DOI: 10.63550/ICEIP.2025.38.58.032

Flushing Device for Hydraulic Autoregulatory of Water Level on a Partition Structure

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Keywords: channel, sediments, flushing, device, speed, economy, water, flow.

Abstract: The article presents the designs of a flushing device for a hydraulic autoregulator of the water level with flexible working bodies in the form of a partition on the channel. This hydraulic automatic water level controller regulates the water level in the channel and ensures the passage of floating objects and the washing out of sediments, preventing their accumulation in the channel using only the renewable hydraulic energy of the water flow. Experimental studies of the structure of the water flow in front of the autoregulator in the area of operation of four types of flushing devices for flushing sediments in the channel in front of the autoregulator were justified and carried out using physical modeling using criteria of geometric similarity of the model and nature. Effective designs of flushing devices for flushing the bottom of the channel from sediments in front of the autoregulator are analyzed and proposed in order to save water by 3.36 times when flushing sediments and the possibility of using the released water for irrigation of water outlets located above the location of the autoregulator.

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1 INTRODUTION

In order to maintain the required water level in front of the partition structure on the irrigation system channel and supply a given water flow rate from it to lower-order channels in order to use water economically by water consumers, automation of the partition structures is carried out, shown in the works of K. M. Melikhov, A. A. Pakhomov, N. A. Kolobanova (Melikhov, Pakhomov, Kolobanova, 2016), V. N. Shchedrin, A. A. Churaev, V. M. Shkolnaya, L. V. Yuchenko (Shchedrin, Churaev, Shkolnaya, Yuchenko, 2015), M. I. Balzannikov (Balzannikov, 2018), S. A. Ovchinnikov, R. Z. Kiseleva, K. M. Melikhov, A. A. Kiselev (Ovchinnikov, Kiseleva, Melikhov, Kiselev, 2022).

The use of valves on the partition structures of irrigation systems and their remote location from power lines, from the point of view of economic efficiency, shows that their hydraulic automation is the most appropriate, that is, equipping them with hydraulic automatic valves, hydraulic autoregulators of the water level, using only the hydraulic energy of the water flow. They save electricity and reduce operating costs.

The existing designs of automatic hydraulic valves by Ya.V. Bochkarev, P.I. Kovalenko, E.E. Makovsky and others are made of metal and require the construction of a capital structure. This is expensive and hinders their widespread adoption in production. Modern elastic rubberized fabrics in the form of building materials with low weight, flexibility, the ability to change shape when loading changes and high maneuverability are shown in the works of T. Tomiyama and I. Nishizaki (Tomiyama, Nishizaki, 2006), D. Weston, G. Chartouni, L. Dalton, D. Force, J. Trovillion, K. Zumbulev, R. (Weston, Chartouni, Dalton, Force, Trovillion, Zumbulev, McMillen, 2021), S. G. Novikov, V. N. Kutsenko (Novikov, Kutsenko, 2019), made it possible to use them as flexible elements in hydraulic water level regulators on shut-off structures. Therefore, combined flexible designs of automatic hydraulic valves and auto regulators already exist today. These constructions are represented in the famous works of O.G. Zatvornitsky, B.I. Sergeev and others.

However, the main disadvantage of these structures is the lack of flushing of the channel in front of the autoregulator from deposits, as well as from driftwood and debris. The widespread use of valves on partition structures of irrigation systems arouses interest in finding simpler designs for such hydraulic automatic level control valves, whose designs are characterized by the absence of metal consumption, lightness, cheapness, passage of floating bodies, automatic flushing of the channel section in front of the partition structure, maintainability, and environmental friendliness. Therefore, a proposed automatic water level regulator with flexible operating organs has now appeared and is under development.

To improve the previously developed designs of hydraulic autoregulators of the water level with flexible working bodies, a design of a hydraulic autoregulator of the level with flexible working bodies of automatic control of the water level in the channel was proposed (Kadirova, Kadirov, 1990). Based on this design, an innovative design of a water level autoregulator with flexible working bodies (AG) was developed, which is shown in the work of Mukaddas-Gaukhar Kadirova (Kadirova, 2021) with a full description of the principle of its operation.

