RESEARCH ARTICLE | MARCH 15 2023

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AIP Conference Proceedings 2612, 020017 (2023)
https://doi.org/10.1063/5.0124148

Study of Kinematic Structure of Low Flood of Water Supply Facilities

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Abstract. This article deals with the quenching of the kinetic energy of the flow to the lower reaches of the low and medium pressure reservoirs and the determination of the strength of the structure, the rational size of the structural elements of power extinguishers, the intermediate distances. The study aimed to ensure that the distance of the hydraulic jump movement of the water flow is shortened, to increase the reliability of the construction and operation of drainage facilities by determining the Froude number in extinguishing the kinetic energy of the water before the flow reaches the lower basin.

INTRODUCTION

At present, the problems of developing experimental models for applying different options for extinguishing the energy of watercourses in sewage treatment plants and the selection of the perfect design and their application in practice have not been sufficiently studied. Therefore, there is a need to study hydraulic processes and develop them in engineering practice, using constructive solutions of various power extinguishers at the facility itself, considering that short-term extinguishing of water flow energy in water discharge facilities prevents water flow overturning.

At the same time, one of the important tasks is to select constructive solutions for quenching the kinetic energy of water flow in water discharge facilities, to determine the hydrodynamic stresses of water flow to lower basin structures, to conduct new experimental research on water connection and discharge structures and conduct scientifically based calculation methods.

In this regard, taking into account the composition and structure of the lower basin soil in reservoirs, the application of operational measures to prevent water flow energy at short distances, to prevent the reversal of water flow, to improve the reliability and service life of the structure is one of the important functions.

METHODS

In the practice of operation of existing hydraulic and hydropower facilities, although the drainage facilities have a relatively simple design, their physical modeling is carried out on a large scale due to the high level of reliability of the structure [1, 2].

The water flow has a free surface on which gravity and friction forces play an important role. When building an experimental device, its compactness and small size make it cheaper. However, its shrinkage increases the effect of surface tension and friction forces on the water flow movement. To overcome this problem, it is required that the scale coefficient is 50-60, the value of the coefficient of flow rate in the water pipe is less than 5%, the water flow rate is higher than 6.5 mm, and the smoothness of the surfaces on which the water flows. Experimental laboratory studies conducted under these conditions provide accurate results for practice when water flows through a water pipe from a discharge facility [3, 4]. In the physical modeling of hydraulic phenomena, it is expedient to fulfill the conditions of geometric similarity, the similarity of initial and boundary conditions, dynamic and kinematic

The Third International Scientific Conference Construction Mechanics, Hydraulics and Water Resources Engineering (CONMECHYDRO 2021 AS)
AIP Conf. Proc. 2612, 020017-1–020017-9; https://doi.org/10.1063/5.0124148
Published by AIP Publishing. 978-0-7354-4337-2/$30.00

similarity laws corresponding to the forces involved in the flow formation.

RESULTS

When studying hydraulic regimes, the following parameters of the flow from the discharge facilities for natural conditions were studied:

- Drainage facility consumption Q = 3.9 ÷ 11.6 l / s;
- Average flow rate = 15 ÷ 150 sm / s;
- The average depths in the lower basin are h = 8 ÷ 21 sm.
- The relative variability range of these modes is assumed to be as follows:
- specific costs where: Q and Qp - current and estimated costs;

utilization factor of the waterfront

- where: b is the width of the working sections; V is the width of the downstream;

The range of defined flow parameters allows us to determine the limits of applying the laws identified in our research.

The flow movement will have a spatial character under the operating conditions of multi-section drainage facilities on real objects. In this respect, research differs from flat case studies. Under such conditions, there is no asymmetry in the distribution of specific costs. This situation requires predicting the dynamics of the pressure and depth, the maneuverability of the barriers, and the consumption of water discharged during the operation of hydraulic structures. It is known from the operation results that the symmetrical distribution of the flow in the maneuvering of the discharge structures leads to its overturning, the formation of water cycles and the occurrence of planar and depth deformations of the lower basin. Therefore, maneuvering schemes that lead to a state of symmetrical distribution of specific consumption during operation are widely used. In the dissertation work, taking into account this situation, the hydraulic regimes of the flow in the symmetrical maneuvering process were studied [5-8].

