KINEMATIC STRUCTURE FLOW FOR BUILDINGS WATERGRADUATION PUMPING STATIONS

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Excess or presence of water in some places and lack in others where it is needed, is relevant both in the past and today. In many forecasts, this problem will grow. Therefore, the water must be fed from one district to another. At the same time there is increased water outlets turbulyaryzatsiya flow, leading to erosion of hydraulic structures.

The purpose of research - the establishment of the distribution of benthic maximum speeds of correlation and spectral analysis of velocity fluctuations assessment eroding the ability of the stream.

Materials and methods research. We studied three, p'yatytrubni vodovypuskni facilities siphon type and structure of shestyprolotna vodovypuskna segment and flat closures. In the study vodovypusknyh facilities siphon type and povehnevymy closures, except in design, some attention is paid to the study of the kinematics of the flow in the bottom for buildings.

Research conducted on spatial models of rigid structures made in scale 1:13 and 1:25 full size. Vodovypuskna spryahalasya construction of drainage canal narrowing transition part, the central angle of taper which was adopted 220 - 300 Reynolds to skip the estimated costs of models varied from 14,000 to 54,000.

In experiments on physical models measured averaged velocity

and maximum instantaneous flow rate bottom. Averaged flow velocity measured mikrovertushkamy type X 6M in fixed alignment located in the transition region and the outlet channel. Created a distance between the transition region and the channel was 50 - 80 cm. Design for measuring velocities were placed so as to get detailed information about the size and nature of the velocity distribution by vodovypusknymy facilities. The maximum instantaneous velocity field in the bottom one-component measured with strain rate converters.

Each alignment bottom velocity measured in three - five points across the width of the stream.

Natural frequency of the transducer was 50 - 80 Hz in the water. Since the bulk of the energy ripple in the water courses focused vortices in frequency from 1 to 20 Hz, the converter is used can be considered little inertia.

Collection and processing of experimental data averaged and maximum speeds bottom were made automatically using the measuring-computer complex based PC. Transducer calibration performed in the stream at the output of a calibration confuser where there was a flow with uniform velocity over the cross section.

During the processing of sorted data obrahovuvaly statistical characteristics - variance, standard ripple (turbulence), asymmetry and kurtosis; series and histogram calculated autocorrelation function and the spectral density.

The accuracy of calculations of the statistical characteristics affect the value of row spacing discrete, time of observation.

Experiments length series taken as 500 value. Poll discrete interval pulsation velocity 0.02 s, the measurement of velocity pulsations 11.2 sec. The term record values averaged velocity was adopted at 60 sec.

Results. Most studies were conducted for the velocity fluctuations in the lower b`yefi drainage facilities where Froude number Fr> 1. In this case, considered flows that were at rest (Froude number Fr> 1).

For these data streams pulsation characteristics for use in the calculation of the lower b`yefa limited. In studying the effects of hydraulic structures for knowledge only averaged characteristics sufficient to explain the real situation and the development of methods of calculation. In these cases, the study pulsation velocity, turbulent characteristics and analysis of the spectrum of turbulent pulsations. Thus the basic task of the study is to describe the turbulent fields of different hydrodynamic quantities. Since the turbulent flow pulsation of these variables in time and space is chaotic, the statistical approach to describe their most expedient. This problem is complex and turbulent flows should essentially rely on experiment. The turbulent flow is stabilized by buildings in the hydrodynamic sense, that is all it averaged characteristics remain unchanged over time. As we know from statistical hydrodynamics hydrodynamic turbulent flow fields are random fields in terms that are accepted in probability theory. In this case, the time functions are stationary and their statistical properties are independent from start counting time of test. And in order to function averaged over the space of values of the random field led to the same results as the averaging in probability studied field should be uniform. Meanwhile, in relation to the fields hydrodynamic characteristics of turbulent flow assumptions about homogeneity is always a mathematical idealization. Of course stationarity and homogeneity enough to climb temporal and spatial average to average statistical values. The last condition for convergence of spatial and temporal statistical averages are ergodicity condition.

