Hydraulic calculation of filtration system in drip irrigation

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Abstract. It is known that water filtration devices are used to increase the efficiency of the drip irrigation system on a large scale. Currently, there are various types of filtering devices, the main purpose of which is to reduce the amount of turbidity in water. In Uzbekistan, vertical and horizontal filters made according to Turkish and Chinese technologies are used. When designing drip irrigation systems, it is necessary to perform a hydraulic calculation. At when performing a hydraulic calculation, it is necessary to calculate the pressure loss in the filtration system and base the pumping unit on this basis. This article presents the results of studies of a vertical filtration device manufactured using Turkish technology. The studies were carried out in natural field conditions, in a filtration system installed in the field of the farm of Ashurov Azizbek Ganievich, located in the Kasbi district of the Kashkadarya region. The filtration system consists of 4 parts and describes studies to determine the coefficient of resistance hydraulic calculation. The studies were conducted in 3 variants. It has been established that the magnitude of pressure losses in the filtration system varies from 2.7 m to 9 m. It has been established that the resistance coefficient of the filtration system varies from 61.9 to 247.1 in option 1, from 32.1 to 229.5 in option 2 and from 32.5 to 218.5 in option 3. As a result of the research, a method was developed for determining the resistance coefficient required for the hydraulic calculation of this filter system. A formula for calculating the pressure loss in the filtration room is recommended system.

1 Introduction

The global climate change taking place in the world, an increase in air temperature, and a decrease in fresh water reserves adversely affect the production of food necessary for mankind [1,2]. In the conditions of the regions of Central Asia, especially in Uzbekistan, the problems of irrigation in the cultivation of agricultural products are becoming more complicated [3,4]. To solve these problems, rational and economical use of water resources in irrigation, improving the quality and quantity of crop yields, and water-saving technologies are widely used [5,6]. From experiments conducted on a global scale, it is known that as a result of the use of water-saving technologies in irrigation, it is possible save water up to 25-

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35% in industrial crops, up to 35-40% in polycultures, up to 40-50% in orchards and vineyards, as well as a significant increase in yield [6,7,8,9]. It is known that there are several types of water-saving technologies, including drip, sprinkler, pulsar and others [10, 11]. One of the world's most advanced water-saving technologies is the drip irrigation system [12, 13]. As a result of the use of the drip irrigation system, it was possible to save water by 35-40% and increase yields by 70-80% [13,14].

One of the most important tasks in the application of drip irrigation systems is the correct and reliable design [16,17]. Scientists have developed a number of recommendations for taking into account the type of soil, type of crops, irrigation rate, duration and calculations when designing a drip irrigation system [17,18]. A certain amount of scientific research has been carried out and recommendations have been given on hydraulic processes in the pipes of the drip irrigation system, hydraulic losses and depending on the pressure of water flow from droppers [19]. It is known that in order to protect the pipes of the drip irrigation system from the risk of siltation, it is necessary to design and build settling facilities [24,25]. Sedimentation tanks consist of a sedimentation pond and a filtration system [20]. When designing a drip irrigation system, it is imperative to carry out a hydraulic calculation of the filtration system. Since the value of hydraulic resistance in the filtration system is large, it affects the operating mode of the pumping station [21-26]. From a hydraulic point of view, the resistances that occur in the filtration system are among the local resistances. When performing a hydraulic calculation of the filtration system, the resistance coefficient must be taken into account. Currently, there are several types of filtration systems in our country, which are widespread. However, it remains difficult to determine the coefficient of resistance that occurs when performing hydraulic calculations. When designing a drip irrigation system, one of the urgent tasks is the correct implementation of the hydraulic calculation of the filtration system, the calculation of the resulting hydraulic resistance.

2 Methodology

Studies have been carried out to determine the resistance coefficient in the filtering devices of drip irrigation systems in natural field conditions. During the research, generally accepted methods of hydraulics and hydrology were used. The pressure values were determined using manometers installed in the device, the water flow rate was determined using a water measuring device installed in the system. The research was conducted on July 15-22 in the sown fields of the farm "Ashurov Azizbek Ganievich" of the Rishton district of the Fergana region. The total area of the farm "Ashurov Azizbek Ganievich" is 70 hectares, of which 45 hectares are sown with cotton and 25 hectares with wheat. Drip irrigation systems were applied to an area of 30 hectares. The filter device consists of 4 sand and an additional 4 disc filter (Fig. 1). The filtering device operates in an automatic self-cleaning mode. Sand filters capture medium and coarse turbid particles in the water, while disc filters capture fine particles.

