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INTENSIFICATION OF WATER TREATMENT TECHNOLOGY BY DISCRETE-PULSE ENERGY INPUT

ІНТЕНСИФІКАЦІЯ ТЕХНОЛОГІЇ ПІДГОТОВКИ ВОДИ ШЛЯХОМ ДИСКРЕТНО-ІМПУЛЬСНОГО ВВЕДЕННЯ ЕНЕРГІЇ

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Annotation. *The application of the method of discrete-pulse energy input for neutralization of the condensate of natural gas combustion products, intensification of aeration treatment of water during purification from iron and manganese ions and reducing the total water hardness is considered. It established that the application of this method allows effectively neutralize condensate by removing dissolved carbonic acid without adding reagents, reduce the total hardness of water as well as to intensify the process of water purification from iron and manganese ions in industrial conditions.*

Keywords: *discrete-pulse energy input, condensate, water, carbonic acid, neutralization, aeration, iron, manganese, rotary-pulse apparatus, ammonium hydroxide, total water hardness.*

The Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine has launched a new scientific field known as the principle of discrete-pulse energy input (DPEI). Within this area, about 50 innovative technologies and more than 900 units of energy-efficient equipment designed and implemented, which successfully used in various industries.

A number of physical phenomena, such as adiabatic boiling and cavitation, accompanied by shear stresses and perturbation of the interfacial surface, developed contact surface of gas-liquid phases, etc. realized in the devices developed within this direction. The study of the influence of DPEI mechanisms on the properties of water and water systems revealed a change in some of their physicochemical properties, in particular, increasing the hydrogen index (pH) while maintaining its stable value for a

long time (up to two years). The use of the DPEI method in water aeration creates a fine-bubble water-air suspension with a significant contact surface, which intensifies the process of water saturation with oxygen. This technology used in the separation of dissolved iron from water.

Today in Ukraine, the issue of modernization of the energy sector, in particular, industrial and municipal gas boilers to reduce natural gas consumption is relevant. To solve this problem it proposed to operate them in the mode of deep utilization of flue gas (condensing mode) by equipping with heat recovery. This will increase the efficiency of boilers by 5÷6 percentage and reduce natural gas consumption by about 500 million m^3 per year.

However, when operating boilers in the mode of deep heat recovery from flue gases, as a result of contact of water vapor formed during the combustion reaction of gas with other combustion products, condensate with pronounced acidic properties (pH=3.8÷4.9) is formed. Given the solubility of individual components of combustion products in water, as well as the design of modern gas boilers and fuel combustion methods aimed at minimizing the formation of nitrogen oxides and carbon monoxide, it can considered that the formed condensate is an aqueous solution of carbonic acid with relatively few impurities.

The volume of condensate formed is approximately 145 l/h for a boiler with a capacity of 1000 kW and increases in proportion to the increase in boiler power. Given the acidity of this condensate, it can`t be drained into the sewer without prior neutralization. In modern practice, neutralization is carried out by passing acidic condensate through a layer of neutralizing reagent (for boilers up to 1000 kW) or dosing liquid reagent (for boilers over 1000 kW), which involves additional costs for neutralizing reagent and contamination of reaction products.

The condensate can be neutralized using absorption devices (decarbonizers), but this method of neutralization is associated with significant specific material and energy costs.

The proposed method of neutralizing condensate, developed at the Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine based on the DPEI principle, based on physical impact on the treated environment without the use of chemical reagents and implemented in high-efficiency small equipment with low specific energy consumption. The use of such DPEI mechanisms as high-frequency hydrodynamic oscillations accompanied by high circumferential velocities and shear stresses, as well as transient phase transitions allows reducing the carbonic acid content to a neutral pH value [1].

In Fig. 1 shows the dependence of the change in the pH of condensate on the duration of treatment. At a final pH value of 6.5 for the condensate, the dissolved carbon dioxide content is 0.03 mg/l (the initial dissolved carbon dioxide content in the condensate at pH 4.7 was 62 mg/l).

Thousands of medium and low-capacity steam and hot water boilers operate in the country's industry, municipal energy, and agriculture. Their reliable operation largely determined by the maintenance of a rational water-chemical regime.

The transparency of water, its hardness, the content of iron and copper, the amount of dissolved oxygen in water, the pH value, and the content of petroleum

products regulated.

The high content of dissolved iron (usually with manganese) in water leads to the formation of sludge during its oxidation, which settles on surfaces. Together with scale, these deposits reduce the diameter of the pipes, thicken the walls of the boilers, clog the filters, and clog the water inside the boiler. Requirements for iron content in feed water for different types of boiler equipment are different and range mainly from 0.03 to 0.6 mg/l.