The hydraulic autoregulator of the water level (AG) consists of a main gate, which ensures the passage of floating bodies, and an automatic gate for flushing sediments, which is combined with the main gate in the lower part and ensures the passage of sediments through the flushing device to prevent their accumulation in the channel in front of it. At the same time, the spillway part of the main gate of the hydraulic autoregulator of the level with flexible working bodies is made of a non-vacuum profile adopted on the basis of hydraulic studies of its capacity and the hydrodynamic interaction of the main gate with the flow described in the articles (Kadirova, 2020; Kadirova, 2020). The results of studies of the passage of a jet of water through an automatic gate for washing sediment of a hydraulic autoregulator of the water level with flexible working organs (AG) were investigated and described in the article (Kadirova, 2021).

2 MATERIALS AND METHODS

The purpose of this work is to select a rational form of flushing device that ensures economical use of water consumption for more efficient flushing of sediments in front of the proposed automatic water level regulator with flexible working bodies in combination with a valve for flushing sediments, which is a partition structure. To this end, the task was set to conduct experimental studies of changes in the velocity structure of the water flow on several projected structures of the flushing device in the zone of influence of the proposed hydraulic water

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level regulator AG mounted on a partition structure.

An analysis of experimental studies of the velocity structure of a water stream conducted to date by V.N. Goncharov (Goncharov, 1962), M.A. Mikhalyov (Mikhalyov, 1971) and a number of other authors has shown that previously partition and discharge structures were studied with the presence of single-function gates. The designs of partition structures with multifunctional gates combining two shutters - the main one and the shutter of the flushing device with flexible working bodies, as in the example under consideration, have not been studied.

Considering this, it was necessary to conduct special experimental studies.

The purpose of the study was to:

- selection of a rational shape of the AG flushing device based on studies of the flow velocity structure of several planned types of flushing devices in the AG area of influence, ensuring complete flushing of sediments before construction with minimal water flow passing through the flushing device.

When conducting research on a partition structure equipped with the proposed AG in combination with a flushing device, the following research composition was outlined.

1. Studies of the velocity structure of the flow in the area of AG influence:

- with a flushing device in the channel in front of the opening of the flushing device in the form of a gallery tapering in length only in the horizontal direction, the angle of narrowing $\gamma = 0.239$ radian, the slope of the gallery $i_{pr} = \underline{i_k} = 0$ (Fig. 1 a, Fig. 1 b);

- with a flushing device in the channel in front of the opening of the flushing device in the form of a gallery extending in length only in the vertical direction, the angle of narrowing $\gamma = 0$, the slope of the gallery $i_{pr} = 0.1$ (Fig. 2 a, Fig. 2 b);

- with a flushing device in the channel in front of the opening of the flushing device in the form of a gallery, tapering in length in the horizontal direction, the angle of narrowing $\gamma = 0.239$ radian, and extending in length in the vertical direction with a slope $i_{pr} = 0.1$ (Fig. 3 a, Fig. 3 b);

- with a flushing device in the channel in front of the opening of the flushing device in the form of a gallery, tapering in length in the horizontal direction, the angle of contraction $\gamma = 0.239$ radian, and extending in length in the vertical direction with a slope of $i_{pr} = 0.1$ and with beveled walls on the upstream side (Fig. 4 a, Fig. 4 b).

During the study, the following was measured: 1) the positions of the curve of the free surface of the water in the pan in the zone of influence of the AG for the four above-mentioned types of flushing devices, 2) the total flow of water in the pan, 3) the velocity of water along the height and length of the tray at different distances from each other. Based on the results of these studies, lines of equal speeds relative to the highest speed were constructed in order to select the most rational form of the device for flushing the bottom of the channel before AG in the mode of free flow of the water stream.

The study was conducted using the method of physical modeling, geometric similarity of the model and nature, Reynolds criteria, Froude gravitational similarity and dynamic similarity of forces, the criterion of similarity of dynamic processes under the action of elastic forces (Cauchy criterion).