Dealing with ergodic random processes is very convenient, because in that case one realization of sufficient duration can judge the characteristics of a random process. This fact enhances the study of turbulent flows, since the measurement results can be considered reliable implementation function approximation process. Important in the study is to establish the nature and function of law distribution.

For plotting of the distribution obtained in experiments statistical series pulsation velocities measured values were processed in accordance with the recommendations in the paper.

For random functions measured in a stable environment, the most common normal distribution. Probability distribution pulsation velocities in turbulent flow, in general, does not meet the normal (Hausovskomu) of the distribution. In the case of homogeneous and isotropic turbulence is normal distribution curve pulsating velocity at the point.

For turbulent flow with a shift in this distribution is generally asymmetric. However, for any random field with the final moments of the first two orders (expectation and variance) can always adjust the Gaussian field having the same mean and the same correlation function ripple field.

A.S.Monin and Ya.N.Yahlom notes that the study of approximate random fields using only data points of the first two orders of magnitude, we can always provide that the fields have studied normal probability distribution. Often random fields hydrodynamic characteristics of turbulent flow are close to Gaussian fields.

To establish the nature of the distribution histogram obtained were compared with theoretical curves distribution. Analysis of histograms and deposited them theoretical distribution curves shows that the distribution law of velocity pulsation in the bottom of the stream close to normal, but strictly does not match. This is because in certain modes of buildings and non-isotropic homogeneous flow.

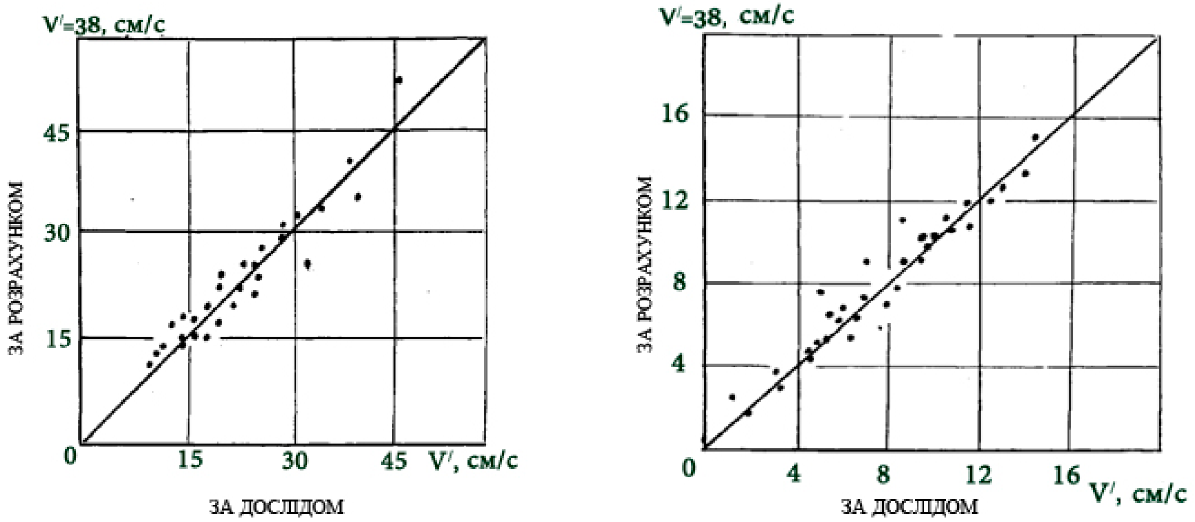
Evaluation of the consistency of the distribution obtained with normal conducted by Pearson criterion. Climbing experimental histograms of normal law observed with Froude number Fr> 0,04 - 0,06 and Reynolds number Re> 20000. In this case, the buildings took place developed turbulent flow, which can be considered locally homogeneous and isotropic. When Froude number Fr> 0,02 and Reynolds number Re> 15000 dominated flow in large anisotropic eddy formation of low frequency. In these cases, the normal distribution of turbulent pulsations is not kept.

