Research of irrigation pipe-line for uniform distribution of liquid

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***Abstract* – Due to the physical experiment that the projected irrigation pipeline provides practically uniform discrete distribution of liquid along the path in pressure pipe-line it was shown.**

Key words – irrigation pipe-line; uniform distribution of liquid.

I. Introduction

Watering of lawn must completely provide irrigation of their area. It may be achieved by uniform distribution from the distributive pipe-lines.

II. The aim of the work

To project the installation for investigation pipe-line for uniform distribution of liquid .

III. Experimental pipeline

The experimental irrigation pressure plastic pipe-line (Fig. 1) was projected taking into account uniform discrete distribution of liquid along the path in pipe-line from it, the term uniformity means linear dependence of flow rate of liquid from its length [1:179].

According to the classification [2], the investigated pipe-line is to be of great hydraulic resistance to provide practically uniform discrete distribution of liquid along the path in pipe-line in identical dimensions of water outlets and their constant pitch. This is reached under small dimensions of porosity of experimental pressure pipe-line [3:30]:

$$f = \varepsilon \cdot n \cdot \Omega_{out}/\Omega_{pipe} , \quad (1)$$

where, n is the amount of settings on the whole water-pipe, $n = 13$; Ω_{out} is the area of cross-section of outlets, $\Omega_{out} = ¼\cdot\pi D_{out}^2$; D_{out} is the diameter of outlet whose length 20.5 mm (Fig. 1), $D_{out} = 7.1$ mm; Ω_{pipe} is the area of cross-section of irrigation pipe-line, $\Omega_{pipe} = ¼\cdot\pi D_{pipe}^2$;$D_{pipe}$ is the diameter of pipe-line, $D_{out} = 18.9$ mm; ε is the contraction coefficient [4:67],

$$\varepsilon = 0.57 + 0.043/(1.1 - d_{out}^2/D_{out}^2) ; \quad (2)$$

d_{out} is the diameter of hole of outlet, $d_{out} = 1.2$ mm.

The porosity of pipe-line was equal to 1.119. With this porosity is an intermediate pipe length, and the greatest pressure is at the end of pressure pipeline [2].

The coefficient, that takes into account changes of consumption along the path in pipe-line was equal to 1.078 was calculated according to the formula [4:67]:

$$C = (1 + 0.5/n)^2 . \quad (3)$$

IV. Experimental device

On the basis of scientific-experimental laboratory No.27 of the department of hydraulics and sanitary engineering the experimental device was projected (Fig. 2). The device works according to circulating schema and consists of reservoir – *6*, pump – *3* and experimental pipe-line – *9*. The device is short current with the long range of spraying water up to 10 m [5]. The pump equipment is of low pressure – up to 0.2 MPa [5]; the pump UPBASIC 25-4 180 by firm Grundfos produces maximum pressure 2.8 m.

The researches were held in such succession:

1. Filled in reservoir *1* with water up to height to provide starting of pump *3* without making watering-can during the suction of water into it.
2. Measured temperature of water in reservoir *1* by thermometer *8*.
3. Turned off pump *3*.
4. Measured waster of water through every water output by volume method with the help of measuring vessels *7* and mechanical stop-watch.
5. Turned off pump *3*.
6. Repeated actions of points 2–5 during changing consumption of water in experimental pipe-line *6*, changing the degree of opening of valve *5*.

V. Results of the experiment

Researches were carried with maximum degree of opening of valve *5* (Fig. 2). The temperature of water during the experiments was 18°C. The value of the Reynolds' number at the beginning of the pipe-line:

$$Re_o = 4Q_o/(\pi D_{pipe}\nu) , \quad (4)$$

where, Q_o is the flow rate of water at the beginning of the pipe-line,

$$Q_o = \Sigma q_i , \quad (5)$$

q_i is the flow rate of water through i-output,

$$q_i = W_i/t_i ; \quad (6)$$

W_i, t_i accordingly are the volume of liquid, that accumulates in measuring vessels and time of filling this volume during the experiment.

