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STUDY OF GEOMETRIC PARAMETERS OF OPEN BRANCHING FLOW

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ANNOTATION: The article investigates the geometric parameters of an open flow in the branching zone. An experimental setup was created and the exhaust flow motion in the branching zone was observed. The results obtained were analyzed and a mathematical model was created. And also given a conclusion and recommendations on the results obtained.

In many practically important flows occurring in nature and technology at low Reynolds numbers, the velocity of a liquid particle in the vicinity of branching changes sharply [7, 8]. During fluid flow, especially in the separation section, vorticity appears, which is created due to the separation of the boundary layer or due to the presence of a zone with a negative pressure gradient. To explain the structure of the flow taking into account the separation, the jet theory was created [2,3,4]. On the basis of these theories, one can write the vorticity region with angular velocity [4,10,11]. To clarify the definition of the geometry of the vortex zone and its effect on the flow rate and depth of the flow, we carried out experimental studies. The purpose of the experiment is to establish the reliability of the adopted jet models, which is solved by the method of N.E. Zhukovsky, and to determine the hydrodynamic parameters of both homogeneous and non-uniform flow during fluid flow in a channel with a side outlet. For this purpose, a special experimental setup with a lateral outflow has been developed. The experimental setup (Fig. 1) allows, on the basis of modeling theory, to obtain all the main parameters in the process of flow separation.

The installation is a straight section of the main channel with a rectangular cross section of 5 cm and a length of 215 cm, at a distance of 103 cm from the beginning of the main channel. To it are connected the outgoing parts of the channel also 5 cm wide, 133 cm long and 5 cm high.

The installation is made of plexiglass in order to reduce hydrodynamic resistance and better visual observation. The experimental setup was made with different division nodes formed by prismatic channels of rectangular cross-section at separation angles and different tilt angles to the horizon.

General view of the experimental setup with a variable flow depth at

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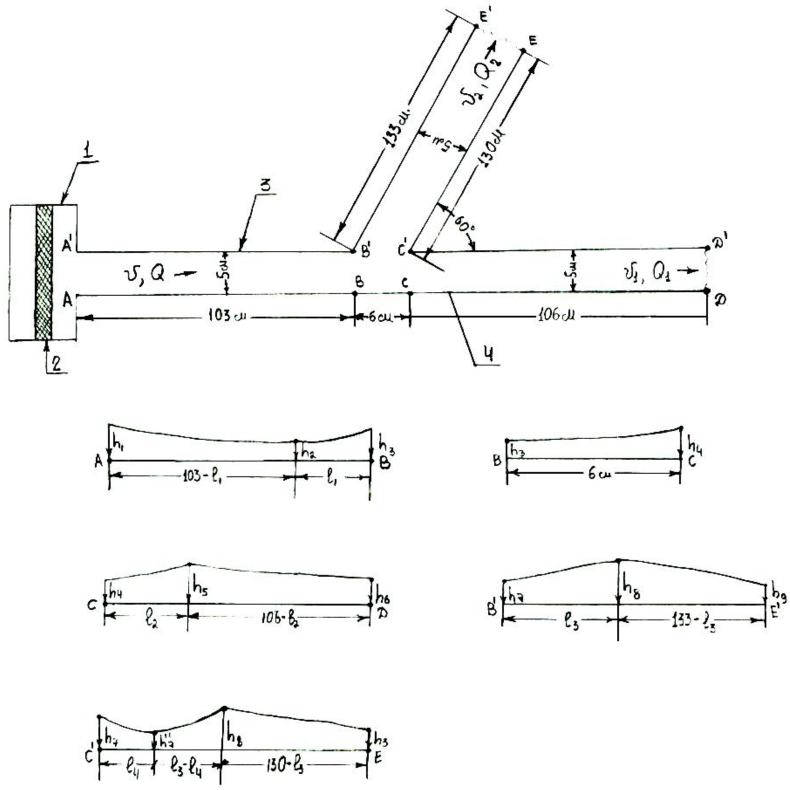

Fig. 1
Let us present the research results in the case of flow separation for. The control of the supplied liquid flow rate was carried out using valves mounted in the pressure pipeline. The total consumption can be controlled using the following formula, where is the initial consumption; - consumption of a continuous section; - consumption in separation. In accordance with the set research objectives, in the course of the experiments, various parameters of the flows in the fission unit were measured.
The change in the flow depth in the bifurcation with the change in the length of the channel tray for a uniform flow is shown in the graph in Fig. 2.
Change in the depth of a uniform flow along the length of the tray for different flow rates