The experimental setup consisted of a tray 10 meters long, 0.47 m wide and 1...0.50 m high. The water was supplied to the tray by a pump. The scale of the models and nature was adopted by 1:4.

When conducting experimental studies of the structure of relative flow rates in the zone of influence of the proposed AG on the design of the partition, in order to choose the rational shape of its flushing device, 3 series of experiments were conducted with a flushing device for the above-mentioned forms of flushing devices in the form of galleries. During the research, various water levels were set in the tray.

The first series of experiments was carried out with the valves of the main and flushing device running. The second is when the flushing device valve is running (open) and there is no overflow through the main valve. In the studies, water flow rates were supplied to the tray in the range of 0.001...0.056 m3/s. At the same time, to account for the spread of the points of the measured values, the range of flow rates fed into the tray was taken from 0.002 to 0.0025 m3/s. This determined the number of experiments in each series of 20...25. In this case, the measurements were carried out after the steady flow mode was set in the tray, each measurement was checked by a subsequent control measurement.

During the study, the following values were measured and determined.

a) the flow rate of water passing through the tray,

b) the position of the curved free surface in the tray in front of the separation structure of the AG and along the vertical measuring surfaces,

c) speeds at five points inside the vertical surfaces included in 17 vertical measuring surfaces, the location of the points was determined with an interval of 0.03...0.04 m vertically depending on the level water in the tray in front of the partition, which

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was determined relative to the geometric dimensions of the model,

d) increasing the regulatory level of AG,

f) the position of the main valve AG and the position of the valve of the automatic flushing device.

The velocity at the points were measured using a SANIIRI microcoil, which was calibrated in a calibration device.

Measurements of the position of the free surface curve in vertical measuring planes and the thickness of the moving water layer were carried out using a Spitzen measuring scale, with an accuracy of 0.1 mm.

The position of the valves and the water level were determined using a grid applied to the transparent walls of the pan and float chamber. Measurements of the flow rate passing through the pan were carried out using a trapezoidal measuring spillway with a thin wall, its calibration was carried out in a volumetric manner.

The study used standard measuring equipment (Spitzen measuring scale, trapezoidal measuring spillway, SANIIRI micro-coil, metal ruler), the measurement accuracy of which is widely covered in the literature, and it fully met the requirements for measurement accuracy.

The dimensions of the flushing devices located under the main valve of the AG, were adopted based on the recommendations of R.D. Julaev, B.V. Popenko (Julayev, Popenko, 1971). This was done to create a streamlined shape of the flushing device for the occurrence of transverse flow circulation during sludge flushing in the structures shown in Fig. 1 a, Fig. 1 b, Fig. 3 a, Fig. 3 b and Fig. 4 a, Fig. 4 b, tapering in length in the horizontal direction with a narrowing angle, according to (Julayev, Popenko, 1971), γ = 0.175...0.349 radians, that is, γ = 0.239 radians. In order to reduce the required flow rate of the flushing stream and enhance the phenomenon of transverse circulation, the flushing device in the designs shown in Fig. 3 a, Fig. 3 b and Fig. 4 a, Fig. 4 b was designed with the possibility of extending its length in the vertical direction.

The following was accepted on the models:

- the height at the overlap point of the flushing device, the automatic sediment flushing gate was adopted

$$h_{pr} = 0.25 \cdot H_z^{\max} = 0.25 \cdot 0.27 = 0.068m$$

- the total width of the gallery at the beginning of the B_{pr}, for the above-described forms of flushing devices that taper in length in the horizontal direction and for flushing devices that do not have a taper, was assumed from the condition of the ratio of the width of the tray to the depth of water in it, equal to b_l / h_{max} = 47/27 = 1.74 < 8 ...10. Therefore, the option of only one flushing device on a structure with a width of was considered.

$$B_{pr} = b_l = 0.47m;$$

- the width of the gallery at the overlap point with the sediment flushing shutter for flushing devices having a horizontal narrowing was taken from the condition

$$b_{pr} = (0.1...0.3)B_{pr} = (0.1...0.3)0.47 = 0.14m$$

- the length of the flushing device to the overlap point with the automatic flushing shutter, for flushing devices having a vertical extension was taken from the condition

$$L_1 = h_{pr}\frac{\sqrt{1-i_{pr}}}{i_{pr}} = 0.068\frac{\sqrt{1-0.1^2}}{0.1^2} \cong 6.77m$$