Based on the research on quenching the kinetic energy of the flow in the discharge nose area and preventing the overturning of the water flow, constructive solutions to quench the kinetic energy of the flow before the water falls into the apron in the discharge area show the dynamics of the front forehead resistance and surge velocity. These parameters can be determined for the energy extinguishers studied [9, 10]. Using several of their design solutions, we investigated rectangular and crescent-shaped power extinguishers in an experimental device that did not have power extinguishers. According to the results of the study, the design that gives us the maximum flow energy dissipation is shown in Figure 1.2 below

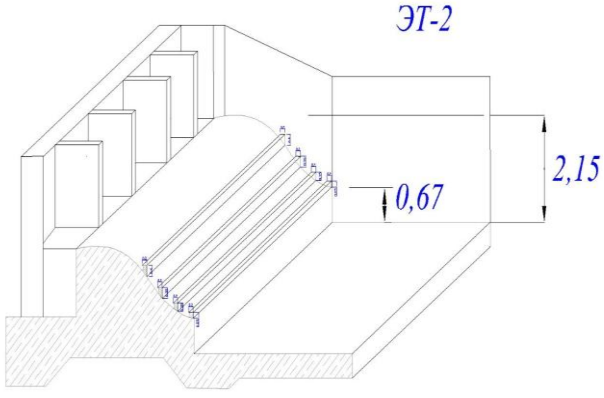

FIGURE 1. Location of power switches at the discharge facility.

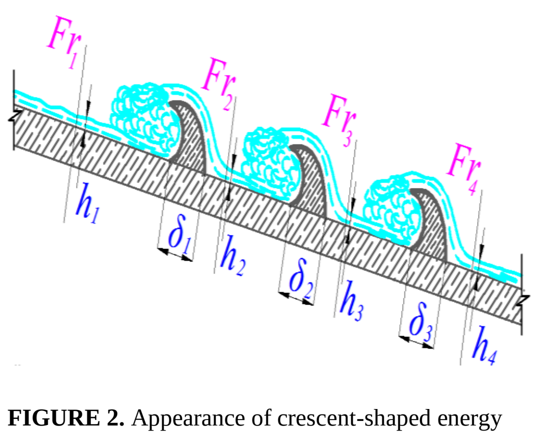

FIGURE 2. Appearance of crescent-shaped energy extinguishers in experimental research

Here: Froude numbers determined after Fr-energy extinguishers, $h_{1,2,3,4}$ is flow depth, $d_{1,2,3,4}$ is the wall thickness of the energy extinguisher.

Depending on the flow velocity moving along the bottom of the stream, the Froude number and the kinetic parameters were determined for the appearance of hydraulic jumps in the absence of power switches in the discharge facility [11-13]. To determine the hydraulic processes in the nasal area of the drainage structure, the values of the

Froude number in the absence of power extinguishers are given in Figs. 3 ÷ 6. In the proposed construction, the results of the Froude numbers obtained from energy extinguishers placed in the discharge area (Figures 7 ÷ 10) are given in [7, 10, 13, 14].

In the absence of power extinguishers in the model of the discharge structure, Froude numbers were determined based on hydraulic parameters determined in experimental studies based on different water consumption, and they are as follows:

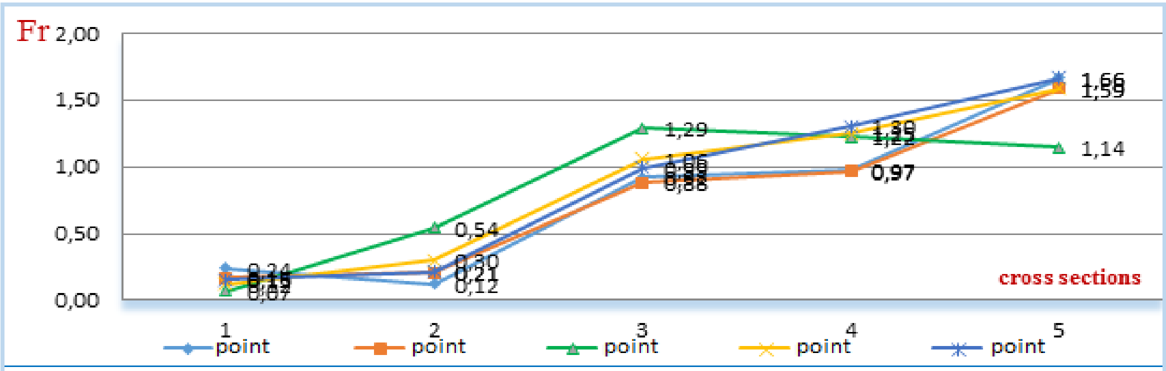

FIGURE 3. When the water consumption of the moving stream in the drainage structure is Q_m = 3.9 l / s, there are no power extinguishers in the discharge section.

The value of the first detected Froude number Fr= 0.07 ÷ 1.66, and in the range Fr= 1 ÷ 1.7, a wave-hydraulic jump occurred.

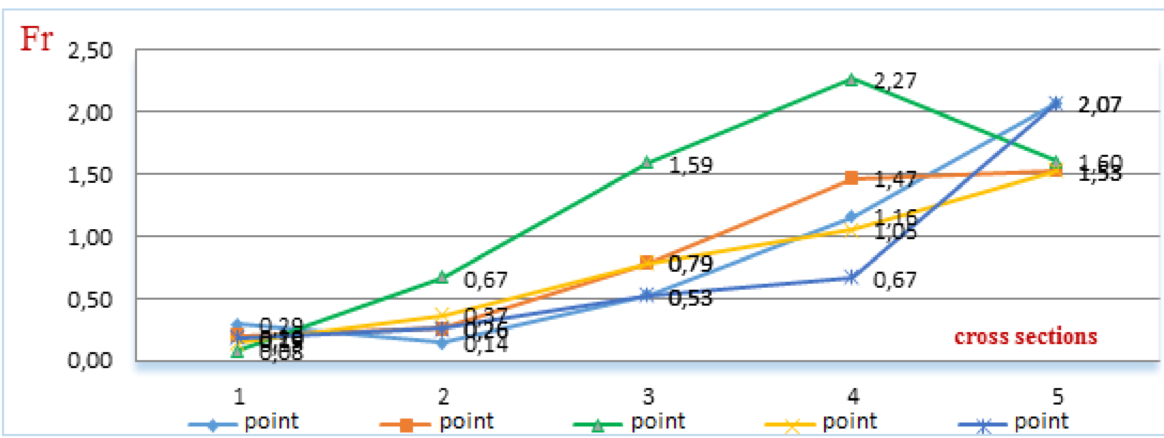

FIGURE 4. When the water consumption of the moving stream in the drainage structure is Q_m = 6.9 l / s, there are no power extinguishers in the discharge section.

The value of the second determined Froude number Fr= 0.09 ÷ 2.27, while in the range Fr= 1.7 ÷ 2.5, a slow hydraulic jump occurs. A small circle appears on the free surface when a hydraulic jump occurs.

