), cathode - steel 10X18HT,
- difference of potentials between electrodes $U = 3$ V;
- distance between electrodes $l = 10$ mm; the field strength $E = 300$ V/m and in the magnetic field the field strength is 240 mT.

These methods of water treatment can be used in technological schemes of geothermal heat supply, based on which the obtaining of clean water - the technique of processing it in the electromagnetic field before its consumption, the task of improving the technological process by: switching to theoretically grounded current frequencies in electromagnets; water treatment in the field of constant electric current at a potential difference between electrodes $U \leq 3$ V for reaching $pH \leq 6.0$ in the process of its magnetization [5].

The basis of the system of magnetic water treatment before its consumption is the task of improving the technological processes by:
- the transition to the theoretically grounded current frequencies in electromagnets $1.0 \div (X)$ kHz, which coincides with sufficient accuracy to the values of the required frequencies in [5] and the intensity (induction) of the magnetic field $200 \div (X)$ mT, which coincides with the results of theoretical studies of processes in weakly magnetic bodies, which include water, oxygen atoms which have paramagnetic properties and the results of experimental and industrial research [6];
- water treatment in the field of constant current at different potentials between electrodes $U \leq (X)$ U for reaching $pH \leq 6.0$ in the process of its magnetization. The essence of the proposed system is explained by the scheme of water treatment system using electromagnetic fields.

Energy system of cities are the main consumers of electric and thermal energy. But in the consumption of energy there are losses and it is due to the fact of the low efficiency of the heat pipes in the distribution of hot water and steam for industrial and household structures in urban areas [6]. The author emphasizes that a certain role in energy savings can be obtained by conversion of city production. That is, such achievements are obtained by using reagent-free water treatment with electromagnetic fields in the heating systems [5]. Previous established scientific laws of obtaining magnetic water and possibilities of their practical use give possibility to state that energy-thermal processes of heating systems at presence of multi-component and multi-level components of the system (intention-production-society-nature) are related to such disciplines: energy, engineering, ecology, economy. Therefore, the principle of consistency is the leading principle at studying such multi-component complex, which given the concept of mass transfer provides an approach to them.

Mass transfer processes in the heating system are associated with the transfer (of substance or mass of magnetic water) from one phase to another (solid - liquid). Diffusion mass transfer of components of the heating system [6] is characterized by the change in free energy in these components, individual parts of the system. As a result of these processes there is a change, specific of volume, free energy of a component of the parameter that best reflects the physical basis of this phenomenon. In addition, the use of the ideas of thermodynamics allows us to conclude that all spontaneous processes in the heating system go in one direction from an ordered state to disordered state [7, 8, 9].

Multi-factorial state of the components of the process of magnetization of water and multilevel nature of the relationships between them causes the establishment of the main principles of management decisions on optimization of production activities in the preparation. Of the water [6] in heating systems we deepened the knowledge about the fundamental interactions of material flows in the process of obtaining magnetic water under certain physical parameters. Thus, the electromagnetic interaction is
due to electric and magnetic fields: electric field and its appearance is the presence of electric charges and magnetic field in their motion. Physical processes confirm the interaction, in our case, of separate components of the electromagnetic interaction parameters and their specific indicators of the overall additive component functions of the process of magnetization of water [6]. To assess and compare the dynamics of changes of the process of magnetization of water in systems engineering, it is convenient to use specific indicators. As to the levels of acceptability of specific indicators it is necessary to add, that their function is growing monotonically to some value of its argument - order material flows magnetization of water, as well as for preliminary levels. Taking into account the specific technological parameters of magnetization and, given the hierarchical approaches of multi-factor components (specific indicators - the index of correlation between technology flows), we have found the optimal limits of structural-functional state changes of the heating system. The estimated level – graduation is a landmark to maintain reagent-free water treatment according to certain parameters and their specific indicators.

Establishment of the maximum gradations of the process of water magnetization became possible thanks to our systematic approach in conducting and evaluating nonchemical water treatment in electromagnetic fields. However, the direction of the goal – the preservation of mass transfer order of material flows is carried out by electromagnetic interaction by getting the relevant information based on the feedback of this mechanism of feedback characterized by the properties of negative feedback loop, and therefore auto regulation of the processes of magnetization of water takes place continuously. That is, identifying positive and negative features (gradations) of preparation of technical water in electromagnetic fields of a heat supply determines the feasibility of water treatment in the application of the appropriate method.