The dimensions of the AG main shutter model are assumed in accordance with the hydraulic justification (Kadirova, 2021) as follows:

$$H_z^{\max} = 0.27m$$

$$\alpha_{\max} = \alpha_p = 0.785radian$$

$$l = L = 0.38m$$

$$\beta = \alpha_{\max} = 0.785radian$$

$$l_{kor} = 0.54m$$

The width of the spillway part of the main AG shutter was assumed to be 0.465 m, depending on size of the hydraulic tray on which the research was conducted, the width of the tray or the width of the model was 0.47 m. The profile shape of the spillway spillway part of the main shutter of the AG was accordance with the hydraulic justification given in the article (Kadirova, 2020) non-vacuum, as the most rational. The elastic material of the models was a rubberized nylon-based fabric, the hinge joints were also made of rubberized fabric glued in two layers. The float controller AG was located in the float chamber outside the tray. The float chamber was connected by an opening with a diameter of 0.02 m to the upper stream of the AG, the float sensor of the AG was connected to the tank of the AG by an opening with a diameter of 0.06 m, and the tank of the AG had drain holes with a diameter of 0.02 m from the capacity of the main gate of the AG and a diameter of 0.01 m from the capacity of the shutter of the flushing device. The capacities of the main shutter and the automatic gate of the

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flushing device were interconnected by an opening with a diameter of 0.04 m.

The dimensions of the float were taken from the condition of equilibrium of the forces acting on it, the diameter of the float is 0.20 m, and the diameter of the float chamber is 0.21 m.

The dimensions of the automatic sediment flushing shutter were adopted in accordance with the hydraulic justification given in Article (Kadirova, 2021):

- the height of the automatic sludge flushing flap corresponds to the height of the flushing device at the overlap point

$$h_z = h_{pr} = 0.068m;$$

- the width of the automatic sludge flushing flap corresponds to

$$b_z = b_{pr} - 2b_{vist}$$

$$b_z = 0.136m$$

where $b_{vist} = 0.002m$ – is the width of the protrusions on the model, $b_{pr} = 0.14m$ - is the width of the flushing device in the place where it is blocked by an automatic flap;

- the length of the rigid board

$$l_{sh} = 1.41h_{pr} = 0.35H_z^{\max} = 0.095m$$

- maximum angle of inclination of the rigid board.

$$\theta_{\max} = 0.785radian$$

- length of the soft shell

$$l_{ob} = 0.9l_{sh} = 0.32H_z^{\max} = 0.086m$$

- the length of the automatic flap along the upper edge

$$l_1 = 2l_{ob}\sin\theta_{\max} = 0.122m$$

- the length of the flushing device on the upper side before the operation of the automatic flap of the flushing device corresponded to

$$L_2 = L_1 - \frac{h_{pr}}{tg\theta_{\max}} = 6.77 - \frac{0.068}{tg0.785rad} = 6.70m$$

3 RESULTS AND DISCUSSIONS

As a result of the processing of the conducted studies, lines of equal speeds were obtained in the form of the ratio of flow velocity to maximum velocity (V/Vmax) in front of the flushing opening of the water level autoregulator with flexible working bodies (AG) with four different types of flushing devices. For an autoregulator of the water level with flexible working bodies (AG) with a flushing device in the form of a gallery tapering in length only in the horizontal direction in front of the opening of the flushing device, the angle of narrowing γ = 0.239 radians, the slope of the gallery $i_{pr} = i_k = 0$, they are displayed under the following conditions:

1) when the flap of the flushing device is open and at the same time the liquid flows out (overflows) through the main flap, shown in Fig. 1 a;

2) with the flap of the flushing device open and there is no drain (overflow) through the main valve shown in Fig. 1 b.

