The filtration efficiency of porous permeable materials of saponite – titanium system composite

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Abstract
The paper presents the calculations of composite system saponite - titanium filtering process. The efficiency of the porous permeable materials filtering is proved. The possibility of computer simulation of the experimental data is shown in the article.
Keywords: PROCESS, COMPOSITE, SYSTEM, SAPONITE – TITANIUM, POROUS PERMEABLE MATERIALS, SIMULATION

Introduction

Based on the analysis of the processes forming as a result of drinking water filtration we determine the filtration efficiency of porous permeable materials of saponite – titanium system composite. The filtration efficiency of permeable porous material consists of the water filtering, impurities removal, adhesion and separation impurities from the surface, determination of porosity and permeability [1].

The aim of the article is to determine the fluid condition in the porous permeable material for saponite - titanium composite.

Analysis of research. The suspension filtering rate is determined by Darcy law. According to this law the amount of liquid or gas is proportional to the hydrodynamic pressure drop in the fluid flow direction:

$$v_n = -k\frac{\partial p}{\partial n}, \quad (1)$$

where p – pressure, n – normal to the unit area, k – filtration coefficient.

Underlining of unsolved. In the existing law of determining the suspension filtration rate is assumed that the liquid and impurities do not change their physical properties, the rate of impurities motion is equal to real liquid velocity, the precipitate has a loose structure and transform the movable liquid in the motionless condition, the precipitate porosity ε is considered to be constant.

Main material. Complex system (Fig. 1) consists of porous permeable materials, mobile water contained in the pores, released impurities particles that move with the water flow, still water associated with the precipitate, the precipitate that has fallen on the porous permeable material.

The system of equations determining the change of the volume fractions *A*, *B*, *C*, *D*, *E* and particles distribution *P* of filter flow is expressed by:

$$m_0 \frac{\partial B}{\partial n} = -\frac{\partial}{\partial x}\left(\frac{B}{B+C} v_n\right) - G_{BD}, \quad (2)$$

$$m_0 \frac{\partial C}{\partial t} = -\frac{\partial}{\partial n}\left(\frac{C}{B+C} v_n\right) - G_{CE} + G_{EC}, \quad (3)$$

$$m_0 \frac{\partial D}{\partial t} = G_{BD}, \quad (4)$$

$$m_0 \frac{\partial E}{\partial t} = G_{CE} - G_{EC}, \quad (5)$$

$$\frac{\partial}{\partial n}\left(\frac{k(D,E)}{(B,C)} \frac{\partial P}{\partial n}\right) = 0, \quad (6)$$

where m_0 – the initial porosity of the porous permeable material; G_{BD} – density of liquid flow from system *B* to system *D*; G_{CE}, G_{EC} – impurities flow density; *t* – time.

The impurities flow density is directly proportional to the volume particle of impurities in a moving medium and increases linearly with raising of the filtration rate v_n:

$$G_{CE} = (\alpha + \alpha_1 v_n) \frac{C}{B+C}, \quad (7)$$

where α, α_1 – the parameters of particles precipitation rate on the surface of porous permeable materials. The flow density raises with increasing the pressure gradient and precipitate volume accumulated within a given time:

$$G_{EC} = \left(\beta + \beta_1 \frac{\partial P}{\partial n}\right) E, \quad (8)$$

where β, β_1 – parameters of impurities lifting rate from surface of the filter layer. The density of the liquid flow from moving condition to the motionless is determined by the difference between flows:

$$G_{BD} = \frac{\varepsilon}{1-\varepsilon}(G_{CE} - G_{EC}). \quad (9)$$

Impurities particles precipitation on the filtrate surface reduces the permeability of medium *k*. To write the dependence of the permeability from the flow porosity value the experimental dependence of porosity is used, which is expressed by the formula:

$$k = k_0 (1 - \sqrt{D+E})^3, \quad (10)$$

where k_0 – the initial permeability of the filter medium.

Based on the filtration efficiency of the porous permeable material of saponite - titanium system composite the numerous algorithms were created and computer programs were designed by means of which a computer study of water purification was conducted and patterns connecting the pore spaces with hydraulic resistance were defined. Water filtering is accompanied by the precipitate accumulation, reducing of medium permeability and growth of the pressure gradient (Fig. 2). At first the precipitate accumulation occurs on the inlet part of the porous permeable material. In process of saturation achieving the accumulation limit moves in the flow direction. When moving the impurities out of the porous permeable material the pressure that is necessary to maintain a constant filtration rate increases as well as the amount of impurities that have not gone out of the filter. Depending