Accordingly, it is understandable why many experimental studies of turbulent velocity fluctuations in flows with a free surface, many researchers take approximately normally distributed and in determining the maximum instantaneous velocities used "three sigma rule".

In our experiments, the maximum instantaneous fluctuating rate close to 3 σ.

A comparison of experimental and calculated values of pulsation velocities shows that they are in good agreement with each other and different from each other in most cases no more than 10-12% (Figure 1).

Among the characteristics of the distribution of a random variable, in addition to the expectation, variance D * standard ς, is a key factor and asymmetry AS "steepness" of distribution, characterized by excess Ek. If the coefficient of skewness AS> 0, the distribution curve skewed to the right, when AS <0 then - to the left.



а *б*

Fig.1. Comparison of experimental values of the pulsation velocity calculation:

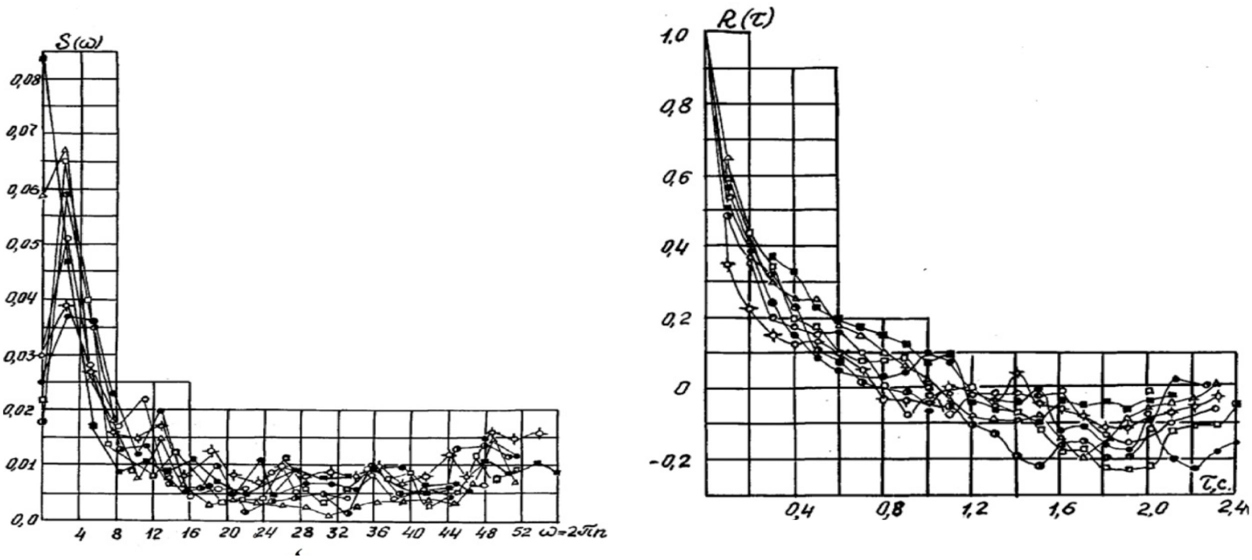
a - for the siphon pipe; b - watergraduation for construction of high-speed shutters

Excess accumulation characterizes the magnitude of the average value of the velocity of a certain number of values in the interval. For peaked curves E_k> 0, and for ploskoverhi E_k <0.

Analysis of asymmetry coefficients bottom pulsation velocities showed that positive and negative values of occur with approximately equal frequency. Thus in the early parts of attenuation dominates positive asymmetry. It is noted in the study D.I.Kumin asymmetric curves instant availability velocity downstream weir. In our case, as far as distance downstream of the start channel more common distribution curves with negative asymmetry.

Value excess in most cases negative. This means that the probability of large (modulo) deviations from the average speed less than the normal law, that is, the distribution curves more ploskoverhi compared to normal.