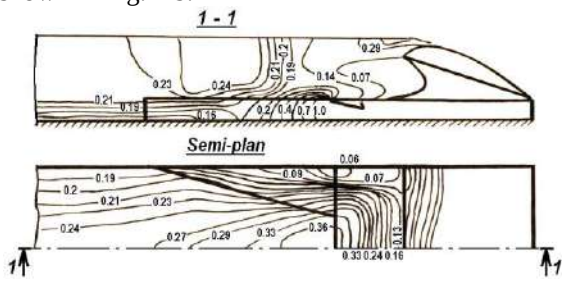

Figure 1 a: Lines of equal speeds in the form of the ratio of the flow velocity to the maximum velocity (V/Vmax) in front of the opening of the AG flushing device with the flushing device in the form of a gallery tapering in length in the horizontal direction, with the flushing device gate open and ensuring simultaneous movement of the water flow through the flushing device and outflow (overflow) through the main shutter of the AG.

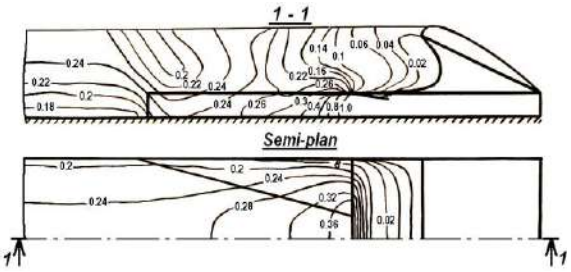

Figure 1 b: Lines of equal velocities in the form of the ratio of the flow velocity to the maximum velocity (V/Vmax) in front of the flushing opening of the AG with the flushing device in the form of a gallery tapering in length in the horizontal direction when the flushing device is open and there is no discharge (overflow) through the main gate of the AG.

For an autoregulator of the water level with flexible working bodies (AG) with a flushing device

DOI: 10.63550/ICEIP.2025.38.58.032

in front of the flushing opening in the form of a gallery running along its length in a vertical direction with an inclination of the gallery i_{pr} = 0.1, show Fig. 2 a and Fig. 2 b lines of equal speeds as the ratio of the value of the actual water flow velocity to the value its maximum speed (V/Vmax) under the following conditions:

1) with the flap of the flushing device open, when the water flow passes through the open flap of the flushing device and simultaneously moves (overflows) through the main flap shown in Fig. 2 a;

2) in the absence of a flow (overflow) through the main gate AG, when the water flow passes only through the open gate of the flushing device in Fig. 2 b.

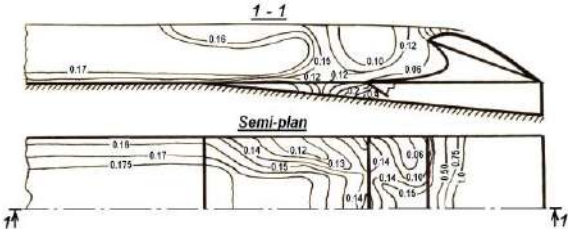

Figure 2 a: Lines of equal velocities in the form of the ratio of the flow velocity to the maximum velocity (V/Vmax) in front of the flushing opening of the AG with a flushing device in the form of a gallery extending along the length in the vertical direction with a slope of ipr = 0.1: with simultaneous movement of the water flow through the open gate of the flushing device and outflow (overflow) through the main AG shutter.

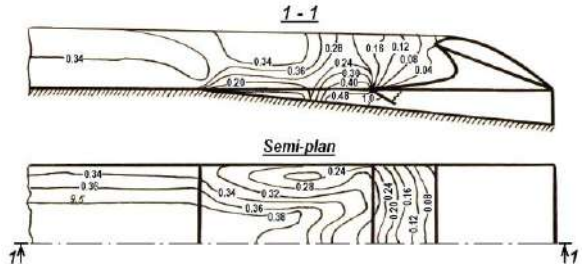

Figure 2 b: Lines of equal velocities in the form of the ratio of the flow velocity to the maximum velocity (V/Vmax) in front of the AG flushing opening with a flushing device in the form of a gallery running along the length in a vertical direction with an inclination of i_{pr} = 0.1: when the flushing device flap is open and the water flow passes only through it, and the drain There is no (overflow) of water through the main valve.