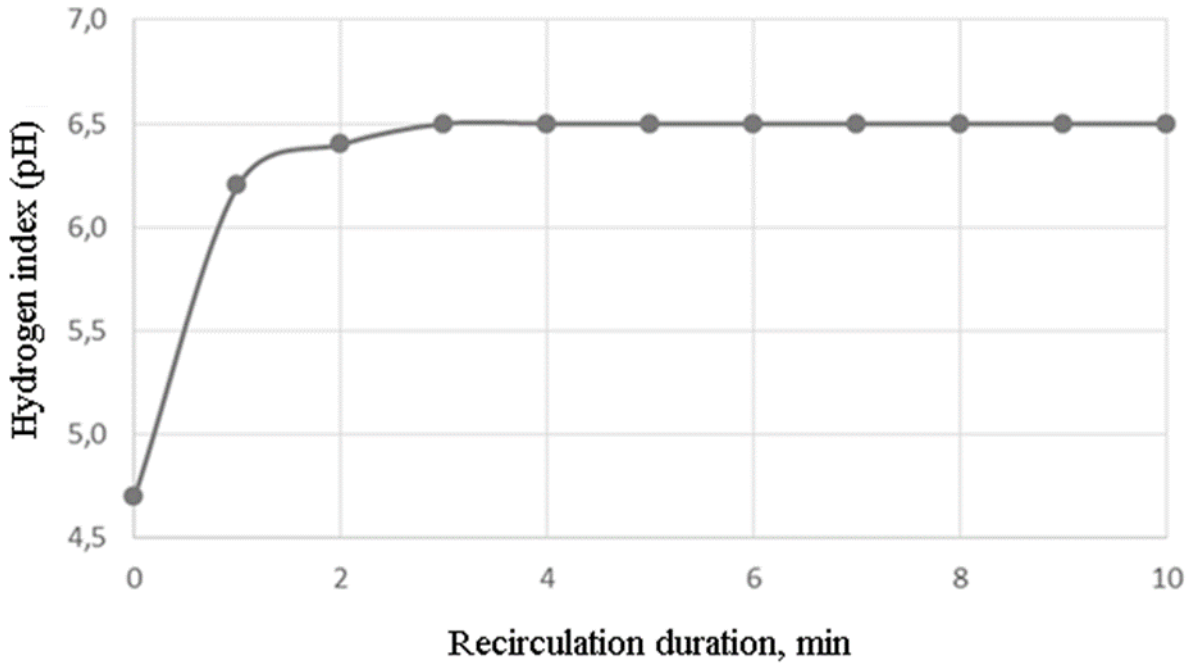

Figure 1 – Changing the pH of condensate after treatment with the DPEI method

Author's development

Intensification of the iron removal from artesian water took place in aeration-oxidation unit of rotary type [2]. In fig. 2 shows the dependence of the change in the concentration of iron ions in water on the number of processing cycles at different speeds of rotor rotation.

The results of studies have shown that the treatment of water in the aerator-oxidant can effectively reduce the concentration of iron ions in water. Thus, at an angular velocity of rotor 3300 rpm, the concentration of iron ions in one treatment cycle decreases from 3.5 to 0.25 mg / l. With the reduction of the angular velocity to 2700 rpm and 2100 rpm to achieve the desired result (≤0.3 mg/l) it is necessary to increase the number of treatment cycles.

Water treatment for energy facilities has become especially important today. Physical and chemical properties of water and steam largely determine the service life of equipment. Scale, oxygen and carbonic acid corrosion lead to reduced heat transfer, reduced service life and equipment failure, increased heat loss. Dissolved in water oxygen and carbon dioxide increase the rate of corrosion of steel, especially at elevated temperatures. Research on the use of the method of discrete-pulse energy input to reduce water hardness conducted at the Institute of Technical Thermophysics of the National Academy of Sciences of Ukraine [2, 3].