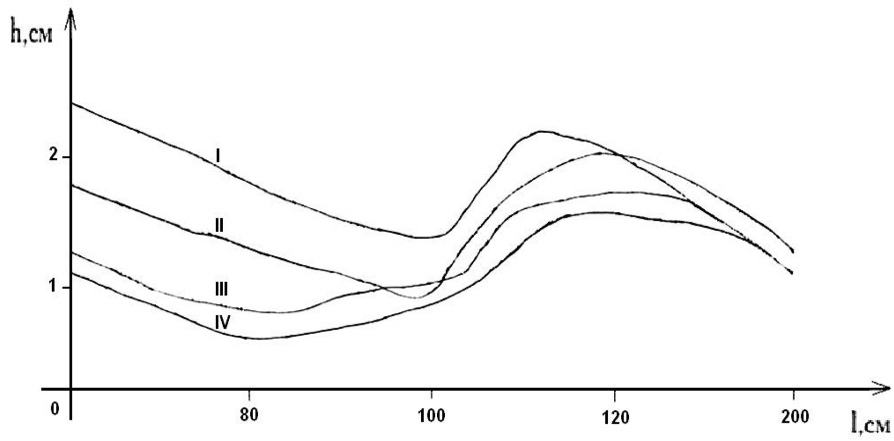

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Fig. 2:
I-Q = 197.5 ml / s; II - Q = 147.5 ml / s; III-Q = 131.2 ml / s; IV-Q = 73.3 ml / s;
To identify the kinematic characteristics of the flows that make up the fission unit, the longitudinal velocities of the motion of a homogeneous and inhomogeneous fluid were measured at various sections of the sections. The depth velocity was determined using the formula [5]. The nature of the flow of the sediment-carrying flow and the "relief" formed at the bottom of the flow were measured with a thin, strong stainless needle, which was lowered with a pointed tip until it touched the water surface. The calculation was determined using a ruler.
Each series of experiments with a sediment-carrying flow was carried out for one hour. After that, the flow stopped. A picture of the nature of the deposited sediment was obtained through visual observations and transparent graph paper (Fig. 3).
The experiments were performed for one fixed concentration, i.e. 500 g of soil with a particle size distribution of less than 0.25 mm was passed into water for 10 minutes with a special dispenser at a certain water flow rate. During the experiment, the flow rates, geometric characteristics of the flow, as well as the depth and dimensions of the dense flow at the bottom of the tray were measured.
Thus, the laboratory study of the issue of flow division is reduced to setting up a multifactor experiment [1]. For a complete analysis of the obtained dependencies, the least squares method was applied.
The location of the vortex in the flow branching zone

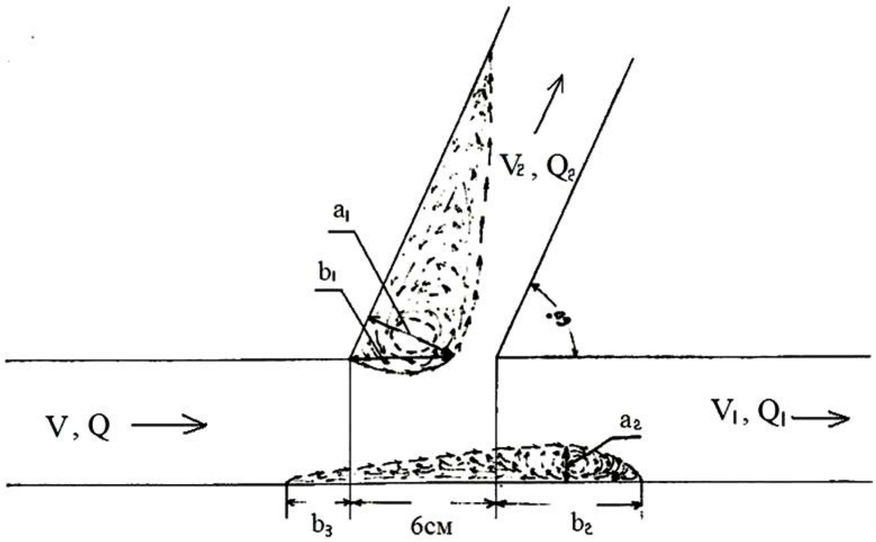

Fig. 3
During the experiment, the relative and absolute deviations of the parameters were determined. For this, the following mathematical formulas were used:

where is the root mean square error in determining the depth; - root mean square error of time recording, determined by the expression:

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where is the measurement number; - measurement time. Thus, you can get the following dependency:

Each specific flow rate has its own root-mean-square error. Relative error

where is the absolute error in measuring the flow rate, taken equal to twice the root-mean-square error.