For an autoregulator of the water level with flexible working bodies (AG) with a flushing device in the form of a gallery, tapering in length in the horizontal direction, the angle of contraction γ = 0.239 radians, and extending in length in the vertical direction with an inclination i_{pr} = 0.1 shows equal velocity lines in the form of the ratio of the velocity of the water flow to its maximum speeds (V/Vmax) under the following conditions:

1) with the flushing device flap open, when the water flow passes through the open gate of the flushing device and simultaneously moves (overflows) through the main gate AG in Fig. 3 a;

2) with no flow (overflow) through the main gate AG, when the water flow passes only through the open gate of the flushing device in Fig. 3 b.

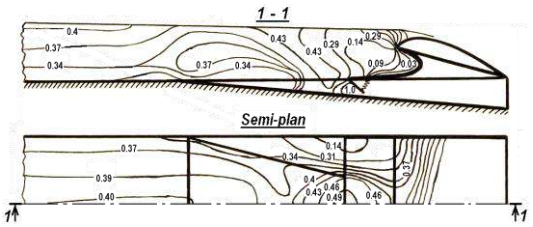

Figure 3 a: Lines of equal velocities in the form of the ratio of the flow velocity to the maximum flow velocity of the water flow (V/Vmax) in front of the flushing opening of the AG with the flushing device in the form of a gallery, tapering in length in the horizontal direction and expanding in length in the vertical direction when the flushing device is open, when the flow of water occurs simultaneously through the flushing device with the expiration (overflow) of the water flow through the main gate of the AG.

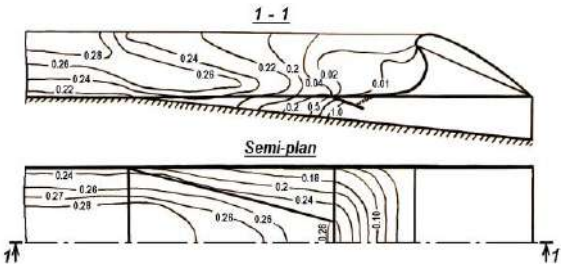

Figure 3 b: Lines of equal velocities in the form of the ratio of the flow velocity of the water stream to its maximum velocity (V/Vmax) in front of the flushing opening of an AG with a flushing device in the form of a gallery, tapering in length in the horizontal direction and expanding in length in the vertical direction when the flushing device is open and the water flow moves only through the flushing device and there is no outflow

DOI: 10.63550/ICEIP.2025.38.58.032

(overflow) through the main gate AG.

For an autoregulator of the water level with flexible working bodies (AG) with a flushing device in the form of a gallery, tapering in length in the horizontal direction, the angle of contraction γ = 0.239 radians, and extending in length in the vertical direction with an inclination i_{pr} = 0.1 and with a beveled side, lines of equal flow velocity ratio are shown on the walls in front of the drain hole, to its maximum speed under the following conditions:

1) when the flushing device flap is open and water enters simultaneously through the flushing opening and through the main flap shown in Fig. 4 a;

2) when the flushing device flap is open and water passes only through the flushing device and there is no outflow (overflow) through the main gate shown in Fig. 4 b.

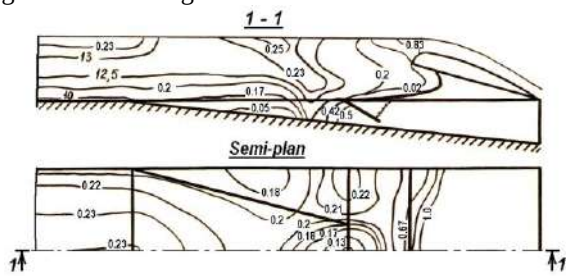

Figure 4 a: Lines of equal velocities in the form of the ratio of the water flow velocity to its maximum velocity (V/Vmax) in front of the AG flushing opening with a flushing device in the form of a gallery, tapering in length in the horizontal direction and expanding in length in the vertical direction and with beveled side walls when the flushing device is open and the flow is moving water through the flushing device simultaneously with the outflow (overflow) of water through the main Gate of the AG.