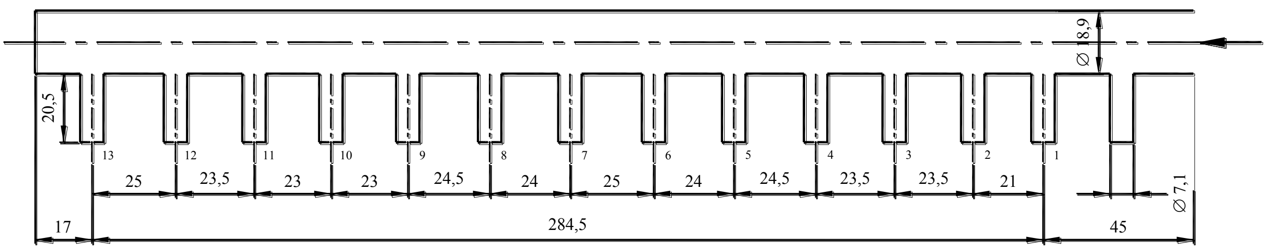

Fig. 1. Experimental pipe-line: 1…13 – water outlets

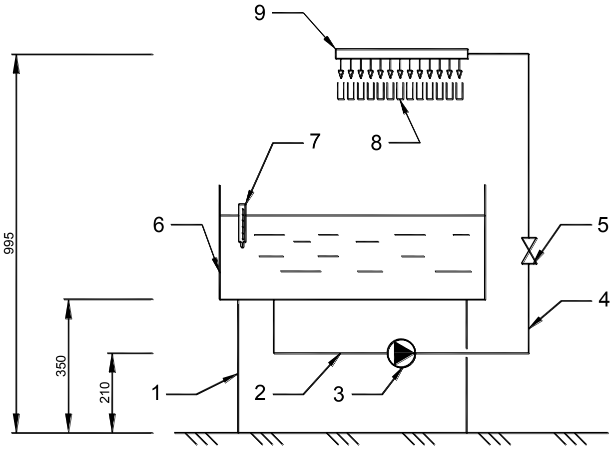

Fig. 2. Experimental device:
1 – support; 2 – absorbing pipe-line ø32 mm; 3 – pump;
4 – pressure pipe-line ø32 mm; 5 – valve; 6 – reservoir;
7 – thermometer ; 8 – measuring vessel;
9 – experimental pipe-line

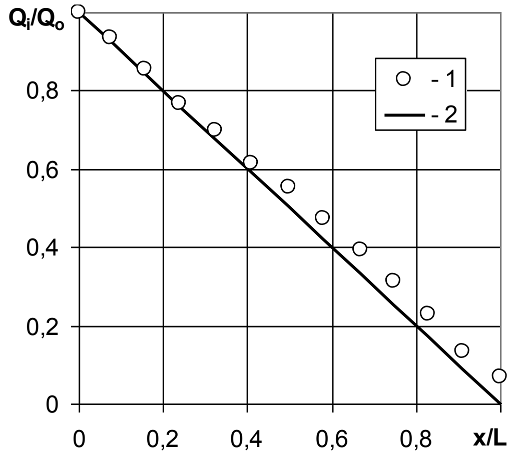

Fig. 3. Change of consumption along the path
of irrigation pressure pipe-line:
1 – experiment; 2 – calculation according to the formula (10)

Thus, $Q_o = 48.03$ sm³/s and $Re_o = 3188$. This indicates that watering pipe-line works in laminar conditions. At the same time the value of expenses is in permissible range: $0.3q_{av} < q_i < 2q_{av}$ [6], where, q_{av} is the average consumption of water output in pipe-line.

Coefficient, that takes into account non-uniformity of the change of consumption along the length of the pipe-line [4:67]:

$$A = (8K^2 + 9K + 3)/[5(K + 1)^2] , \quad (7)$$

where, K is the non-uniformity of distribution of liquid,

$$K = q_1/q_n , \quad (8)$$

q_1, q_n are the consumption of liquid correspondingly through the first and the last water output (Fig. 1).

Coefficient of the uniformity of consumption of water along the pipe-line [7]:

$$K_{flow} = ½·(q_{av}/q_1 + q_n/q_{av}) . \quad (9)$$

The meaning of coefficients $K = 0.965$ and $A = 0.991$, and also $K_{flow} = 1.238$ points to approximately uniform discreet way of distribution of liquid.

For invariable diameter of experimental pressure pipe-line (D_{pipe} = const) uniform change of the consumption along the path path:

$$Q = Q_o·(1 – x/L) , \quad (10)$$

where, Q is the flow rate of water between outlets;
x is the current coordinate;
L is the length of the section of pipe-line, where distribution of liquid along the path in pipe-line takes, $L = 284.5$ mm (Fig. 1).

For the experimental pipe-line the dependence $Q/Q_o = f(x/L)$, was obtained, that paints to the linear dependence of the consumption of the flow of liquid in the from its length (Fig. 3).

Conclusion

The results of the experiment showed, that the projected irrigation pipe-line provides practically uniform discrete distribution of liquid along the path in pressure pipe-line.

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