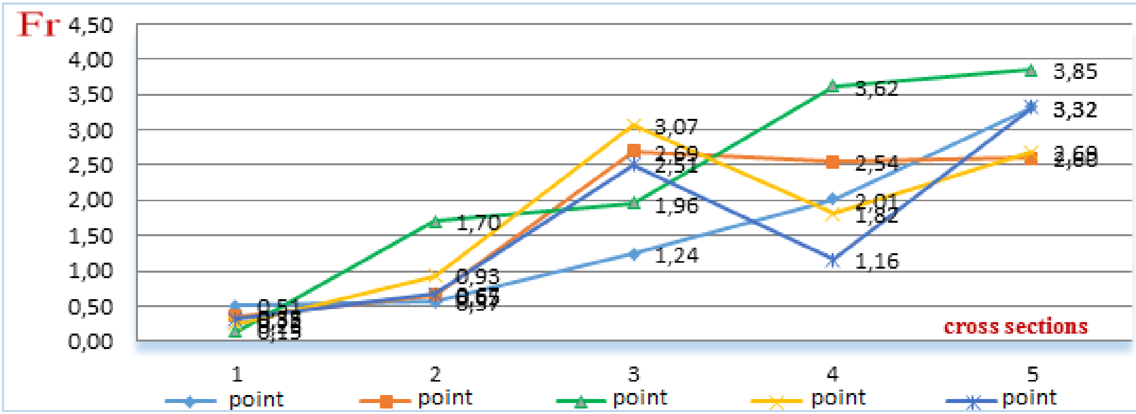

FIGURE 5. When the water consumption of the moving stream in the drainage structure is Q_m = 10.07 l / s, there are no power extinguishers in the discharge section.

When the value of the third detected Froude number is Fr= 0.09 ÷ 2.27, and in the range Fr= 1.7 ÷ 2.5, a slow hydraulic jump occurs. When a hydraulic jump occurs, small rotational appearances appear on the free surface in the field.

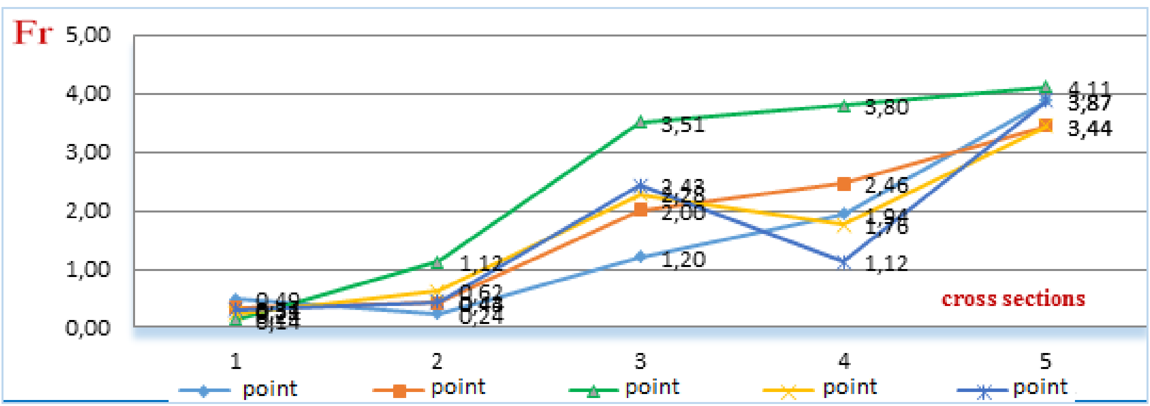

FIGURE 6. In the absence of power extinguishers in the discharge section when the water consumption of the moving stream in the discharge structure is Q_m = 11.6 l/ s

The value of the fourth detected Froude number is Fr= 0.2 ÷ 4.11, and an oscillating hydraulic jump occurs at values in the range Fr= 2.5 ÷ 4.5. After a certain distance along the stream, a wave appears. In this case, the hydraulic jump is not constant.

The value of the fifth detected Froude number was found to be Fr= 0.2 ÷ 1.21.

Based on the data obtained, the study did not limit the length of the jump, the appearance of the contact depths, the distribution of flow velocity under the jump conditions, changes in velocities, changes in flow washing capacity. [15, 16].

Based on the results found in the experimental studies, it was found that when the flow in the discharge structure flows from the discharge structure at high speed, it is mainly connected to the flow in the lower basin in the mode of movement in the area near the bottom of the river. It was observed that the number of Froude's increased with increasing water consumption. They were installed, the results obtained were compared, and the most efficient extinguisher was approved as a crescent-shaped energy extinguisher, which yielded the following results (Figures 7 ÷ 10):