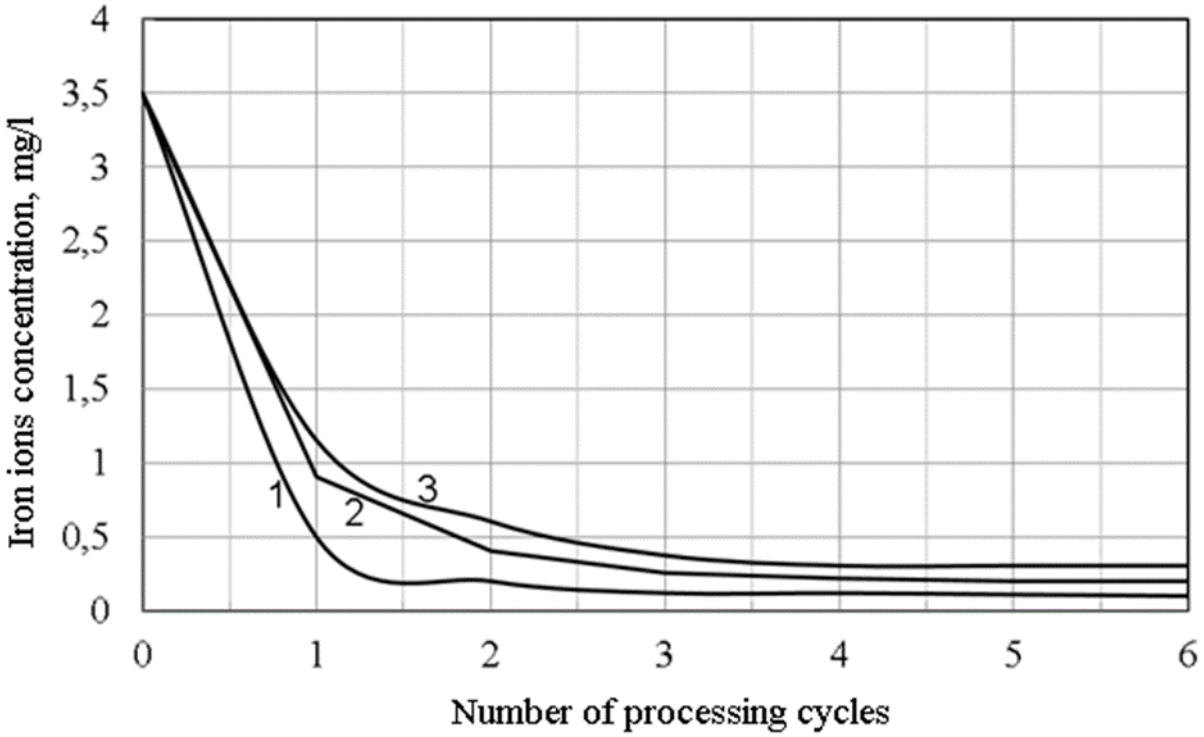

Figure 2 – Dependence of changes in the concentration of iron ions in water on the number of processing cycles at rotor rotation speed:
***1** – 3300 rpm; **2** – 2700 rpm; **3** – 2100 rpm*

Author's development

Table 1 shows the results of changes in physicochemical parameters of artesian water depending on the time of treatment by discrete-pulse energy input in the rotor-pulsation apparatus (thickness of the inter-cylinder gap 100 μm) [3] at an initial temperature of 20°C.

An additional experimental study found that the addition to artesian water of ammonia hydrate in amount of 0.01% mass under the same conditions leads to an increase in pH and a decrease in overall hardness (table 1).

Table 1 - Physico-chemical parameters of artesian water under different processing conditions using the method of discrete-pulse energy input

Indicator	Source water	One-time treatment (1 cycle)	Processing for 5 cycles	Treatment of 5 cycles with 0.01%mass ammonium hydroxide	Regulatory indicators of feed water for boilers
Hydrogen index (pH)	7,12	7,51	7,81	9,05	8,5÷10,5
Total hardness, °H	1,8	1,74	1,72	0,36	0,04

Source: [3], author's development (treatment of 5 cycles with 0.01%mass ammonium hydroxide).

Conclusions.

1. Implementation of the condensate neutralization apparatus will improve the environment by reducing the amount of harmful wastewater (chemically contaminated neutralized condensate and wastewater softening apparatus), rational use of water resources by saving up to 8.5 million m^3 of water in case of reuse of neutralized condensate.

2. The high efficiency of the DPEI method in the process of aeration water treatment confirmed, which allows intensifying the process of its purification from iron and manganese ions in industrial conditions.

3. Addition to water of ammonium hydroxide in amount of 0.01%mass followed by processing using the method of discrete-pulse energy input in the rotor-pulsation apparatus provides a significant reduction in water hardness.

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Анотація. *В статті розглянуто застосування методу дискретно-імпульсного введення енергії для нейтралізації конденсату продуктів згоряння природного газу, інтенсифікації аераційної обробки води при очищення від іонів заліза та марганцю і зниження її загальної жорсткості. Наведені фізичні явища, що виникають при роботі даного методу і їх вплив на властивості водних систем. Обґрунтовано доцільність застосування методу для нейтралізації конденсату продуктів згоряння природного газу, що дасть змогу підвищити ефективність роботи котлів на 5÷6% і скоротити споживання природного газу приблизно на 500 млн. м^3 протягом року, а також поліпшити стан довкілля за рахунок зменшення кількості шкідливих стоків (хімічно забрудненого нейтралізованого конденсату і відходів установок пом'якшення води) і раціонально використовувати водні ресурси шляхом економії до 8,5 млн. м^3 води у випадку повторного використання нейтралізованого конденсату. Досліджено влив методу на інтенсифікацію процесу знезалізнення артезіанської води в аераційно-окиснювальній установці роторного типу. Виявлено, що при кутовій швидкості обертання ротора 3300 об/хв концентрація іонів заліза за один цикл обробки знижується з 3,5 до 0,25 мг/л. Зі зменшенням кутової швидкості до 2700 об/хв та 2100 об/хв для досягнення бажаного результату (≤0,3 мг/л) необхідно збільшувати кількість циклів обробки. Встановлено, що застосування методу дискретно-імпульсного введення енергії дозволяє ефективно нейтралізувати конденсат шляхом вилучення розчиненої вуглекислоти без додавання реагентів, більш ефективно знижувати жорсткість води шляхом її обробки даним методом з додаванням гідроксиду амонію, а також інтенсифікувати процес очищення води від іонів заліза та марганцю в промислових умовах.*

Ключові слова: *дискретно-імпульсне введення енергії, конденсат, вода, вугільна кислота, нейтралізація, аерація, залізо, марганець, роторно-пульсаційний апарат, гідроксид амонію, загальна жорсткість води.*

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