A very important principle of environmental management, which is implemented in this technology, is not only obtaining of expected material and energy feedbacks to enhance mass transfer processes, but also saving natural and energy resources. We have proposed technologies manufacture using high-frequency electromagnetic devices for magnifying "I" ("Votali"), as well as the device "II" ("Kalmat", company "Edelweiss"). Magnetic water was received on the stand with two devices that can operate independently from each other (figure 1) [6]. The task of the research is to carries out comparative studies of the optimization process of magnetic water according to this technology, field parameters.

![Figure 1. A stand for magnetic water preparation: 1 - device "Illios"; 2 – device "Kalmat"; 3 - water; 4 - valve](image)

Environmental management of production processes is directly connected with environmental and economic issues. The ecological and biological components of a potential man-made hazards include biological formations, which are formed through reagent treatment of water in heating systems and in the transition to reagent less preparation of water in heat supply systems they are reduced due to the breakage of the biomass that affects material flows (precipitation) of magnetic water.

Considering the issue of anthropogenic impacts from thermal power equipment, the use of reagent-free water treatment with electromagnetic fields, it can be stated that virtually there is no direct impact on the atmosphere on local-territorial level. One can only you attest to the presence of mediated effects,
regarding the use of natural resources and energy, the nature of the change which is of positive nature, a significant level of safety.

4. Conclusions
The methodology, processing of geothermal energy for energy-thermal objects with high energy efficiency for all industries, in particular for construction, with increased environmental properties with magnetic water treatment [5] is proposed.

Areas of application: thermal objects (in water and steam systems of heat supply, for prevention and destruction of scale and deposits on heat exchange surfaces, prevention of corrosion of metal surfaces, damage to polymeric and other materials).

The water treatment system using electromagnetic fields has been used in many test series and has shown energy savings, water consumption and materials.

Properties of magnetized water lead to an increase in the speed and amount of water entering the capillaries and bind to the surfaces. In micro-capulars there is a large osmotic pressure (up to 40 atm), which leads to the destruction of the walls of the capillaries of capillary-porous bodies, such as scum. As pilot projects have shown, energy savings reach 40%, materials and water up to 25%.

The scientific principles of the structural and thermophysical properties of water under influence of temperature and electric fields are developed.

References
[1] REN21. 2014. Renewables 2014 Global Status Report (Paris: REN21 Secretariat). ISBN 978-3-9815934-2-6., p. 214, 2014.
[2] “Power engineering: history, present and future”. Kн. 5/2.8. Geothermal energy, 2013.
[3] Y. G. Dorfman, “Magnetic properties and structure of matter”, State Publishing House of Technical and Technical Literature, p. 377, 1955.
[4] Y. I. Frenkel, “Kinetic theory of liquids”, AN SSSR, p. 409, 1966.
[5] E. S. Malkin, I. E. Furtat, N. Zhuravska, “The system of preparation of magnetized water in the electromagnetic fields of water and solutions and compounds based on it”, the patent for useful model 102494, 2015.
[6] E. S. Malkin, “Preparation and use of magnetized water”, Bulletin of National University of water management and nature. Vol.1(69). Rivne: Educational and scientific Institute of correspondence distance learning of the National University of water management and nature resources use, pp. 66-72, 2015.
[7] N. Zhuravska, “Use of resource-saving ecological-economic technologies with magnetic processing of water in various industries”, The International Conference IV Underwater Technologies. KNUCA, pp. 52-55, 2018.
[8] P. Kulikov, “Environmental management of production processes in heating systems when receiving magnetic water in reagent-free method with the aim of environmentalization”, International journal of engineering and technology (UAE). Vol. 7, no 3.2. pp. 621-625, 2018.
[9] M. Mykytias, “Models, methods and tools of optimizing costs for development of clusterized organizational structures in construction industry”, International journal of engineering and technology (UAE). Vol. 7, № 3.2. pp. 250-254, 2018.