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SPECTRAL CHARACTERISTIC OF OSCILLATORY WATER FLOW IN CAPILLARIES

The results of spectral analysis of the experimental data of the oscillatory nature of the water flow in the capillary with a diameter of 30 microns are given. The change in the frequency response of natural oscillations of the rate of water flow through the capillary in time is shown.

The filtration rate of water through a layer of fine suspensions sludge decreases over time [2]. This phenomenon can't be explained by the compressibility of sediment or the redistribution of fine particles in height of filtered layer [3].

Kinetics of fluid filtration through porous media is one of the most important technological parameters influencing the choice of dewatering equipment, its performance and the humidity of the final product.

The slurry precipitate may be represented as a set of capillaries, whose number and size are determined by the particle size and shape characteristics of particles constituting this sediment [1]. In this connection it is interesting to study the kinetics of fluid flow through separate capillaries.

In [4], the study of the kinetics of water flow through the polyethylene capillary with a diameter of 30 mm and a length of 16.2 mm is given. Fluid flow was carried out at a pressure drop of 0.08 MPa. Flow measurement was conducted by a drip flowmeter with automatic registration of indications. The period of following of drops was measured with an accuracy of 1/1000.

Fig. 1 shows the changes in the flow rate of distilled degassed water through the capillary on time. Filtration rate is proportional to the flow rate of water up to a constant multiplier. As can be seen from Fig. 1, for the first 4 minutes water flow decreased by more than 12 %, and further reduction of water flow was less significant, and in 45 minutes was about 18%. More detailed results of the water flow in the last 10 minutes of the experiment are presented in Fig. 2. As can be seen from the figure, the fluid flow obviously has an oscillatory character.

The traditional approach to the study of the spectral characteristics of oscillatory processes is the Fourier transform, as a result of which the frequency spectrum of the signal is obtained. Fourier transformation is not possible to localize the frequency components of the signal in the time that is necessary for analyzing non-stationary process.

In such cases it is advisable to apply the generalized Fourier method (local Fourier transform) for the analysis of a signal. This method is based on the fact that the investigated function is split into time slots, for every of which the Fourier transform is performed. As a result we have several time-shifted amplitude-frequency characteristics (AFC), which allows analyzing their change.