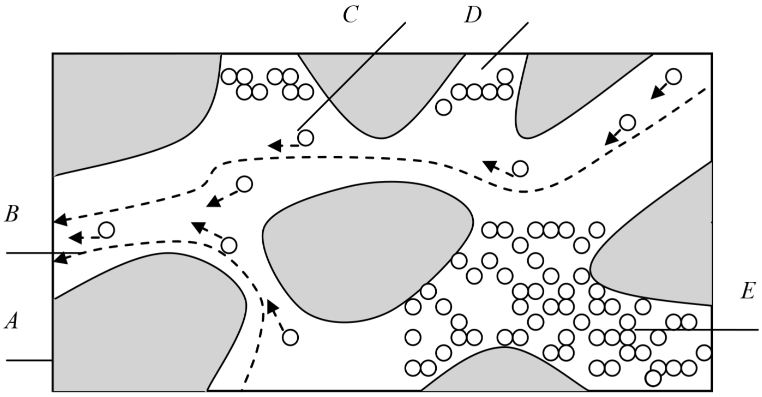

Figure 1. The scheme of the filtration efficiency of the porous permeable materials of saponite - titanium system composite: *A* - porous permeable medium; *B* - water movement; *C* - particles release; *D* - water associated with the precipitate; *E* – precipitate

on the filtration mode and mass transfer parameters there are two possible reasons for the filter operation ending: exceeding the maximum pressure or exceeding the concentration of impurities in the filter with set value [2].

Correspondence of the computer simulation experimental data results presented in the literature and obtained by the author confirms the correctness of the calculations [3].

On the basis of the study the precipitate porosity is calculated as 240, which indicates the formation of a very loose structure. We can draw a conclusion that the main impurity load falls on the first layer of porous permeable material.

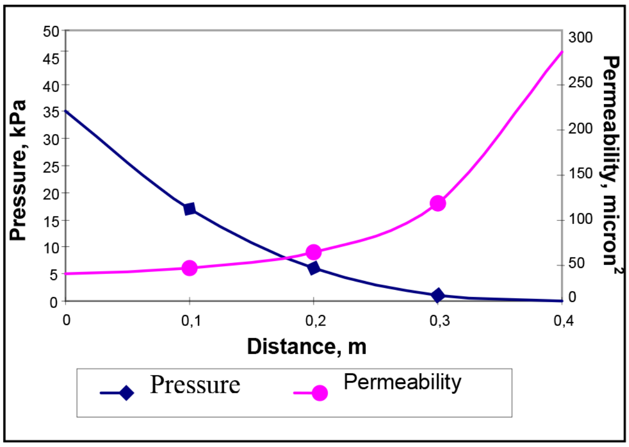

Figure 2. Distribution of permeability *k* and pressure *P*

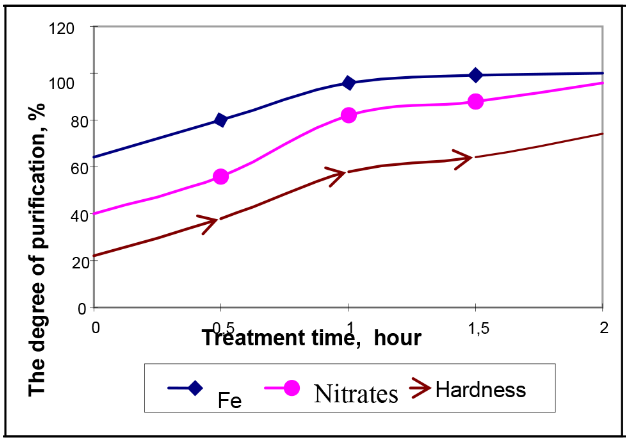

Figure 3. Influence of high-frequency electric treatment on the degree of water purification

Conclusions

The result of simulation and physico-chemical studying of precipitate properties shows that to increase dirt-holding capacity of the filter it is necessary to optimize coagulation and precipitation modes with increasing the particle volume of the solid precipitate phase [4]. For this purpose the electric treatment aimed at the impact of water treatment processes when impurities removing has been used.

Under laboratory conditions action of the frequency electrochemical neutraliser of the original design has been studied. Unlike conventional electrochemical devices electrolyzers allow us to affect the water pollution by specially shaped impulses. The essence of the process is as follows: a primary water is prepurified and subjected to electrochemical treatment with direct current density of 50-500 A/m^2 using the insoluble anodes such as stainless steel, titanium or other metals, which are almost insoluble under the influence of electric current. Anode space is filled with powder of metal oxide from the group of iron, zinc, cobalt, zirconium (in amount of 0.5-10 g powder per 1 sm^2 of the anode area). This leads to the exclusion of anode passivation and reduces its costs due to the lack of formation of metal hydroxides on the electrodes. Influence of high-frequency electric treatment on the degree of water purification is shown in Fig. 3.

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