Note that the obtained distribution curves for alignment, located at the end of ripple attenuation areas where flow aligned, closer to the normal distribution law. This is somewhat consistent with the findings of other researchers and E.M.Minskoho of what the ripple in the bottom layer of uniform turbulent flow and end parts of attenuation in the lower b`yefi subject to the normal distribution law.



a б

Fig. 2. Correlation functions (a) and spectral density (b) energy pulsations bottom speed watergraduation structure (Q = 5 m3 / s is the average siphon h = 0,65 m):

1 - 8 - create measurements. o - 1; ● - 2; Δ - 3; □ - 4; + - 5; ☼ - 6; ■ - 7

Ripple instantaneous velocity of the flow is stabilized, as noted above, a stationary random process, one of the characteristics which have correlation function. In our case, the variance is considered normalized autocorrelation function, which is called the correlation coefficient R (τ). Analysis of the correlation function can give a more accurate indication stationary process, as it shows the internal structure of random processes and describes the relationship between the individual values of the random function at different time intervals t τ. Signs stationary random process is independent nature of the correlation function of the early period of research.

Figures 2 and 3 shows autocorrelation functions for all the above facilities. As seen from the figures, the design change does not lead to a qualitative change autocorrelation function. Note that in this case the field for speed vodovypusknym buildings not homogeneous and the correlation function must change both width and length.

However, as noted by Townsend, the fluid flow in the channel to some extent characterized by uniformity turbulent movement in the middle reaches.

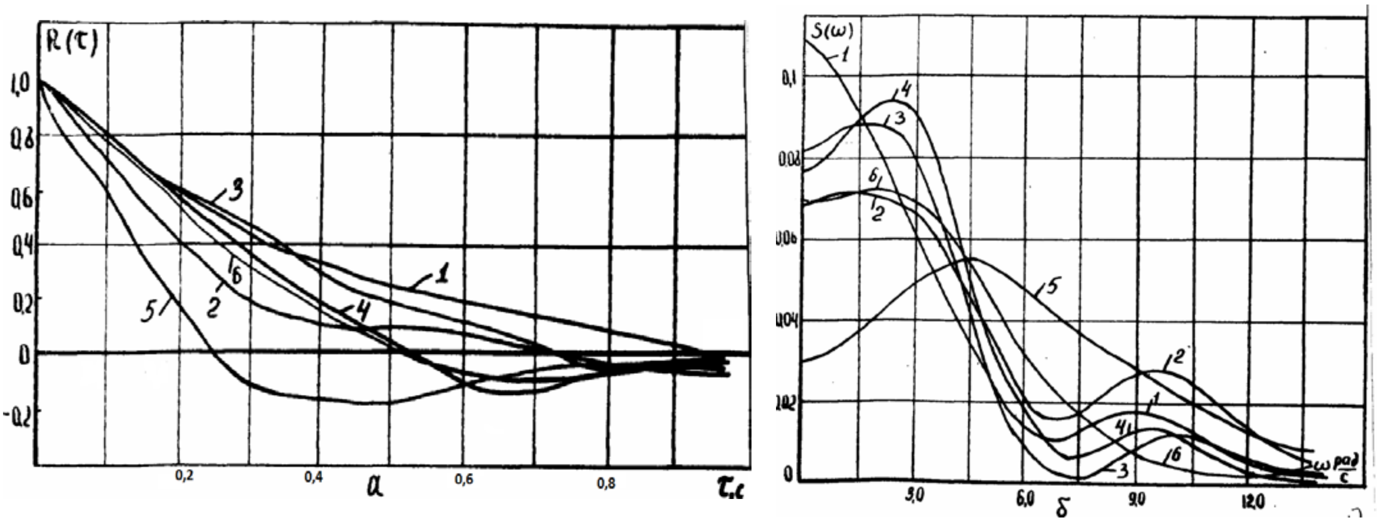


Fig. 3. Correlation functions (a) and spectral density (b) energy pulsations bottom speed trohtrubnoyu vodovypusknoyu structure (Q = 5 m3 / s is the average siphon h = 0,65 m):