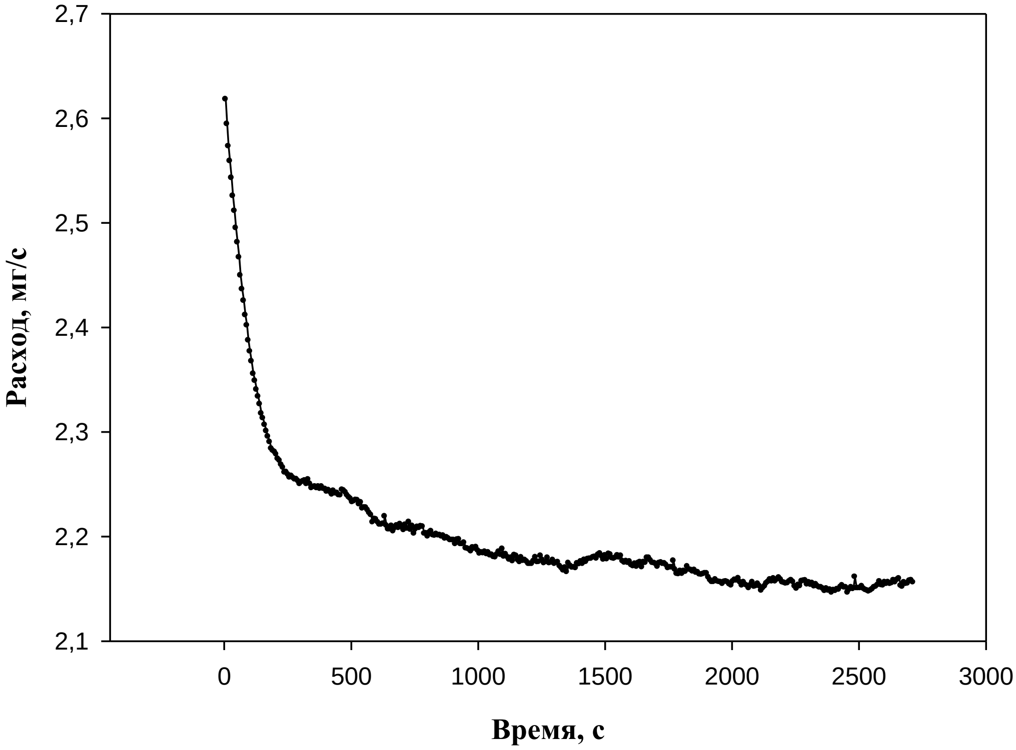

Fig. 1. Dependence of water flow through the capillary on time

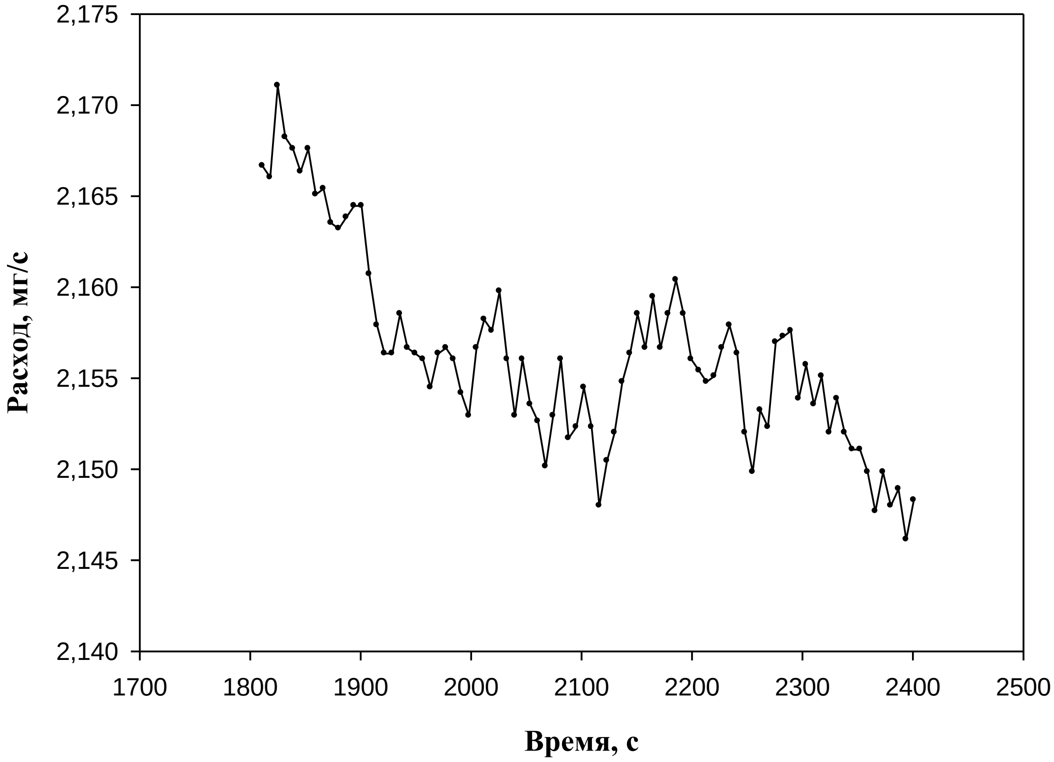

Fig. 2. Dependence of water flow through the capillary on time for the last 10 minutes of the experiment

Spectral function can be found as a result of the well-known direct Fourier transform:

$$V(\omega) = \int_{-\infty}^{\infty} v(t) e^{-i\omega t} dt .$$

Here $V(\omega) = Ae^{i\varphi} = A\cos\varphi + iA\sin\varphi$; $v(t)$ – the rate of filtration, m/s; t – time, s; ω – angular frequency, s^{-1}.