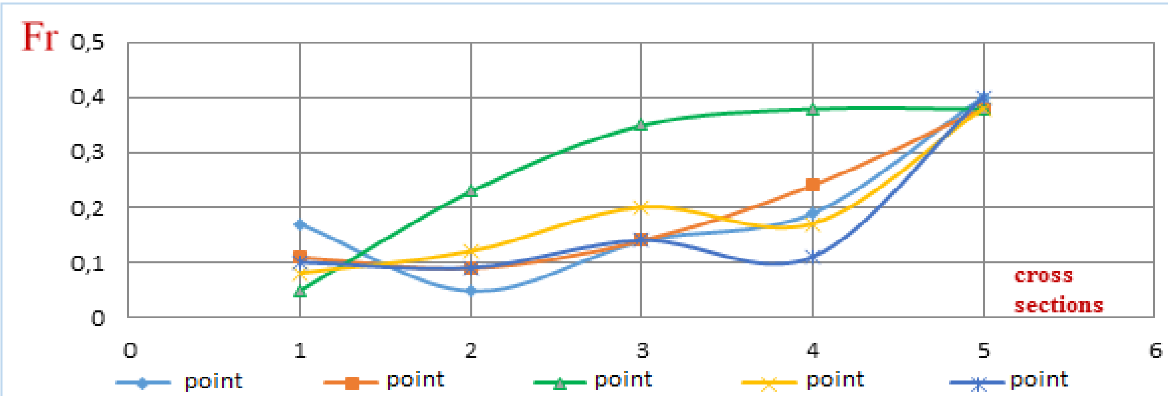

FIGURE 7. The water consumption of the moving stream in the drainage structure is Q_m = 3.9 l / s.

The situation after the installation of power extinguishers in the discharge section. The value of the first detected Froude number Fr= 0.05 ÷ 0.4.

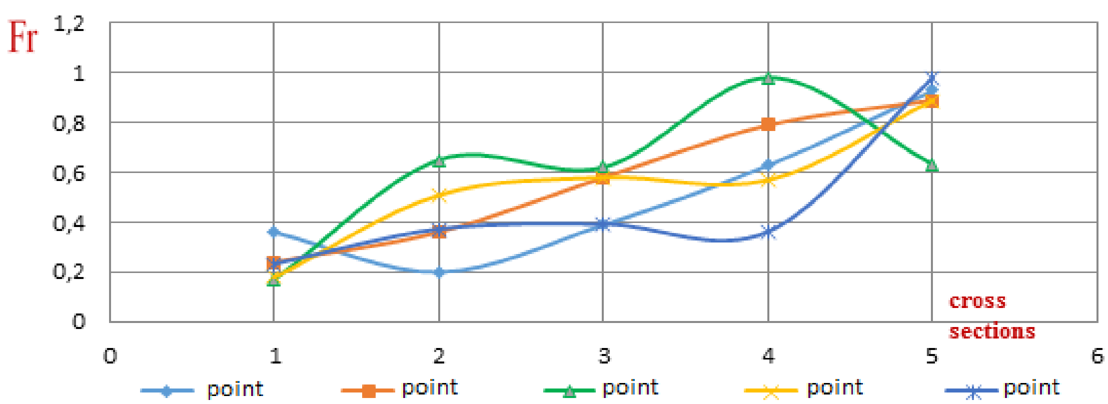

FIGURE 8. The water consumption of the moving stream in the drainage structure is Q_m = 6.9 l / s.

Power extinguishers are installed in the discharge section. The value of the second detected Froude number Fr= 0.02 ÷ 0.78