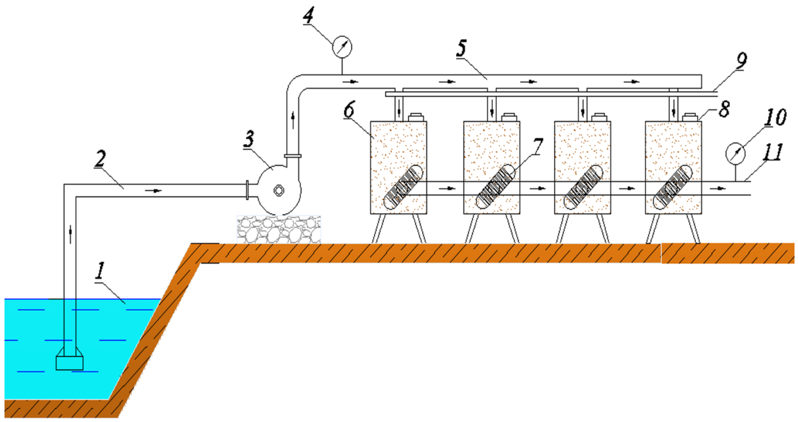

Fig. 1. Filtration system

1. Reservoir and sedimentation pond, 2. Pump suction pipe, 3. Pumping unit, 4. Manometer (shows the pressure at the inlet to the filtration system), 5. Drive pipe (performs the function of pumping water into the filtration system).), 6. Sand filter device, 7 - Disc filter device, 8 - Sand filter cover, 9 - Filter flushing discharge tube, 10 - Manometer (indicates the outlet pressure of the filter system), 11 – Drive pipe (Transfer of water from the filter system to the main pipe, which delivers water to the cultivated fields)

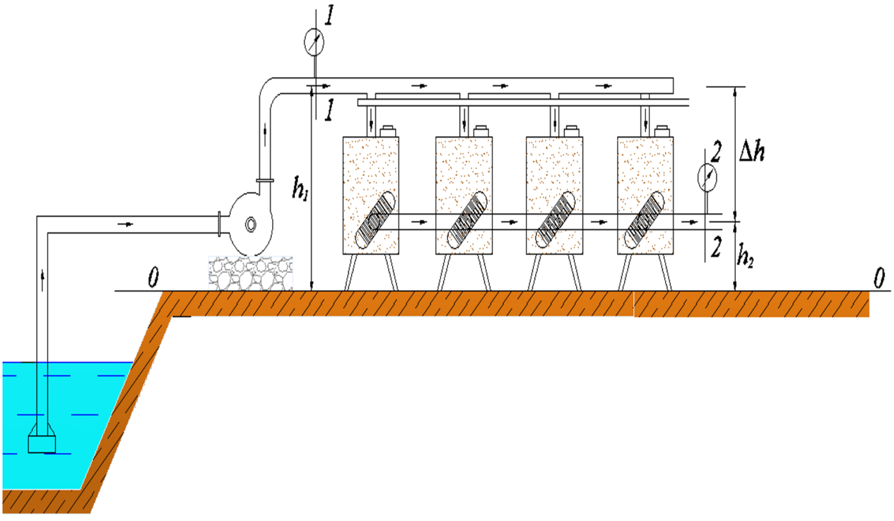

Fig. 2. Calculation scheme

The equation of D. Bernoulli was used to determine the coefficient of resistance of the system. The Bernoulli equation for sections 1-1 and 2-2 defined in the scheme is written as follows:

$$h_1 + \frac{p_1}{\gamma} + \frac{\vartheta_1^2}{2g} = h_2 + \frac{p_2}{\gamma} + \frac{\vartheta_2^2}{2g} + h_f \quad (1)$$

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Here: the coordinate of sections 1-1 and 2-2 relative to the plane of comparison 0-0, the pressure in sections 1-1 and 2-2, the h_1, h_2 – average flow velocity in sections 1-1 and p_1, p_2 – 2-2, ϑ_1, ϑ_2 – the h_f – pressure loss between sections.