Since the value of the signal are measured only at discrete points in time: $t_n = n\Delta t$, $n = 0 \ldots N-1$, then apply the summation for the numerical integration:

$$V_k = V(\omega_k) = \Delta t \sum_{n=0}^{N-1} v(t_n) e^{-i2\pi kn/N} .$$

Original curve in Fig. 1 is split into three intervals in time: 0 – 986, 986 – 1811, 1811 – 2700 s. On each of the intervals direct Fourier transform is performed, in result of it AFC of the process of water filtering through the capillary are obtained. These amplitude-frequency characteristics are shown in Fig. 3, 4 and 5.

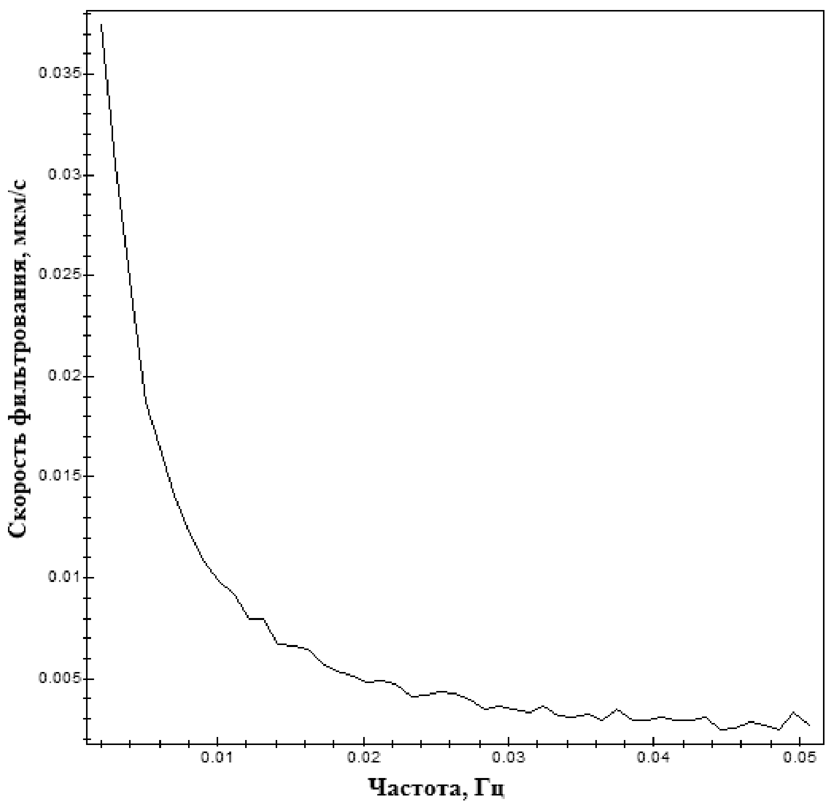

Fig. 3. Frequency response curve of the kinetics
of the capillary filtration in the time interval 0 - 986 sec

