International Journal of Chemistry, Mathematics and Physics (IJCMP)
[Vol-8, Issue-1, Jan-Mar, 2024]
https://dx.doi.org/10.22161/ijcmp.8.1.2
ISSN: 2456-866X

Calculation and Design of Reagent Activator

Stanislav Dushkin

Department of Applied Mechanics and Environmental Protection Technology, National University of Civil Defence of Ukraine, Kharkiv, Ukraine
Email: d.akass@ukr.net

Received: 18 Jan 2024; Received in revised form: 25 Feb 2024; Accepted: 10 Mar 2023; Available online: 20 Mar 2024

Abstract**—** *The problems of analysis and design of the activator reagent used to improve natural water purification in water systems. The questions of calculation and planning of the activator reagents, which used for the increase of efficiency of treatment of natural waters in the water systems, are examined.*

Keywords**— *Water treatment, Activated solutions, Coagulation, Reagent activator.***

I. INTRODUCTION

Analysis of the operation of treatment facilities has shown that the disadvantages of reagent-based water clarification and decolourisation are significant dimensions of the reagent farm, high consumption of reagent, especially at low temperatures, as well as during spring floods and water blooming. At this time, facilities operate with a heavy load, often do not provide the required degree of water purification and design capacity of treatment facilities [1].

The use of activated solutions of reagents has shown that water treatment with activated coagulant solutions allows to reduce their doses, improve the quality of water clarification, increase the productivity of treatment facilities, reduce the size of the reagent farm of water treatment facilities [2, 3].

The purpose of this work is to develop a method of calculation and design of reagent activator, which provides sequential activation of the initial solution of coagulant by magnetic field and electrocoagulation.

The method of calculation of the reactant activator is tested on a prototype at the water treatment plant [4, 5].

II. EXPERIMENTAL

The scheme of the magnetic activator is shown in Fig. 1. The device consists of a cylindrical magnetically conducting body 1 and a magnetic system installed on it, including pole lugs 2, 3, core 4, magnetic coil 5 and diamagnetic plate 6 with waterproofing gaskets 7. The pole lugs 2 are connected to the housing and the core 4. The other pole lug 3 is connected to the casing 1 through the diamagnetic plate 6 having waterproofing gaskets 7.

The device works as follows: when current is applied to the magnetising coil 5, an electric current flows through its winding, causing magnetic flux in the core 4 and in the pole lugs 2, 3. The magnetic flux passing through the core 4, pole lug 2, housing 1 and the opposite lug 3 forms a closed magnetic circuit, which makes it possible to expose the treated liquid to the magnetic field.

After exposure to the coagulant solution magnetic field, the latter is directed into a special electrocoagulator, the constructional scheme of which is shown in Fig. 2. Electrocoagulator coagulant solution consists of 2 sections, through which the magnetised coagulant solution is successively passed, which is saturated with anodic dissolved iron.

The electrocoagulator body and cover are made of 20-30 mm thick plexiglass. Inside the housing there are overflow and passage bridges made of plexiglass. In the cover of the electrocoagulator body there are fittings and bushings for hydrogen discharge and wire supply for current supply to the anode plates. The electrocoagulator traverse is used to connect metal anode plates in a package and to supply them with electric power.

Bonding of individual parts is made with dichloroethane, anode plates of 6 pieces are made of steel 3 with thickness of 5 mm.

Plate and other electrolysers can be used as electrocoagulator.

Reagent activator is installed on the reagent pipeline before feeding the coagulant solution into the mixer [6].

Calculation of magnetic parameters of reagent activators of the experimental unit is performed for one magnetising coil, which creates an independent magnetic circuit.