In the problem under consideration, $h = h_1 - h_2$ expression (1) is written as follows: $\vartheta_1 = \vartheta_2$

$$h + \frac{p_1}{\gamma} = \frac{p_2}{\gamma} + h_f \qquad (2)$$

from this:

$$h_f = h + \frac{p_1}{\gamma} - \frac{p_2}{\gamma} \qquad (3)$$

The head losses between sections was determined using the Weissbach formula as follows:

$$h_f = \xi_s \frac{\vartheta}{2g} \qquad (4)$$

from this

$$\xi_s = h_f \frac{2g}{\vartheta} \qquad (5)$$

where: the ξ_s – resistance coefficient of the filter system.

3 Results and discussions

The experiments were carried out in several versions. The head of the pumping unit H = 22 m, the water flow rate Q = 150 m^3/hour. The amount of turbidity in the water is S = 1.8-1.9 g/l, it is retained in the filtration system, and clean water is supplied to the drip irrigation system. Research work was carried out on 3 options and the resistance coefficient of the filtration system was determined. According to the results of studies conducted under option 1, it was found that the water flow rate is 0.0265 m^3/s and 0.0367 m^3/s, the magnitude of head losses is 4 m and 9 m, the resistance coefficient of the filtration system varies from 61.9 to 247.1 (Table 1).

Table 1. Table for determining the resistance coefficient of the filtration system

№	p_1, bar	p_2, bar	h_f, m	Q, m^3/s	d, mm	ω, m^2	ϑ, m/s	p_2/p_1	ζ_s
1	2.15	1.57	5.80	0.0352	200.0	0.0314	1.12	0.73	92.3
2	2.15	1.32	8.30	0.0278	200.0	0.0314	0.89	0.61	211.8
3	2.15	1.27	8.80	0.0265	200.0	0.0314	0.84	0.59	247.1

4	2.15	1.44	7.10	0.0307	200.0	0.0314	0.98	0.67	148.5
5	2.15	1.63	5.20	0.0342	200.0	0.0314	1.09	0.76	87.7
6	2.15	1.72	4.30	0.0367	200.0	0.0314	1.17	0.80	63.0
7	2.15	1.55	6.00	0,0325	200.0	0.0314	1.04	0.72	112.0
8	2.15	1.75	4.00	0.0357	200.0	0.0314	1.14	0.81	61.9
9	2.15	1.25	9.00	0.0290	200.0	0.0314	0.92	0.58	211.0
10	2.15	1.32	8.30	0.0315	200.0	0.0314	1.00	0.61	164.9

According to the results of studies carried out under option 2, the water flow rate is 0.0295 m m^3/s and 0.0407 m^3/s, the value of head losses is 2.70 m and 8.80 m, the resistance coefficient of the filtration system was found to vary between 32.1 and 229.5 (Table 2).

Table 2. Table for determining the resistance coefficient of the filtration system

№	p_1, bar	p_2, bar	h_f, m	Q, m^3/s	d, mm	ω, m^2	ϑ, m/s	p_2/p_1	ζ_s
1	2.15	1.55	6.00	0.0325	200.0	0.0314	1.0	0.72	112.0
2	2.15	1.72	4.30	0.0345	200.0	0.0314	1.1	0.80	71.2
3	2.15	1.88	2.70	0.0407	200.0	0.0314	1.3	0.87	32.1
4	2.15	1.27	8.80	0.0275	200.0	0.0314	0.9	0.59	229.5
5	2.15	1.56	5.90	0.0313	200.0	0.0314	1.0	0.73	118.8
6	2.15	1.75	4.00	0.0347	200.0	0.0314	1.1	0.81	65.5
7	2.15	1.48	6.70	0.0317	200.0	0.0314	1.0	0.69	131.5
8	2.15	1.38	7.70	0.0295	200.0	0.0314	0.9	0.64	174.5
9	2.15	1.82	3.30	0.0385	200.0	0.0314	1.2	0.85	43.9
10	2.15	1.45	7.00	0.0315	200.0	0.0314	1.0	0.67	139.1

According to the results of studies conducted on the 3rd option, the water flow rate is 0.0285 m^3/s and 0.0405 m^3/s, the amount of head loss is 2.70 m and 9 m, the resistance coefficient of the filtration system is between 32.5 and 218.5 (table 3).