The study of flow separation in rectangular sections showed that the general picture of fission is similar to that noted in [6]. An analysis of the nature of depth changes for a homogeneous flow is shown in Fig. 2 and Fig. 3, where the characteristic values are connected by straight lines.

The depth change has been found to depend on the flow rate and flow regime. The flow regime is calculated using the following formula:

where is the Reynolds number; - kinematic viscosity of the test fluid; - wetted perimeter; - flow rate in the investigated sections.

Hydrodynamic drag coefficient:

,

where is the slope of the liquid surface.

From the graphs in Fig. 4, a, b it can be seen that on the left bank in the initial sections a vortex is formed, depending on the flow rate and flow regime, creating a backwater of the level. On the right bank in the initial section, a drop in the water level is formed. From this it can be concluded that a compressed section is formed near the right bank at the beginning of separation [9, 10, 11].

Let us calculate the compression ratio using formula (1) derived from the jet theory:

To determine the size of the vortices in the sediment-carrying flow, we set up a special experiment at the angle of diversion. The flow rate of the second measurement of the liquid flow rate was from 73 to 200 cm3 / s with the aforementioned concentration (Fig. 4).

Determining the geometry of the dimensions of the vortex zone was difficult, since the vortex zone from the transit stream does not have sharp outlines. Visual observations showed that vortex formations are wave-like, and such waves are characteristic, also characterized by a rapid change in the numerical values of the width and length of the vortex, as well as the outlines of the boundary from the transit flow.

Nevertheless, despite the difficulties in measuring them, we measured the size of the vortex after the experiment near the separation of the flow for individual flow rates of the liquid flow, Table 1, Fig. 5.

Change in depth along the length in the sediment-carrying flow at the section

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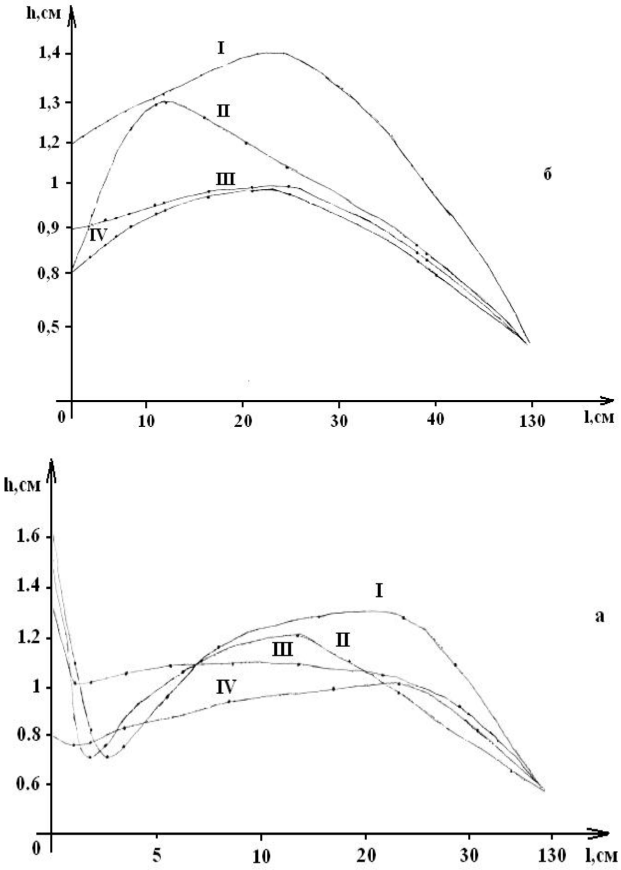

Fig. 4:

Fig. 4:
a - right bank, b - left bank.
I - Q = 50.7 ml / s; II - Q = 39.2 ml / s; III-Q = 27.1 ml / s; IV-Q = 17.3 ml / s;