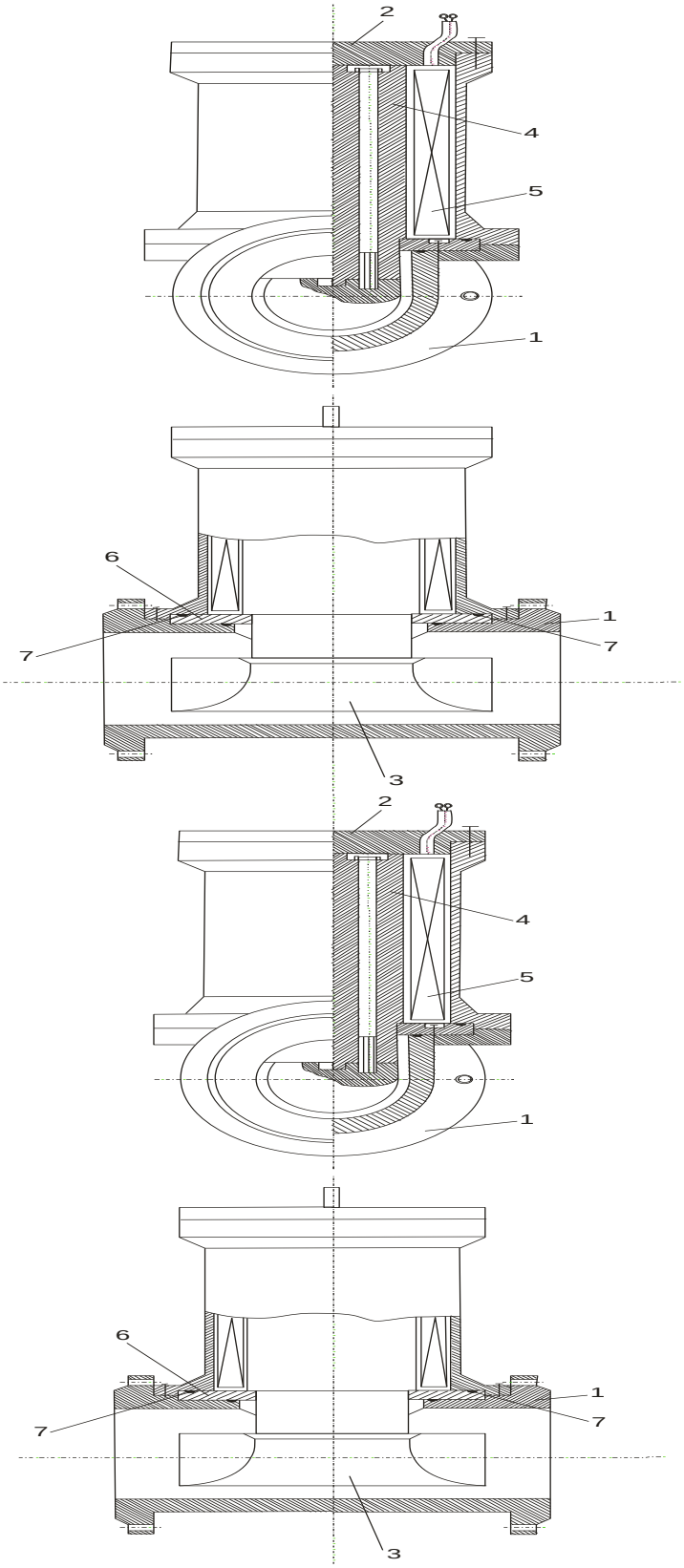

Fig. 1 - Magnetic solution treatment device

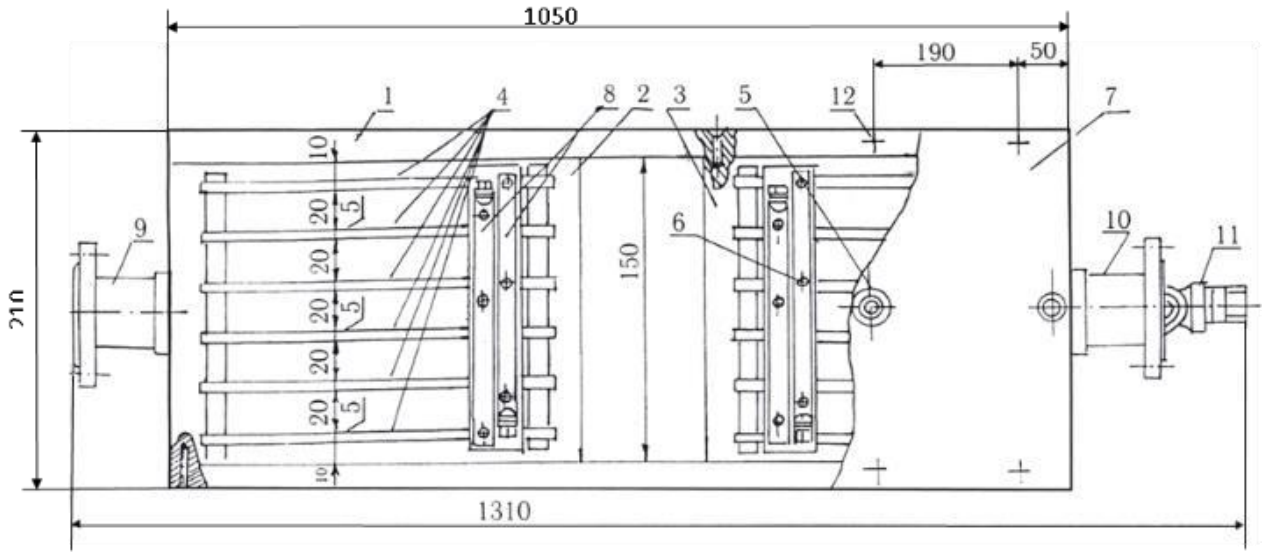

Fig. 2 - Schematic diagram of the electrocoagulator of the reagent

1-case of the electrocoagulator; 2, 3-bar overflow and pass-through; 4-plate; 5-nipple for hydrogen withdrawal; 6-sleeve; 7-cap; 8-connecting terminal; 9, 10-outlet and inlet pipe; 11-drain cock; 12-fastening bolts.

III. RESULT AND DISCUSSION

Calculation of magnetic parameters of reactant activators of the experimental unit is performed for one magnetising coil, which creates an independent magnetic circuit.

The calculation was performed on the basis of the laws of magnetic circuit. Separate sections of the magnetic circuit were calculated on the basis of the given value of the magnetic field strength in the working zone and the actual induction in separate sections of the magnetic circuit (Fig. 3).

The magnetic potential drop was determined by the equation:

$$Hl = \frac{\Phi}{\mu \cdot S} \cdot l = F, \quad (1)$$

