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Siphon for measuring water at the intake from the tray engineering structures

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Abstract. Currently, in the context of an increasing shortage of water resources, metering and measurement of water in engineering channel communications is of particular relevance. Especially with water distribution between consumers, there always arises the need for accurate metering of water. This article discusses the issues of water distribution by siphon pipe and determining the actual amount of flow rate. Using the basic equations of hydraulic engineering, a mobile siphon water meter has been developed. The proposed design of the siphon performs two functions: water intake from the trays and water measurement. The paper presents the results of a field study on the use of a siphon water meter for the condition of the tray networks of Uzbekistan. Based on the hydraulic calculation, siphon parameters for abstraction and water measurement are proposed. For each specific case, the siphon throughput is calculated. Water discharge calculation with Siphon determined by vacuum meter a set at the rotating part of it is, depending on the display of the vacuum meter, the water flow rate is determined using the connection diagram of. For this, the graph is built or aggregated graph of. Based on laboratory research, the amount of discharge determined which takes siphon. Based on the research, was obtained a patent from the Intellectual Property Agency for a mobile siphon water meter. By installing this irrigation trays device to the farms through the existing irrigation systems, gotten opportunity to accurately assess the actual water intake and the actual amount of water it receives. According to the results of the work, a graph of the dependence of water flow on pressure is proposed for practical use.

1. Introduction

According to the laws of hydraulics, the movement of water to determine the flow rate in pressure flows is sufficient to measure the speed of the water. The cross-sectional area is usually known and limited by the walls of the conduit. The flow rate is determined by multiplying the fluid flow rate by the living cross-sectional area of the flow [1-4]. However, the practical implementation of this approach is very difficult. Therefore, at present, there are various methods for measuring water [5-8]. Depending on the task, it is possible to use various measurement methods, however, it is always necessary to take into account the existing technical conditions at the measuring object and think over measures for further maintenance and operation of measuring instruments [9-12]. In hydraulic engineering, methods based on measuring differential pressure have been widely used. The diaphragm, nozzle, and venturi are used as a flow meter. However, the quality of irrigation water and drinking water is different. Therefore, the application of the above methods is difficult due to the presence of suspended matter in the irrigation water, and also large pressure losses occur in these devices.

Today, one of the main tasks of the agriculture and water sector is to increase labor productivity, water supply, and energy-saving with using energy-efficient technologies and techniques [13, 14, 15]. Due to this, the actual problems of melioration and irrigated agriculture are an improvement of water supply systems, calculation of hoists, creation and effective use of new structures. Internal irrigation networks in our country are mainly equipped with tray and pipes. In this case, not only one can decrease water loss until 96-98%, but also the pressure generated by these systems can be used for the irrigation of crops. When used properly, tray can exploitate long time. The streams are designed for water consumption of 0.05-5.0 m^3/s, slopes of 0.0005- 0.003, and the rods do not exceed 6 m/s.

In order to improve the water intake from irrigation trays uses different siphons with various hydraulic elements. Nowadays, there are damaging the constructional parameters of irrigation trays by using various local methods. At the same time, it is quite difficult to carry out accurate calculations of the received water in these methods [16, 17, 18]. A solution of these problems can only found by improving the water intake facilities and the ability to carry out water calculations using these devices. This requires the determination of the optimum parameters of the siphon pipe in laboratory conditions with the help of hydraulic calculations according to the material, construction, and consumption of the siphon pipes for a particular environment.

2. Method

The main purpose of laboratory research is to select an optimum technical scheme for the siphon pipe which with a minimum value of hydraulic resistance and with the maximum water giving capacity. For this purpose, have been performed hydraulic calculations for a number of siphonic pipe structures and have been tested under laboratory conditions. In this, the main focus was given to changing the local resistance for unstable pipe diameter and to determine its optimal horizons.

As mentioned above, in the analysis of the siphon pipe which provided hydraulic calculation local resistance type was similar and changeable value was only rotation in the upper part of the siphon pipe and the slope of the outlet [19, 20]. The remaining local resistance does not change if the diameter will not change.

