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I. Ya. Flys[1], V. V. Ivaniv[2], I. V. Bihun[3]
[1]"Instal Plaza" private enterprise,
vilage of Povitno, Horodok district, Lviv region,
[2]Lviv Polytechnic National University, department of hydraulics and sanitary engineering,
[3]Lviv Polytechnic National University, departametn of heat supply and ventilation

CYLINDRIC NOZZLES WITH LATERAL INLETS INSTALLED IN DISTRIBUTIVE PIPELINE. INVESTIGATIONAL BENCH FOR INVESTIGATION OF OPERATION OF NOZZLES

Branches of application of pressure distributive pipelines are presented. Critical analysis of known methods of reduction of non-uniformity of dispensation of fluid from pressure pipelines along the path has been analyzed. It has been shown that mobile regulation of fluid dispensation from pressure pipelines can be achieved by means of installation of cylindrical nozzles with lateral and orthogonal to the longitudinal axis inflow of a stream-line into the nozzle, provided the nozzles can be rotated about their longitudinal axes in the course of operation. The suggested technique of regulation of fluid dispensation from pressure pipelines is obtained due to solution of the differential equation of variable flow rate fluid flow.

An investigational bench for experimental determination of values of coefficient of flow rate of cylinder-shaped nozzles with lateral inflow of stream-line, which are installed in a pressure distributive pipeline with the possibility of rotation about longitudinal axes of the nozzles, has been manufactured. The coefficient of flow rate of these nozzles depends on the angle β between the direction of water stream flow in the distributing pipeline and the direction of the outflowing jet. The angle β can be changed by means of rotating the nozzle about its longitudinal axis.

Key words: distributive pipeline; cylindrical nozzle with lateral inlet

І. Я. Флис[1], В. В Іванів[2], І. В. Бігун[3]
[1]Приватне підприємство "Інстал-Плаза",
81510, Львівська обл., Городоцький район, Повітно,
[2]Національний університет "Львівська політехніка", кафедра гідравліки та сантехніки,
[3]Національний університет "Львівська політехніка", кафедра теплогазопостачання та вентиляції

ЦИЛІНДРИЧНІ НАСАДКИ З БІЧНИМ ВХОДОМ, ВСТАНОВЛЕНІ У РОЗПОДІЛЬНОМУ ТРУБОПРОВОДІ, І СТЕНД ДЛЯ ДОСЛІДЖЕННЯ ЇХНЬОЇ РОБОТИ

Представлено галузі застосування напірних розподільних трубопроводів. Здійснено критичний аналіз відомих методів зменшення нерівномірності шляхової роздачі рідини із напірних розподільних трубопроводів. Показано, що мобільного регулювання роздачі рідини з цих трубопроводів можна досягти, застосувавши на них циліндричні насадки з бічним (ортогональним до поздовжньої осі насадки) входом струменя у насадку. Запропоновану методику регулювання роботи розподільних трубопроводів отримано розв'язанням диференціального рівняння руху рідини зі змінною витратою.

Виготовлено стенд для експериментального встановлення значень коефіцієнта витрати циліндричних насадок із бічним ортогональним входом струменя. Відрізок розподільного трубопроводу із насадкою закріплено на внутрішньому боці торцевої кришки напірного бака. Насадку змонтовано у стінці розподільного трубопроводу з можливістю обертання навколо її поздовжньої осі. Коефіцієнт витрати μ цих насадок залежить від кута β

між напрямком руху потоку води у розподільному трубопроводі та напрямком руху струменя, котрий входить до насадки, від'єднуючись від потоку у розподільному трубопроводі. Обертанням насадок відносно їхніх поздовжніх осей змінювали значення кута *β*. Значення витрати води крізь досліджувані насадки встановлюється об'ємним способом. Робочою рідиною слугує вода. Маса води, котра надходить у мірний бак, вимірюється електронною вагою, а час її надходження – електронним секундоміром. Монтажем відрізка розподільного трубопроводу з насадкою усередині напірного бака відтворюються умови роботи насадки із бічним входом у розподільному трубопроводі. Дослідний стенд забезпечує змінювання напорів у напірному баку в межах від 0 до 17,0 *м*.

Подано схему експериментального стенду та схеми визначення кута *β* між напрямками руху потоку води у розподільному трубопроводі та струменя, котрий від'єднується від нього. Представлено об'ємні зображення вузла кріплення розподільного трубопроводу та насадки.