where H - magnetic field strength, kA/m;

l - is the length of the considered section of the magnetic core, cm;

Φ - magnetic flux, Wb;

μ - magnetic permeability of the material of the section of the magnetic core or the of the air gap, $\frac{Wb}{A/cm}$;

S - cross-section of the calculated section of the magnetic core, cm^2;

F - magnetising force of the coil of the activator electromagnetic system, A.

The magnetising force of the electromagnet coil required to create magnetic flux in the working gap of the activator was determined by the ratio:

$$F = \frac{\sum \Phi}{\sum G}, \quad (2)$$

where F is the magnetising force of the coil of the activator electromagnetic system, A;

$\sum \Phi$ - is the total calculated magnetic flux of one magnetic circuit, Wb;

$\sum G$ - total conductivity of the magnetic circuit, Wb/A.

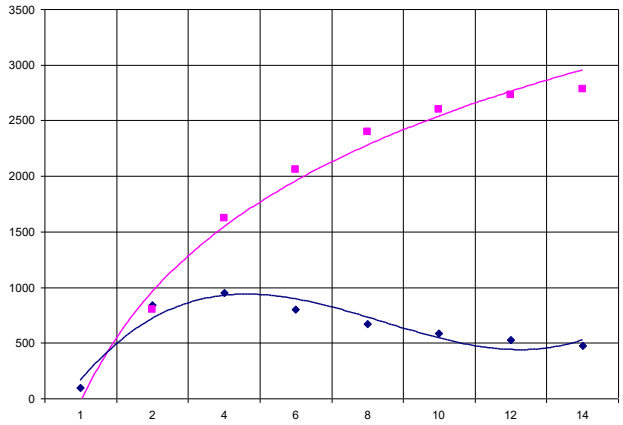

Fig. 3 - Dependence of induction and magnetic permeability for steel St2 and St3

♦ magnetic induction, B (gs=10^{-8} Wb s/cm^2),

■ magnetic permeability, μ (10^{-8} Wb/A cm)