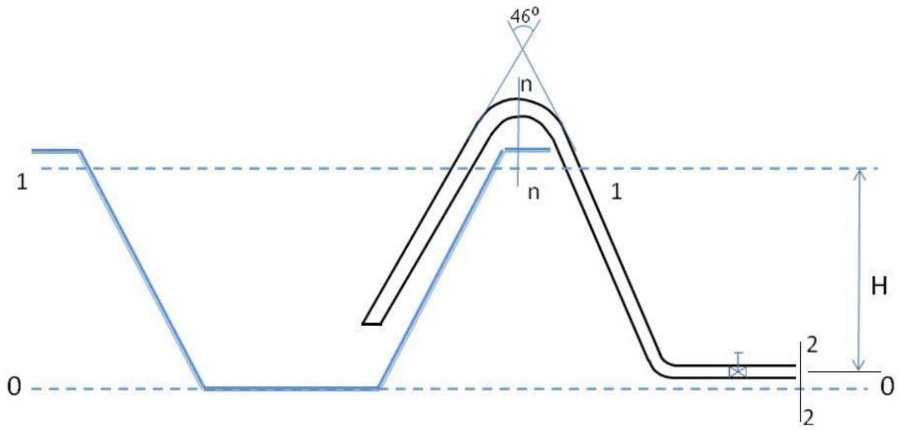

Figure 1. Calculation scheme of siphon device

The theoretical foundations of the siphon water intake system were determined by the equations for calculating water metering devices in the system. Discharge equation in pipes with pressure.

$$Q = \mu\omega\sqrt{2g\left(H + \frac{P_0 - P_1}{\rho g}\right)} \quad (1)$$

Laboratory experiments were provided to determine the coupling for the siphon water meter using the Siphon pressure piping detection equations. Calculated siphon tube consumption and siphon pressure reduction from the following equation:

$$\frac{P_V}{\gamma} = h + (1 + \zeta_c)\frac{Q^2}{\omega^2 2g} \quad (2)$$

Where: ω – siphon tube section surfac;

ΔP – difference in water pressure;

P_V – vacuum quantity in the siphon.

There μ- is the discharge coefficient of the pipe;

$$\mu = \frac{1}{\sqrt{\xi_{sis}}} \quad (3)$$

ξ_{sis}- the sum of all resistance in the system's.

The total coefficient of resistance of the siphon, which takes into account the pressure loss along the length of the siphon and the pressure loss at local resistances. The local resistance is taken into account at the entrance and exit of the siphon, it bends, as well as at gate valves.

The results of the calculations are given in the table (Table1).

Created graph of Q = f (d) with using the information in the table and calculated diameter of pipe which corresponds to the given discharge.

3. Results and Discussions

As a result of the research, the created device for detecting water volume and discharge in the process of water giving from channels and irrigation trays. Investigated improved siphon gives the possibility to calculate water value with high accuracy in the channels and irrigation trays in the territory of WUAs. At the same time, the proposed siphon pipe is made with polyethylene, which can be used for a long time.

During the siphon exploitation, water discharge will be determined by the vacuum meter which installed on it. As a result of the device's hydraulic calculation, the water consumption is determined by the pressure dependency graph Q=f(P).

Additionally, the proposed siphon installed with water consumption control tools, one of them is vacuum meter it has the ability to detect water consumption and it has lock incoming and outgoing part of siphon to control or reduce water value. In addition to the siphon pipe, it has been installed vacuum meter in the upper part of the device, according to the vacum meter value Q=f(P) has possibility to determine the actual amount of water.

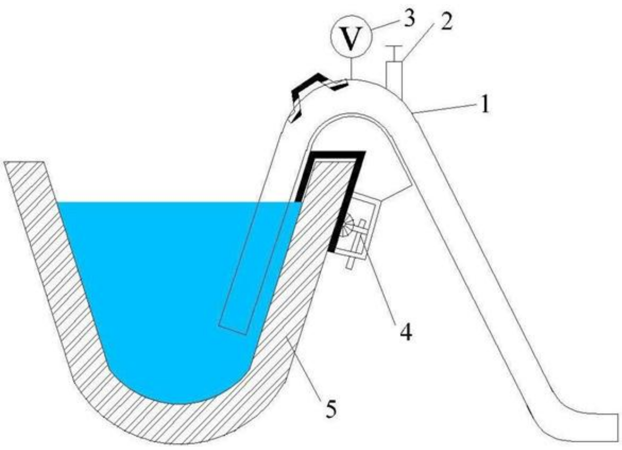

Figure 2. Scheme of the siphon pipe: 1-siphon pipe; 2-air release pouch; 3-vacuum meter; 4-tray; 5-screw

Table 1. Calculating the parameters of the water inlet siphon

d, m	ω, m^2	υ, m/s	Re	λ	$\xi_{сис}$	M	Q, l/s
0.05	0.002	1.413	70652.3	0.0211	3.93	0.504	2.773
0.075	0.0044	1.485	111348	0.0191	3.561	0.53	6.556
0.1	0.0079	1.521	152125	0.0178	3.391	0.543	11.94
0.125	0.0123	1.543	192884	0.0168	3.296	0.551	18.93
0.15	0.0177	1.557	233608	0.0161	3.236	0.556	27.51
0.175	0.024	1.567	274300	0.0155	3.194	0.56	37.68
0.2	0.0314	1.575	314962	0.015	3.164	0.562	49.45
0.225	0.0397	1.58	355599	0.0145	3.142	0.564	62.81
0.25	0.0491	1.585	396217	0.0141	3.124	0.566	77.76
0.275	0.0594	1.588	436816	0.0138	3.11	0.567	94.3
0.3	0.0707	1.591	477402	0.0135	3.099	0.568	112.4

Detection of water discharge provides by vacum meter which installed in to devise. The water flow rate of the device is calculated based on the pressure dependence graph Q=f (P) (Figure 3).