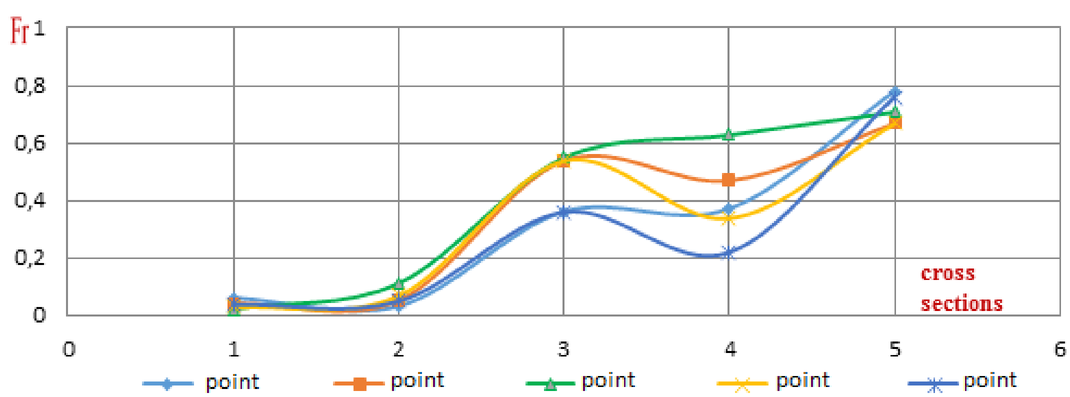

FIGURE 9. The case where there are power switches in the discharge section when the water consumption of the moving stream in the drainage structure is Q_m = 10.07 l / s.

The value of the fourth determined Froude number was Fr= 0.17 ÷ 0.98.

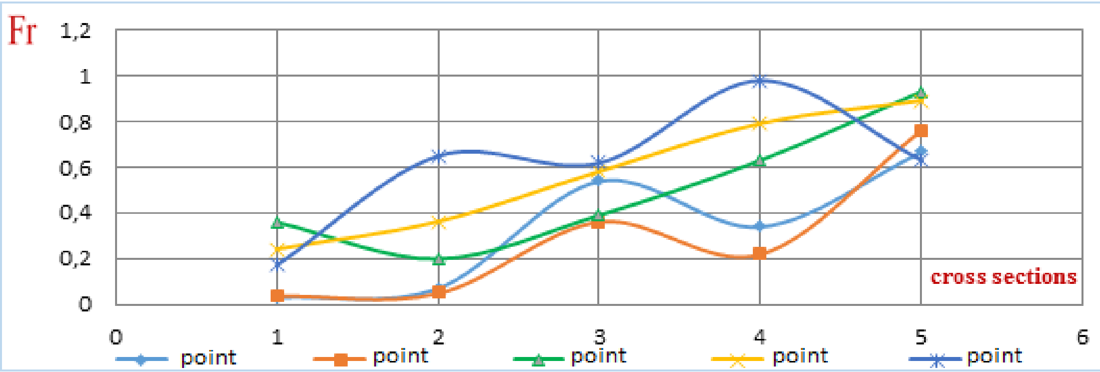

FIGURE 10. The water consumption of the moving stream in the drainage structure is Q_m = 11.6 l / s.

There are power extinguishers in the discharge section. The value of the fourth detected Froude number Fr= 0.17 ÷ 1.21.

Based on the data obtained from the experimental model at the dewatering facility, we presented graphs comparing the effect of the Froude number on the hydraulic conditions regimes of operation of different constructions. In the first case, the absence of power extinguishers, in the second case, the rectangular shape of the power extinguishers, and in the third case, the crescent-shaped power extinguishers were plotted by correlation graphs (Figures 11 ÷ 14).