Based on the given magnetic field strength, the magnetic flux (Φ_1), flux in the edge gaps (Φ_2) and magnetic leakage flux (Φ_3) in the working zone of the activator were determined by the equation

$$\sum \Phi = \Phi_1 + \Phi_2 + \Phi_3 , \quad (3)$$

Magnetic conductivity of ferromagnetic sections of the activator magnetic circuit (external magnetic conductor, core) was calculated by the formula:

$$G = \mu_{St} \frac{S_м}{L_м} \quad (4)$$

Where G - magnetic conductivity of the ferromagnetic section of the magnetic circuit, Wb/A;

μ_{St} - is the magnetic conductivity of steel at the corresponding induction "B", taken from the curves relative to magnetic induction according to Fig. 3.;

$S_м$ - cross-sectional area of the magnetic core, cm^2;

$L_м$ - length of the magnetic core, cm.

The magnetic conductivity of air gaps is determined by the formula:

$$G = \mu_o \frac{q_n}{\delta} , \quad (5)$$

where G - conductivity of the air gap, Wb/A;

q_n - magnetic flux cross-section, cm^2;

δ - air gap (value of the magnetic field line path in the air), cm;

μ - magnetic permeability of air, Wb/A cm (μ =1,26·10^{-8} Wb/A cm).

Calculation of conductivity of air gaps of separate sections of the magnetic circuit (including conductivity of edge gaps) was performed according to the formulas given in technical literature and others.

The conductivity of the figure having the shape of a quarter cylinder was determined by the formula:

$$G = \mu_o \cdot 0{,}52 \cdot l , \quad (6)$$

quarter of a hollow cylinder:

$$G = \mu_o \frac{2l}{\pi\left(\frac{\delta}{m} + 0{,}5\right)} , \quad (7)$$

where l, δ - design dimensions of the magnetic core;

m - coefficient, accepted in the range of 1-2.

The magnetising force of the coil of electromagnets was determined with the reserve coefficient (K_1 = 1.2) for the unaccounted leakage fluxes etc.

$$F = \sum \Phi \cdot \sum R \cdot K_1 , \quad (8)$$

where F is the magnetising force of the coil, A;

Φ - total calculated magnetic flux of one magnetic circuit, Wb;

$\sum \Phi$ - total magnetic resistance of one magnetic circuit, A/Wb;

$\sum R$ - reserve factor, taking into account unaccounted magnetic fluxes and dissipation fluxes.

Calculation of the magnetising coil consisted in determining:

- cross-section of the winding wire:

$$S_{cu} = \frac{F \cdot l_{cs} \cdot \rho}{U_n} , \quad (9)$$

where S_{cu} - cross-section of the wire (copper), mm^2;

F - magnetising force of the electromagnet coil, A;

l_{cs} - average length of one coil of the winding wire, m;

ρ - specific electrical resistance of wire material (copper), Om·mm^2/m;

U_n - nominal voltage of the power supply source, V

- number of coil turns:

$$W = \frac{F}{\gamma \cdot S_n} , \quad (10)$$

where F - magnetising force of the coil, A;

γ - current density, A/mm^2;

S_n - cross-section of the winding wire, mm^2;

- numbers of turns in a row of the magnetising coil:

$$W_p = \frac{b}{K_2 \cdot d_n} , \quad (11)$$

where b - structural size of the frame, mm;

d_n - diameter of the winding wire with insulation, mm;

K_2 - coefficient of unevenness of laying (K_2 =1,1-1,2);

- number of layers of the magnetising coil wire:

$$n = \frac{W}{K_3 \cdot W_p}, \quad (12)$$

where is the coefficient of laying reserve;

K_3 - coil resistance, Om:

$$R_k = \rho \frac{l_{cs} \cdot W}{S_n}, \quad (13)$$

- design current (A) and power consumption (W):

$$I = \frac{U_n}{R_k}, \quad (14)$$

$$P = m \cdot I \cdot U_n, \quad (15)$$

where *m* is the number of magnetising coils.