Table 1
The quantitative value of the relief in the flow separation area

№		h_1, см	h_2, см	h_3, см	h_4, см	h_5, см	h_6, см
I	1	0.7	0.7	0.7	0.7	0.7	0.7
	2	0	0.4	0.65	0.7	0.8	1.1
	3	0	0.7	0.7	0.9	0.9	1
	4	0	0.7	0.8	0.8	0.9	0.9
	5	0.1	0.9	0.8	0.7	0.8	0.8

	6	0.3	0.8	0.7	0.7	0.8	0.7
II	1	0.2	0.28	0.4	0.3	0.3	0.3
	2	0	0.6	0.5	0.4	0.6	0.9
	3	0	0.1	0.6	0.4	0.6	0.8
	4	0	0.1	0.5	0.4	0.5	0.7
	5	0.1	0.1	0.7	0.4	0.5	0.6
	6	0.2	0.3	0.7	0.5	0.5	0.6
III	1	0	0	0	0	0.3	0.5
	2	0.7	0.8	0.8	0.7	0.7	0.4
	3	0.6	0.7	0.8	0.9	0.9	0.8
	4	0.3	0.5	0.6	0.7	0.9	0.9
	5	0.3	0.4	0.5	0.6	0.9	0.7
	6	0.3	0.3	0.4	0.4	0.4	0.5

Note: a: I - first experiment Q = 50 cm3 / s; b: II- second experiment Q = 70 cm3 / s; s: III- third experiment Q = 80cm3 / s.

General picture of the topography of the channel bottom in the branch section

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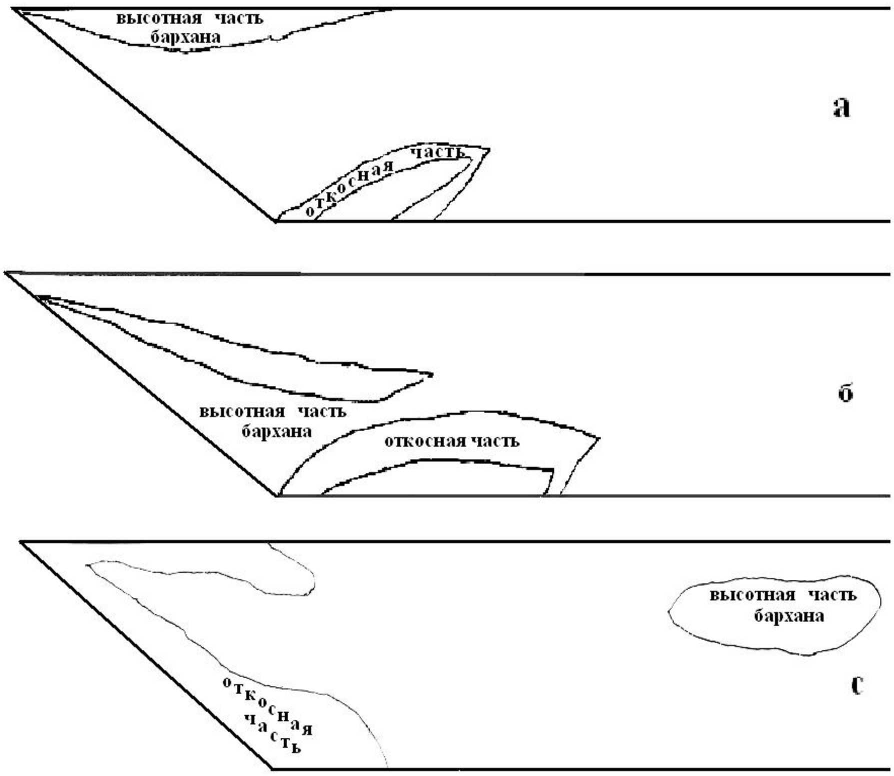