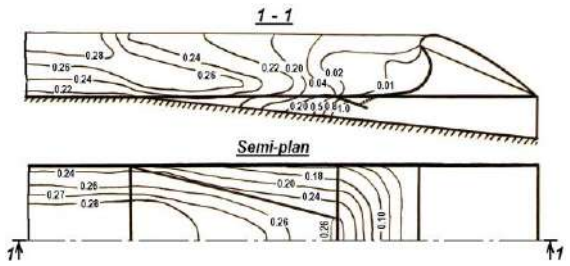

Figure 4 b: Lines of equal velocities in the form of the ratio of the flow velocity of the water stream to its maximum velocity (V/Vmax) in front of the AG flushing opening with a flushing device in the form of a gallery, tapering in length in the horizontal direction and expanding in length in the vertical direction with beveled side walls, with the flushing device gate open and the water flow, passing only through the flushing device, and without outflow (overflow) of water through the main gate AG.As a result of studies of water flow through the automatic sludge flushing valve, in the absence of overflow through the main valve of the water level autoregulator with flexible working bodies (AG), the values of water flow through the automatic sludge flushing valve for all four types of flushing devices were obtained. They were considered with the same opening height of the automatic sediment flushing flap, in the absence of overflow through the main flap of the water level autoregulator with flexible working bodies (AG).

As a result of mathematical processing of the data from these studies, curves were constructed representing the ratio of the opening height of the automatic sludge flushing valve to its maximum opening height, relative to the ratio of water flow through this automatic sludge flushing valve to its maximum flow rate, Fig. 5.

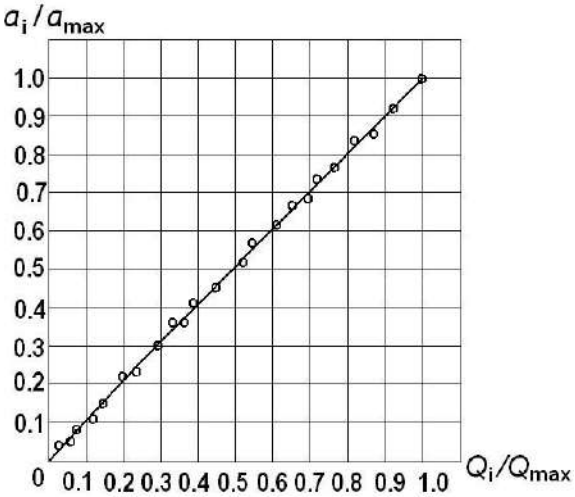

Figure 5: Graph of the ratio of the opening height of the automatic sediment flushing gate to its maximum opening height, relative to the ratio of the water flow through it to its maximum water flow. The circles indicate experimental data obtained as a result of research.

These curves in the form of a dependence graph (Fig. 5) make it possible to determine the water flow through an automatic sludge flushing valve and are

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described by the same expression for all four types of washing devices considered to determine the water flow through an automatic sludge flushing valve (1).

$$Q_i = \frac{a_i}{a_{\max}} Q_{\max} \quad (1)$$

where Q_i - is the water flow rate going through the automatic sediment flushing gate, $Q_{\max}$ - is the maximum flow rate going through the automatic sediment flushing gate, a_i - is the opening height of the automatic sediment flushing gate, $a_{\max}$ - is the maximum opening height of the automatic sediment flushing gate.

However, it should be noted that the flow rate of water passing through the automatic sludge flushing valve, which is used to flush the bottom of the channel in front of the AG, will be significantly lower for flushing devices in the form of galleries tapering in length in the horizontal direction, shown in Fig. 1 a, Fig. 1 b, Fig. 3 a, Фиг. 3b, фиг. 4a, and Fig. 4b, than when using a flushing device having only a gallery running along its length only in a vertical direction with an inclination (Fig. 2a, Фиг. 6v). 2, b), since the width of the flushing device with horizontally tapering galleries will be 3.36 times less than the total width of the AG (Bpr/bpr/ = 0.47m/0.14m = 3.36). These types of flushing devices are well used in cases where it is necessary to use water sparingly to clean the bottom of the channel in front of the AG from deposits, when maintaining the water level in front of the AG requires economical use of water.