1 - 8 - create measurements. o - 1; ● - 2; Δ - 3; □ - 4; + - 5; ☼ - 6; ■ – 7

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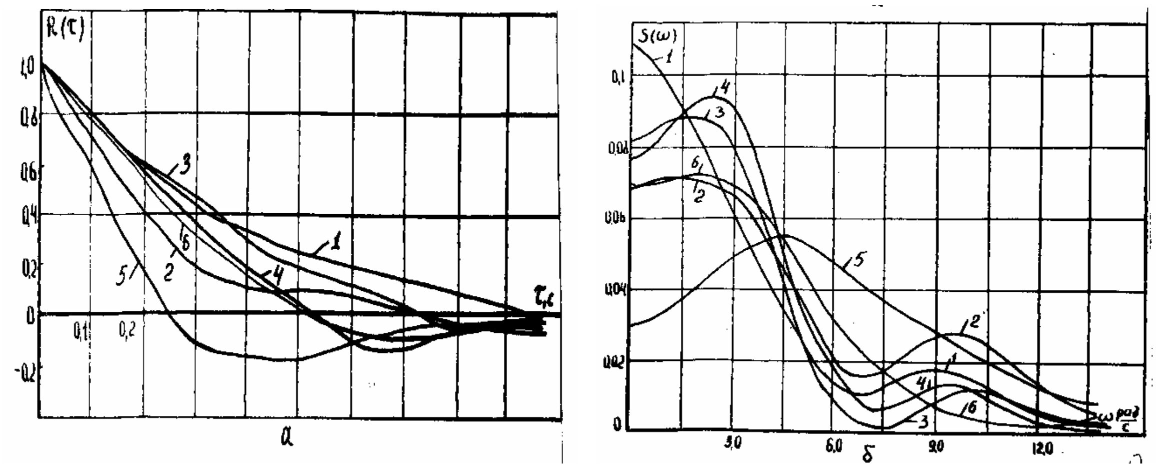

Fig. 4. Correlation (a) and spectral (b) energy density ripple longitudinal speed watergraduation closures:

1 - Fr = 0,07 - 0,09; 2 - Fr = 0,04 - 0,06; 3 - Fr = 0,022 - 0,035; 4 - Fr = 0,13 - 0,17; 5 - Fr = 0,058 - 0,08; 6 - Fr = 0,02 - 0,036

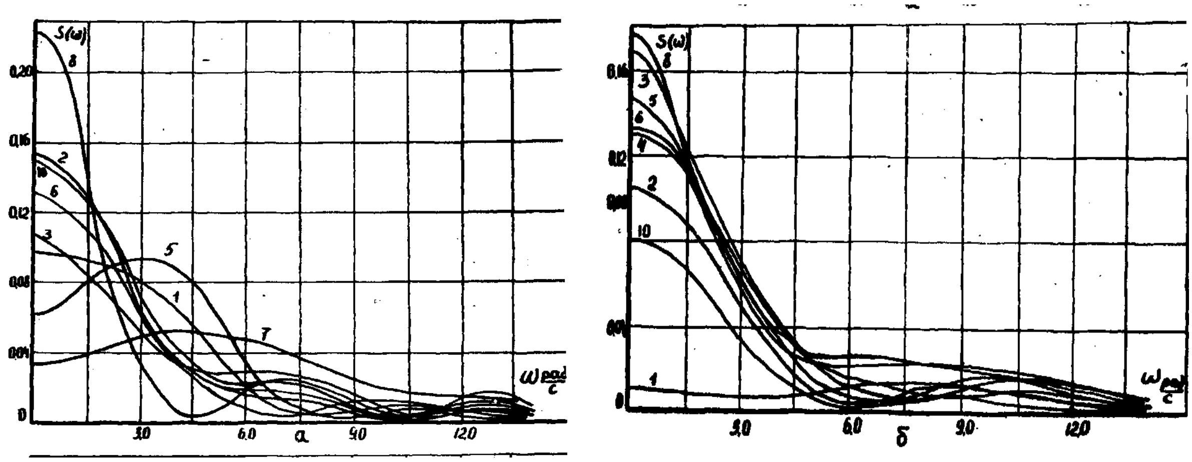

Fig. 5. The spectral density ripple longitudinal speed watergraduation structure with surface closures:

a - Fr = 0,058 - 0,08; b - Fr = 0,0065 - 0,015; 1- 10 - Design

Let's call shows graphs of the spectral density l order. The spectral density of the order of ll have a schedule with a distinct maximum at frequencies l - 6 rad / s (0.16 - 0.96 Hz), the second most frequencies adjusted to 8 - 11 rad / s / (1.3 - 1.6 Hz). For the second peak amplitude is 25 - 30% S (ω) max (see. Fig. 5).

Spectra III procedure with flattened shape (see. Figure 4). They may have one or two peaks that do not differ from each other in amplitude. The first maximum of the spectrum observed at frequencies of 3 - 9 rad / s / (0.5 - 1.4 Hz). In the case of two other peaks observed at frequencies of 11 - 14 rad / s / (1.75 - 2.2 Hz).

The spectra of these orders is the energy characteristics of eddy formations that dominate the tranquil flow for different values of Froude number Fr. Experiments found that vortices described by spectrum and order prevail in the flow at Froude number Fr = 0,0005 - 0,08, and the amplitude spectrum increases with decreasing numbers of Froude. The frequency of these vortices 0 - 3 rad / s (to 0,48Hts) and for the period of the model was 20 s.

Fluctuating component of velocity 'of such flows averaged commensurate with such flows. And as for the autocorrelation function can not set the size of the vortices, as in this case it rarely reaches zero.

The value of the actual bottom velocities in small streams studied. This indicates that large-amplitude low-frequency large vortices do not contribute to erosion, despite the fact that they account for the bulk of the kinetic energy of the stream. This is a great period of occurrence and a short period of action. With increasing numbers of Froude graphics spectral density become flattened outline energy more evenly distributed over a wide frequency range, amplitude range decreases.

When Froude number (Fr = 0,1-0,33) in the flow is dominated by vortices described spectral curves II and III orders that have a high frequency.

The period of the vortices is short, and the period of the great. When Froude number to Fr = 0,13 - 0,17 50% spectral curves accounted for curves II and III order, the amplitude of which 0,05 - 0,08 S (ω) max. When Froude number Fr = 0,27 - 0,33% 30 curves falls on the third order spectra, amplitude spectra of reduced to 0,03 - 0,05 S (ω) max. Thus, the greater the flow velocity and Froude number, the smaller the amplitude spectra and the higher frequency range covered by them.

It follows that the channel bed erosion is the result of vortex actual instantaneous velocity fields of high frequency, which are medium and small scale relative to the size of the channel, ie the erosion of energy consumption and meso mikroturbulentnosti. As you know, the graph spectral density can be divided into a number of areas. Area "A" is characterized by several significant peaks in the background of some close to the "white noise". Vortices belonging to this frequency range, are the most energy. This portion of the spectrum, where the energy transfer from the averaged motion to pulsating. In the high-frequency region "b" stands inertial subregion, reflecting cascade energy transfer in the frequency spectrum.

From the theoretical and experimental analysis it is known that the microstructure of most real non-isotropic turbulent flow is approximately isotropic (locally isotropic). Therefore, many of the properties fully investigated isotropic turbulence applied to real turbulence.

In fully developed turbulent flow the maximum kinetic energy vortices will be in the range of high wave numbers and turbulence in this region can be considered statistically stationary and independent of external conditions. The nature of turbulence at high wave numbers determined by the parameters related to the flow parameters: average rate of energy dissipation coefficient ξ and kinematic viscosity. According to the theory AN Kolmogorov [3] This area is called the universal rivnovisnoyu area.