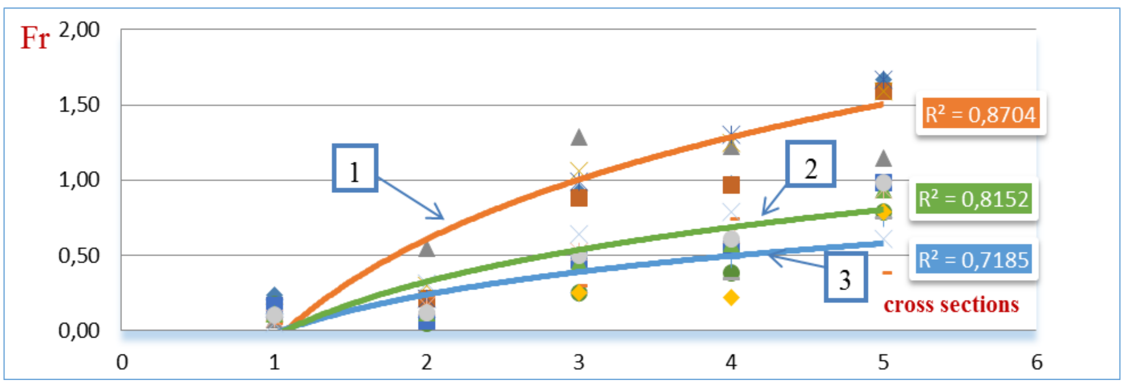

FIGURE 11. The water consumption of the moving stream in the drainage structure is Qm = 3.9 l / s. 1 is the absence of power extinguishers; 2 is a case of installation of rectangular power extinguishers; 3 is comparison graphs of the situation after the installation of half-moon-shaped power extinguishers.

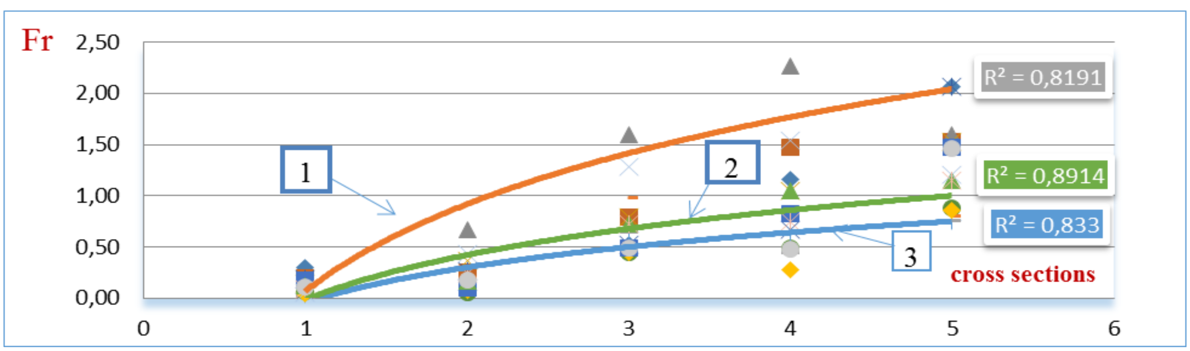

FIGURE 12. The water consumption of the moving stream in the drainage structure is Qm = 6.9 l / s. 1 is the absence of power extinguishers; 2 is a case of installation of rectangular power extinguishers; 3 is comparison graphs of the situation after installing half-moon-shaped power extinguishers.

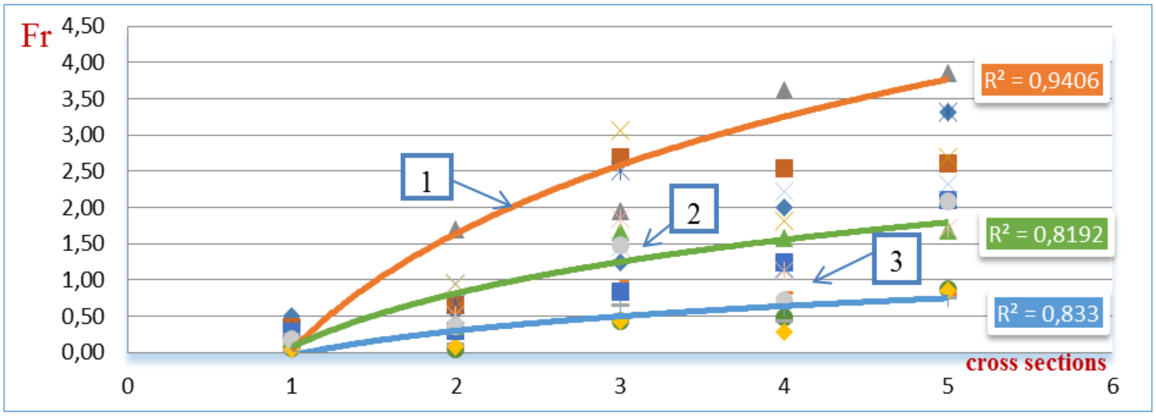

Figure 13. The water consumption of the moving stream in the drainage structure is Qm = 10.07 l / s. 1 is the absence of power extinguishers; 2 is a case of installation of rectangular power extinguishers; 3 is comparison graphs of the situation after installing half-moon-shaped power extinguishers.