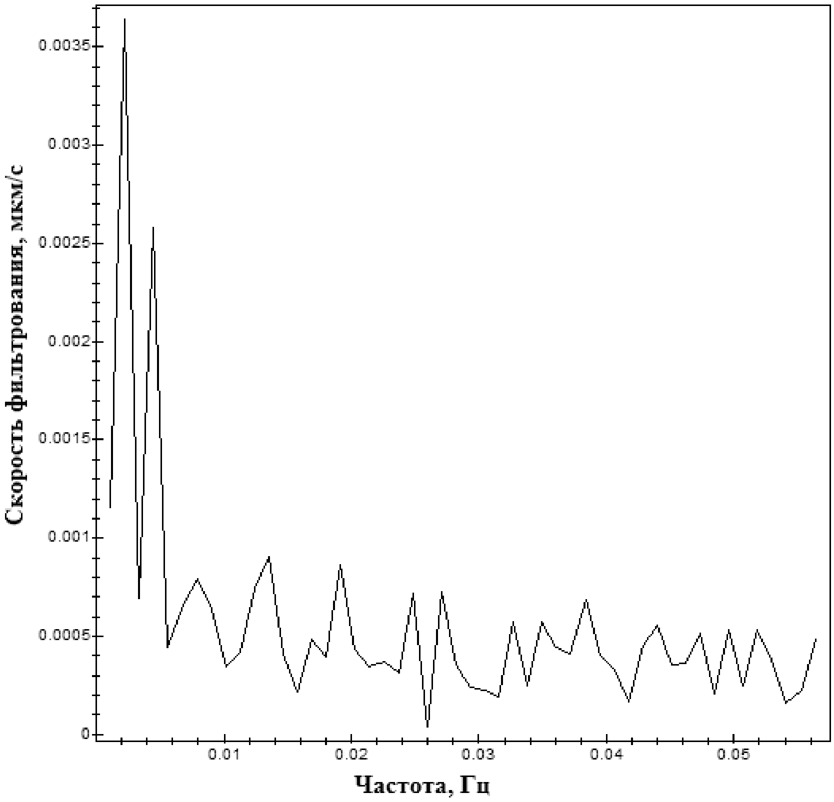

Fig. 4. Frequency response curve of the kinetics of the capillary filtration in the time interval 986 – 1811 с sec

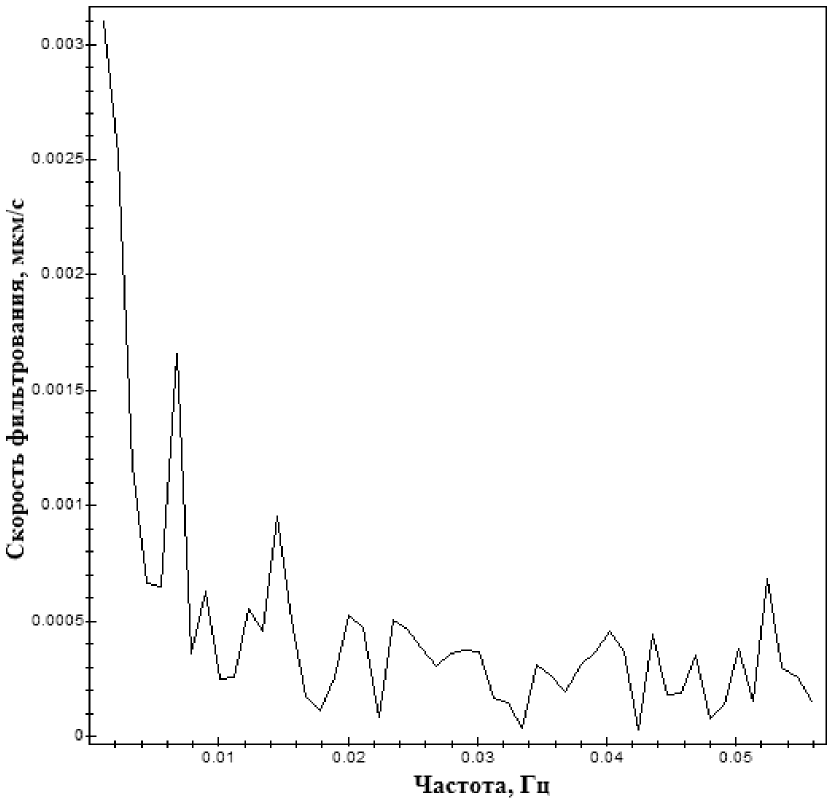

Fig. 5. Frequency response curve of the kinetics of the capillary filtration in the time interval 1811 - 2700 p

As can be seen from the figures, at the first interval of time AFC corresponds to the monotonously proceeding process without significant fluctuations. During the second time interval explicit low-frequency oscillations with a frequency of 2 and 4 MHz are observed. Later, the nature of the oscillatory process has not changed significantly, except for changing the ratio of the signal amplitudes.

The present results indicate that during the filtration of water through fine capillaries auto oscillations of flow and filtration rates in time with the characteristic frequencies are arising. Perhaps such a character of the water flow is caused by the periodic formation and breakdown of hydrate film on the surface of the capillary wall. To prevent the formation of such a film it can be affected by various physicochemical methods, and it is advisable to carry out exposure in a pulsed mode with a frequency equal to the natural frequency of the capillary.

The porous media are composed of a totality of capillaries, therefore the above reasoning are apparently applicable to them.

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