If the disturbance in question in this thread much more kolmohorivskoho microscale ("internal" scale turbulence), while remaining much less than some "external" scale at sufficiently high Reynolds numbers, all the statistical characteristics of the velocity field determined by only one parameter ξ. This interval is called inertial interval scale, which is a "cascade" of turbulent energy transfer from large scale disturbances.

By number of smaller scale disturbances transmitted frequency energy cascade is numerically equal dissipation ε. In the inertial range turbulence spectrum is:

$$S(\omega) = Const\ \xi^{2/3} k^{-5/3}, \qquad (1)$$

where $k = \frac{2\pi}{\lambda}$ - wave number, m-1; λ - wavelength, m; ξ - dissipation rate of turbulent energy.

At the time frequency spectrum can be represented as:

$$S(\omega) = a\omega^{-5/3}. \qquad (2)$$

This approximation corresponds to the structural features 2/3 law.

Zh.Kont-Bello notes that cascade energy transfer spectrum minus 5/3 the law is observed in a range of Reynolds numbers. The same conclusion was, in particular, came T.Moulden and U.Forst, indicating the existence of an inertial range is provided with a subdomain numbers Reyoldsa at least 105.

In our experiments, the Reynolds number varied from 14,000 to 54,000, however we were able to watch the inertial subregion (Fig. 6.7).

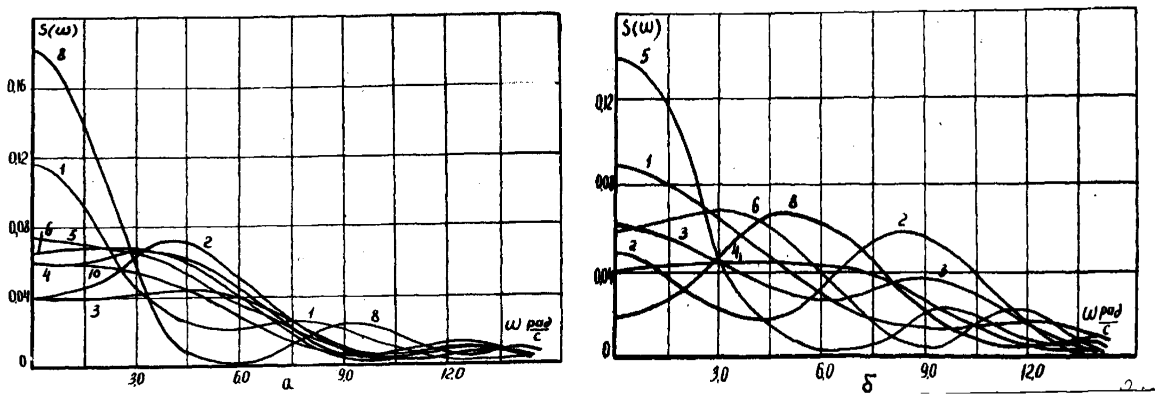

Fig. 6. The spectral density ripple longitudinal speed water discharge to surface facilities closures:

a - Fr = 0,07 - 0,09; b - Fr = 0,13 - 0,17; 1 - 10 - create

From Figure 6 shows that the fluctuation spectrum for siphon water outlets contain small interval during which they change frequency proportional to the power minus 5/3. This inertial interval within 8 - 15 rad / s. Moreover, changes in the law minus 5/3 spectra obtained for initial alignment (the output of the ring and at the beginning of the channel), exist in a narrower range than the final measurement will create.

Deviations from the law minus 5/3 at low frequencies due to the fact that a large scale, which correspond to low frequencies, turbulence can not be considered locally isotropic. In Figure 7 shows the change of amplitude spectra S (ω), and the initial frequency inertial sub-areas for buildings with flat segment and closures for different Froude numbers. In order spectra and inertial subregion begins with ωin frequency = 0.9 - 2 rad / s. With decreasing Froude number decreases parameter ωin and increases the absolute value of the exponent in equation (2), that is more rapid transfer of energy on stage and increases the size of the vortices, which starts a cascade energy transfer as anisotropic vortex formation is unstable and quickly rozdroblyuyutsya.