Electrical and other parameters of the magnetic activator electrocoagulator were determined according to the method described earlier. At the same time, the current intensity supplied to the electrocoagulator should be sufficient to obtain the required amount of anodic dissolved iron in accordance with the technological maps of magnetic-electrical activation of reagent solutions. For the reactant activator on the basis of operational tests, special nomograms have been developed to select the current supplied to the electrocoagulator, the concentration of aluminous coagulant and the calculated saturation of the solution with anodic dissolved iron (Fig. 4,5).

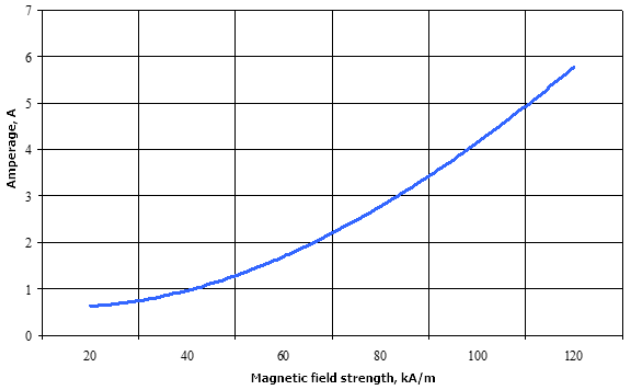

Fig. 4 - Variation of the magnetic field strength in the working gap of the reactant activator depending on the current applied to the magnetising coil

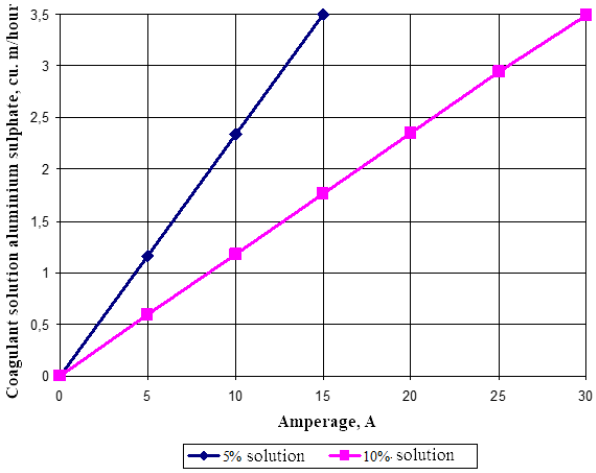

Fig. 5 - Nomograms for the choice of the current applied to the electrocoagulator of the reagent activator at different concentrations of aluminous coagulant

IV. CONCLUSION

1. For activation of reagent solutions used in the process of water treatment, a special device has been developed that provides for sequential activation of the initial solution by magnetic field and electrocoagulation.

2 The reactant activator is installed on the reagent pipeline before feeding the coagulant solution into the mixer.

3 The method of calculation of the reactant activator is tested on a prototype at the water treatment plant.

REFERENCES

[1] Tugay A.M., Orlov V.O. Water Supply. (2008). 735.

[2] Epoyan S.M., Dushkin S.S. Influence of activated solutions of sulphate and aluminium oxychloride on water clarification efficiency. 2012. Kharkiv. KHNUBA. HOTV ABU, Issue 69. 348-352.

[3] Stanislav Dushkin. Study of the process of activation of aluminum sulfate coagulant solutions during filtration on rapid filters. International Journal of Chemistry, Mathematics and Physics (IJCMP). [Vol-7, Issue-6, Nov-Dec, 2023]. https://dx.doi.org/10.22161/ijcmp.7.6.1

[4] Dushkin S.S. Methodical aspects of research in the use of activated solutions of coagulants in the process of water treatment. 2012. Kharkiv: KNAMG. Issue 105. 320-334.

[5] Epoyan S.M., Dushkin S.S. Activated solutions of reagents in the processes of natural water treatment. // Programme and abstracts of the XXXVI scientific and technical conference of teachers, graduate students and staff of the Kharkiv National Academy of Urban Economy. - Kharkov, 2012 - P. 126.

[6] Epoyan S.M., Dushkin S.S. Technological schemes of water purification, conditions of their application. 2012. "Vodopostachannya ta vodovidvedennya". No. 4. 8-10.