Table 3. Table for determining the resistance coefficient of the filtration system

№	p_1, bar	p_2, bar	h_f, m	Q, m^3/s	d, mm	ω, m^2	ϑ, m/s	p_2/p_1	ζ_s
1	2.15	1.48	6.70	0.0302	200.0	0.0314	1.0	0.69	144.9
2	2.15	1.25	9.00	0.0285	200.0	0.0314	0.9	0.58	218.5
3	2.15	1.46	6.90	0.0325	200.0	0.0314	1.0	0.68	128.8
4	2.15	1.88	2.70	0.0405	200.0	0.0314	1.3	0.87	32.5
5	2.15	1.82	3.30	0.0387	200.0	0.0314	1.2	0.85	43.4
6	2.15	1.29	8.60	0.0287	200.0	0.0314	0.9	0.60	205.9
7	2.15	1.62	5.30	0.0347	200.0	0.0314	1.1	0.75	86.8
8	2.15	1.47	6.80	0.0313	200.0	0.0314	1.0	0.68	136.9
9	2.15	1.59	5.60	0.0357	200.0	0.0314	1.1	0.74	86.6
10	2.15	1.32	8.30	0.0297	200.0	0.0314	0.9	0.61	185.5

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The results of the research were analyzed by the methods of mathematics and statistics and $\left(\frac{p_2}{p_1}\right)$ the relationship between the resistance coefficient of the filtration system and the relative pressure was obtained (Fig. 3).

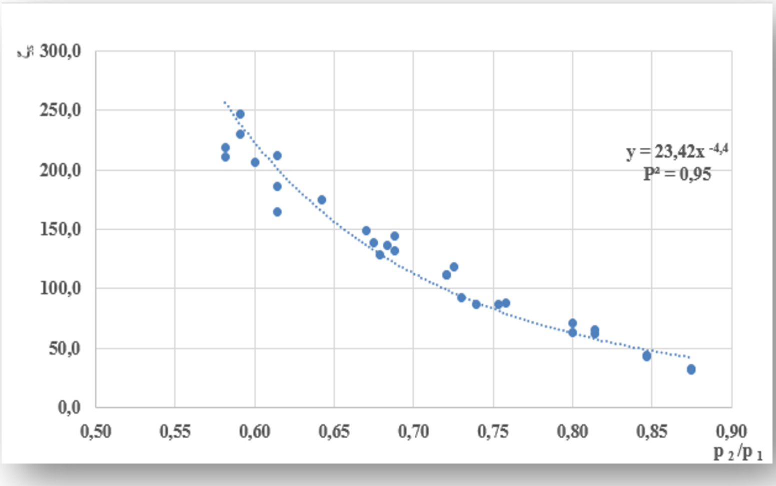

Fig. 3. The Relationship between the resistance coefficient of the filtration system and the relative pressure

Based on this, the following formula was developed to determine the resistance coefficient of the filtration system in drip irrigation.

$$\xi_s = 23{,}42\left(\frac{p_2}{p_1}\right)^{-3{,}4} = 23{,}42\left(\frac{p_1}{p_2}\right)^{3{,}4} \quad (6)$$

where: $\left(\frac{p_1}{p_2}\right)$ – relative pressure, i.e. the pressure p_1 – at the inlet of the filtration system, the p_2 – pressure at the outlet of the filtration system.

Using the above expressions (4) and (6), the following formula was proposed to determine the forces lost in the filter system:

$$h_f = 23{,}42\left(\frac{p_1}{p_2}\right)^{3{,}4} \frac{\vartheta}{2g} \quad (7)$$

Using this formula (7), it is possible to perform a hydraulic calculation of the filtration system used to filter the water in the drip irrigation system. It should be noted that the recommended formula is used to perform a hydraulic calculation of a filter system of this type in special cases.

4 Conclusion

1. According to the results of the research, it was found that the resistance coefficient of filtering devices used to filter water during drip irrigation is variable. According to him, the minimum value of the resistance coefficient was 32.1, and the maximum value was 247.1. The main reason for the change in the resistance coefficient is the increase in the number of turbid particles in the filter tanks. Therefore, it is necessary to improve the technology of flushing filter tanks, shorten the flushing interval.

2. Based on the mathematical and statistical analysis of the research results, a formula for determining head losses in the filter system is proposed. Using the proposed formula, it is possible to perform a hydraulic calculation of the vertical filtration system, manufactured according to Turkish technology, and determine the head loss.

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