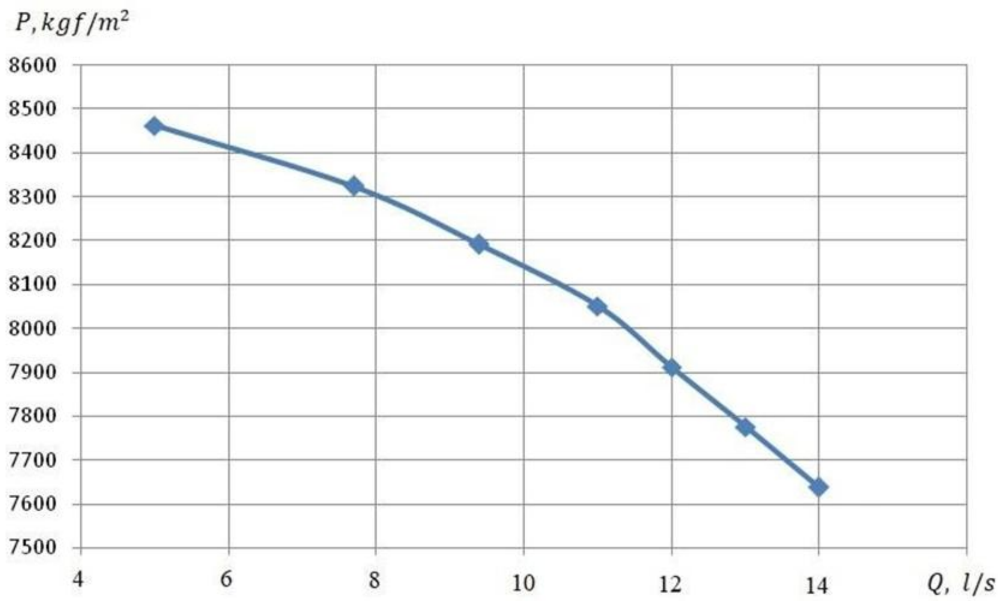

Figure 3. Graph of Q=f(P) to determine water discharge

In addition to the siphon pipe, it has been installed vacuum meter in the upper part of the device, according to the vacummeter value Q=f(P) has possibility to determine the actual amount of water.

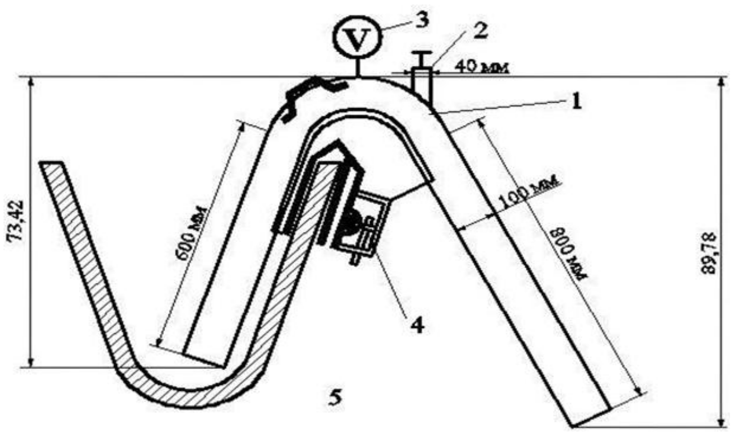

Figure 4. Portable siphon water meter

4. Conclusions

The proposed new design of the siphon, on the one hand, facilitates the measurement of water, on the other hand, there improves the water intake from the channel networks. As a result, we achieved water saving and to estimate the amount of water accurately.

Installation of improved siphon device in the channels and irrigation trays of WUAs gives the possibility of obtaining water quantity with high accuracy and the reason which they made with polyethylene material let us long-term exploitation of it.

At the same time, the device is constructed as portable and it let us to install it everywhere according to consumer's requirements.

The advantage of this siphon for measuring water lies in the stability of the measurement, due to design features; high reliability, as it does not require additional energy sources, low maintenance requirements.

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