Analysis of the obtained lines of equal velocities in the form of the ratio of the flow velocity to the maximum velocity (V/VMAX) with the flap of the flushing device open and the flow of water flowing (overflowing) through the main gate on all types of AG flushing devices considered (Fig. 1 b, Fig. 2 b, Fig. 3 b, Fig. 4 b) showed that maximum flow rates are observed when the water flow passes through flushing devices consisting of galleries that taper in length in the horizontal direction (Fig. 1b, Fig. 3 b, Fig. 4 b).

Analysis of the obtained lines of equal velocities in the form of the ratio of the flow velocity to the maximum velocity (V/VMAX) with the flushing device flap open and no discharge (overflow) through the main valve AG for all types of AG flushing devices considered (Fig. 1 b, Fig. 2 b, Fig. 3 b, Fig.4 b) showed that the maximum flow rates are observed when the water flow passes through all the considered types of flushing devices. This means that all types of the considered flushing devices can be used in practice, ensuring that the water level is maintained in front of the partition equipped with AG.

However, the water flow rate used to flush the channel section in front of the AG, which includes a flushing device in the form of a gallery tapering in length in the horizontal direction (Fig. 1 a, Fig. 1 b, Fig. 3 a, Fig. 3 b, Fig. 4 a, Fig. 4 b) will be 3.36 times smaller than when using a flushing device in the form of a gallery, which has an elongation in length only in the vertical direction with an inclination (Fig. 2 a, Fig. 2 b), as already shown above. These types of flushing devices are convenient to use when it is necessary to use low water consumption to flush the bottom of the channel from deposits, when maintaining the water level before AG requires economical water consumption.

It should be noted that flushing the bottom of the channel from sediments in front of the water level autoregulator with flexible working bodies (AG) with the lowest possible water consumption is carried out using flushing devices in the form of a gallery, which narrows in length in the horizontal direction and expands in length in the vertical direction (Fig. 3 a, Fig. 3 b), and also in the form of a gallery, tapering in length in the horizontal direction and expanding in length in the vertical direction, with a slope and with beveled side walls (Fig. 4 a, Fig. 4 b). An autoregulator of the water level with flexible working bodies and a flushing device in the form of a gallery, tapering in length in the horizontal direction and expanding in length in the vertical direction with a slope and with beveled side walls (Fig. 4 a, Fig. 4 b) during flushing, it always provides more efficient cleaning of the channel bottom in front of the partition structure in the form of AG.

5 CONCLUSIONS

Based on the analysis of the conducted research and all of the above, the followingconclusionscan be drawn:

1. The article considers the velocity structure of the water flow in the zone of influence of the proposed hydraulic autoregulator of the water level with flexible working bodies, powered by renewable water energy and equipped with an automatic sludge flushing valve mounted on a flushing device.
2. The research results are analyzed and the most effective types of designs of flushing devices

for flushing the bottom of the channel from sediments in front of the hydraulic autoregulator of the water level are proposed, ensuring the minimum possible water consumption for flushing, saving water on washing sediments by 3.36 times. This will make it possible to use the water released during the cleaning of the canal bottom from sediments for water outlets located upstream in front of the partition structure.

3. The most effective flushing devices for flushing the bottom of the channel from deposits in front of the autoregulator turned out to be flushing devices in the form of a gallery tapering in length in the horizontal direction and extending in length in the vertical direction with a slope (Fig. 3 a, Fig. 3 b) and in the form of a gallery tapering in length in the horizontal direction and extending in length in in the vertical direction, with a slope and with beveled side walls (Fig. 4 a, Fig. 4 b), which are proposed for implementation.

4. The considered designs of flushing devices for a hydraulic autoregulator with flexible working bodies ensure the flushing of deposits from the channel, preventing their accumulation in the channel, do not require operating costs for cleaning the channel from deposits, are environmentally friendly, since they use only renewable hydraulic energy of the water stream.

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