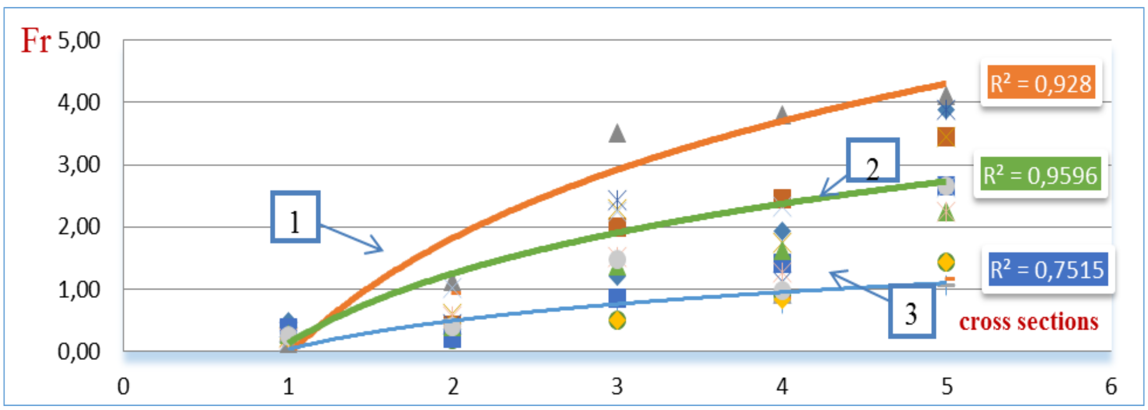

Figure 14. The water consumption of the moving stream in the drainage structure is Qm = 11.6 l / s. 1 is the absence of power extinguishers; 2 is a case of installation of rectangular power extinguishers; 3 is comparison graphs of the situation after installing half-moon-shaped power extinguishers.

In the study of comparable variants of power extinguishers, the calculated consumption range was determined based on the parameters characterizing the flow mode and hydraulic parameters of the flow, and comparison graphs based on the Froude number were given [17-20] a reduction of 20-35% compared to the case. The crescent-shaped energy extinguishers we proposed were based on reducing the kinetic energy of water by 65-72% compared to the non-existent condition.

CONCLUSION

In all variant studies, the kinematic structure of the water flow at different calculated flow values and the ranges of change of motion modes were studied. A characteristic feature of this study is that during the studies, it was ensured that the connection of the pounds in the form of a hydraulic jump was formed not by adjustment by the downstream but under the actual operating conditions of the structure.

The calculated specific sizes of the structural elements in the water extinguishers of the drainage structure were determined. The work carried out in this regard. The dimensions of the rectangular power extinguishers are h = 2; 2.5; 3; 4; 5 cm, b = 1.5; 2; 2.5; 3; 4; Studies were conducted on the size of 5 cm, the size of the crescent-shaped power extinguishers h = 2; 2.5; 3; 4; 5 cm, b = 1.5; 2; 2.5; 3; 4; Studies were conducted at 5 cm and the most suitable construction was based on a crescent-shaped structure with h = 3 cm b = 3 cm.

The dynamics of the Froude number and the critical parameters of the flow were compared comparatively based on the data obtained from the studies on the dynamics of the calculated costs, depending on the calculated specific sizes of the structural elements and its shape dimensions.

Figures 11-14 above provide comparison graphs based on the calculated flow range, the parameters characterizing the flow mode, and the Froude number determined depending on the hydraulic parameters of the flow in the study of comparable variants of right-angled and crescent-shaped power extinguishers. At the same time, mainly rectangular uncut valve energy extinguishers managed to reduce the kinetic energy of water by 20-35% compared to the current state of the Froude number. Through the proposed crescent-shaped energy extinguishers reduced the kinetic energy of the water by 65-72% was achieved compared to the non-existent condition.

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