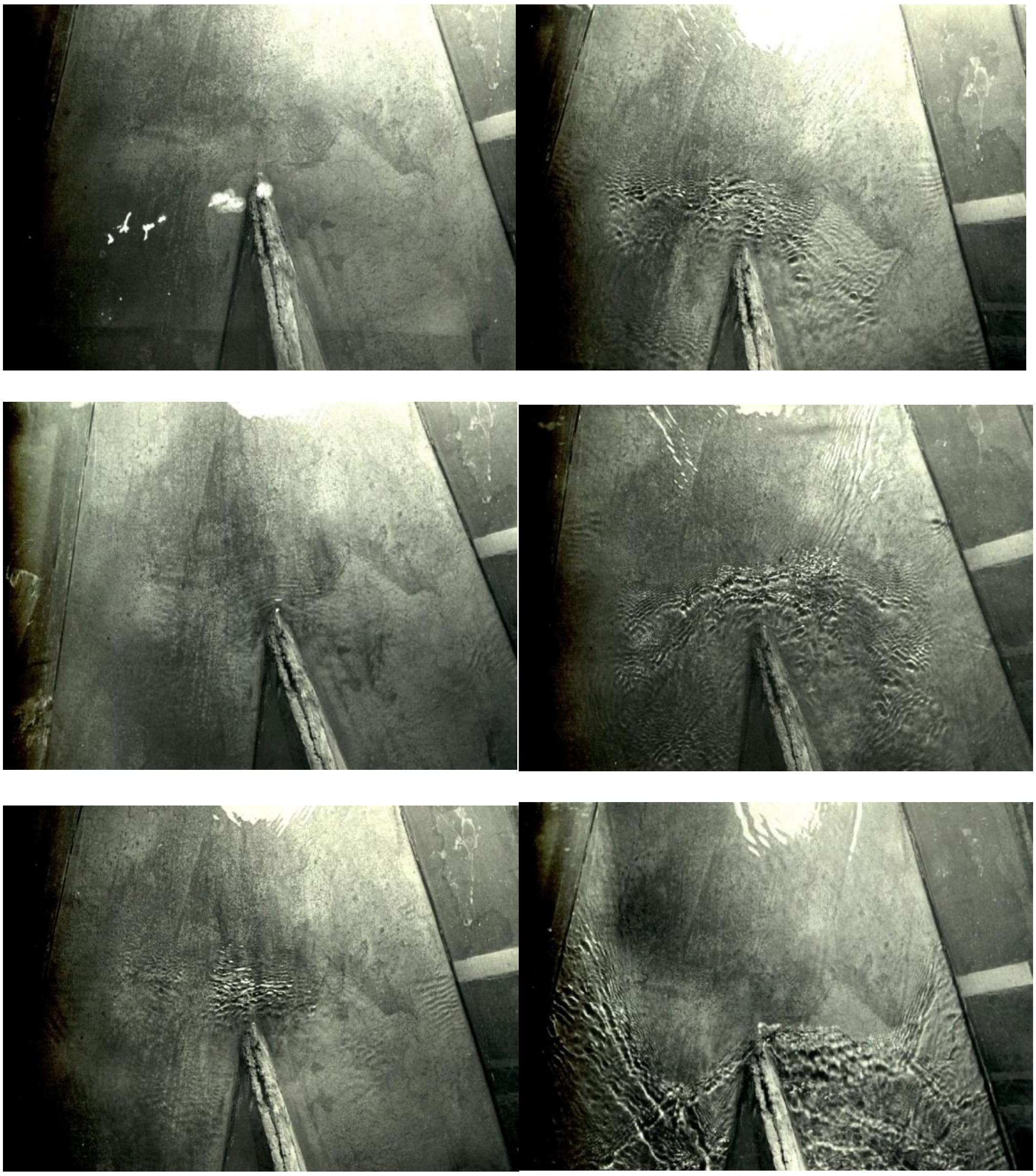
Fig. 5:
a) Q = 50cm3 / s; b) Q = 70 cm3 / s; s) Q = 80cm3 / s.

Experimental studies with sediments have shown that with a change in the concentration of sediment within the mouths of the separate zone, in some cases, two compressed sections are formed, and a dune appears in the middle of the channel, which grows over time. The formation of a whirlpool zone in the outlet channel is caused by a sudden increase in the width of the main channel and the rotation of the outlet stream by a certain angle, as well as by a change in the flow regime. During separation, due to a change in the direction of the flow stream, a centrifugal force arises in the outlet channel, as a result of which transverse circulation appears. As established (Fig. 3.6, a, b, c, a ', b', c '), the appearance of eddies and their size largely depend on the intensity of turbulence and circulation:

,

where is the pulsation rate; - average speed.

Thus, the results of the studies carried out give grounds to assert that we have established the regularity of changes in the depth of homogeneous and inhomogeneous flows, the geometry of the vortex region and, in some cases, its dimensions. The general relief picture and their calculated values by coordinates are presented in Fig. 5 and in Table 1.
flow characteristics, as well as the depth and dimensions of the dense flow at the bottom of the tray.



(laminar and transient mode) (turbulent regime and quadratic region)
Fig. 6

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