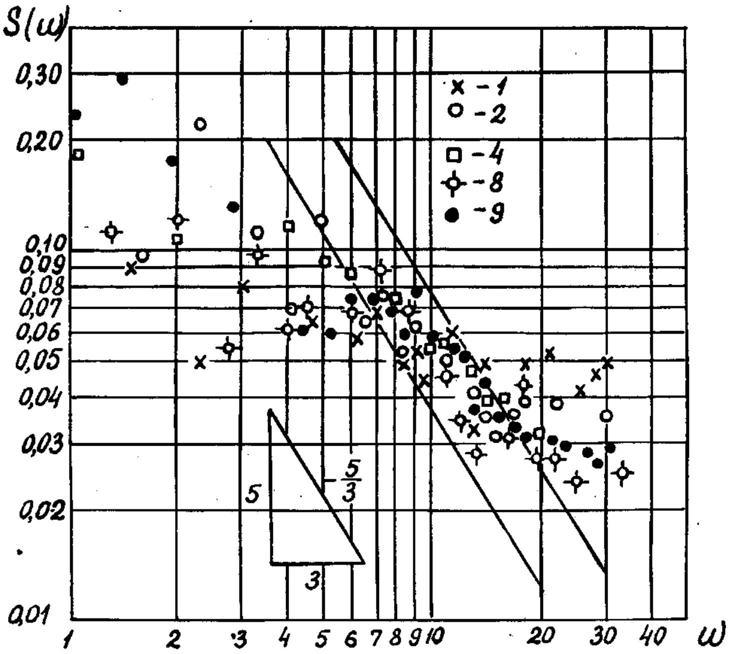

Figure 7. The energy spectra of velocity fluctuations in the flow by trohtrubnoyu siphon vodovypusknoyu structure (Q = 5m3 / s, h = 0.6 m):

1, 2, 4, 8, 9 - create change

In the spectra of the second and third orders, characterizing stable isotropic eddy formation, initial frequency inertial subregion increased to ωin = 6 - 9 rad / s. The transfer of energy to cascade begins among small-scale vortices high, the exponent in equation (2) also takes great importance in absolute value, due to the small scale vortex structures within which enter into force viscosity forces. Consequently, the greater the Froude number and Reynolds number, the farther in frequency posuvayetsya inertial subregion and the smaller size of the vortices, which starts a cascade energy transfer spectrum.

This supports the hypothesis that the presence of a stable vortex flow can result in a slowdown of cascade energy transfer spectrum.

So, the more stable vortex structures, the more they affect the displacement spectrum in the inertial sub-areas zone treble and the shorter is the inertial interval.

As noted above, a characteristic feature of the spectral curves I and II order is the presence of two or three peaks, reflecting a burst of energy in certain areas of the scale.

In this regard V.I.Nikora identifies two areas for energy channels with movable bottom. From considers that the first zone is related to the instability of mean motion caused by fragmentation ridged surface stream bottom. The second zone is associated with the generation of energy vortices in ridges foundation followed the release of their transit flow.

In our studies on sustainable model, as shown above, in the spectra of the first and second orders were also observed two zones of additional energy. Obviously the presence of additional energy zones due not only the reverse effect on the structure of the channel bed flow. This phenomenon can be explained by a complex structure of vortex flows. The largest low vortex includes a high. Energy frequencies uneven. So the second and third maxima of the spectral curve indicate the superposition of vortices. In the spectrum of the third order energy is uniformly distributed over the frequencies that also leads to a smoothed speech as a result consistent imposition of small-scale vortices.

Conclusions

On the basis of the statistical characteristics of bottom ripple speed vodovypusknymy structures established law of distribution of benthic maximum speed, given the correlation and spectral analysis of velocity fluctuations, as well as evaluating the ability of eroding stream.