Ключові слова: розподільний трубопровід; циліндрична насадка з бічним входом.

Introduction. Pressure distributive pipelines (PDs) are used in irrigation, water supply, power engineering, water drainage, ventilation, agricultural aviation (spraying the plants), water transport, mechanical engineering, chemical industry [1], and others. In majority of cases, industrial processes call for ensuring of uniform dispensation of fluid along the PD.

Literature review. The regulation of fluid dispensation is achieved in different ways. The introduction of hydrodynamically active additives into the stream essentially decreases the non-uniformity of fluid dispensation along the path without changing the geometrical parameters of the PD. The degree of reduction of non-uniformity depends on the concentration of the additives which are introduced into the stream [2]. The method ensures continuous or periodic regulation.

Reduction of non-uniformity of fluid dispending from PDs is achieved by means of reduction of the diameter of the PD in the direction of the stream [3 pages 274–276], as well as by means of the distance between outlet holes and by increasing their areas along the stream. It is detected [4] that the non-uniformity of water dispensation along the path from a conic PD is less than that of cylindric PD. The least non-uniformity is achieved when the initial diameter D_{beg} of a conic PD is twice greater than the terminal diameter D_{end}. Further increase in the ratio D_{beg}/D_{end} of the diameters caused increase in non-uniformity of water dispensation along the path [4].

It has been investigated [5] that the shapes of outlet holes made in a wall of a rectangular PD and the thickness of the wall of the PD influence geometric characteristics of outflow jets. With the increase in the thickness of the wall of a PD from 2 to 10 mm, the flow compression ratio E at the outflow from the hole increases, and the non-uniformity of water dispensation along the path decreases. The non-uniformity of operation of PD decreases with the decrease in its porosity. The coefficient μ of flow rate in outflow of fluid from investigated holes changed within the range of 0.66 to 0.68. Less non-uniformity of water dispensation along the path was observed in its outflow through holes which had been made in the PDs whose walls were thicker [5]. The results which were obtained in the work [5] give us a reason to think that in fluid outflow through nozzles this tendency enhances.

In outflow of water from holes which are made in a wall of irrigational pipeline, the value of the coefficient μ of flow rate depends on the angle β. In the case of the outflow through holes, the angle β was considered as a function of speed of the stream and of the pressure in the site of outlet holes inside the pipeline [6].

On the basis of analysis of literature sources, the authors of [7] came no the conclusion that the least non-uniformity of fluid dispensation from a pressure PD can be achieved in PD-reducers with a continuous slot in its wall.

The considered works [3-7] concern water outflow from pressure PDs through holes. The authors of the works [3] and [7], with the aim to reduce non-uniformity of water dispensation along the path from PD, suggest to manufacture PD-reducers and to replace holes by continuous slots. However, the holes, slots, and geometric shape of the manufactured PDs remain the same.

For this reason, they do not ensure further regulation of dispensation of fluid from the PD along the path. In the work [2], a method of regulation of fluid dispensation from a PD along the path without any change in geometric parameters of the PDs is suggested.

The authors of [8] have invented a way of regulation of fluid dispensation from pressure PDs along the path by means of equipping the PDs with turn able nozzles with lateral inflow of stream-line. By means of rotation of nozzles about their longitudinal axes the angle β of the jet outflow can be changed, and consequently, the change in the value of the coefficient μ of flow rate. Thus, the dispensation of fluid along the path is regulated. The suggested technique is obtained due to solution of the differential equation of variable flow rate fluid flow [9]. However, in literature there are no data on values of the coefficient μ of flow rate for cylindric nozzle with lateral inflow of stream-line which are installed in a pressure PD.

Aim of the work: to suggest and to manufacture an experimental investigational bench for determining the values of the coefficient of flow rate for cylindric nozzles with lateral inflow of stream-line which are fixed in a pressure PD depending on the angle of inflow of the stream-line into a nozzle.

Experimental bench. The task of this work was to create an experimental investigational bench in order to simulate in it the conditions of water inflow into cylindric nozzles with lateral inflow of stream-line for a pressure PD. Values of the coefficient μ of flow rate of the investigated nozzles are determined in volumetric way. There, as operating fluid we use water. The mass of water which inflows into the measuring tank is measured by electronic balance, and the time of the inflowing is measured by electronic stop-watch. The suggested bench (Fig. 1, Fig. 2) enabled us to investigate water outflow from cylindric nozzles under the action of the head which was changed from 0 to 17 m .

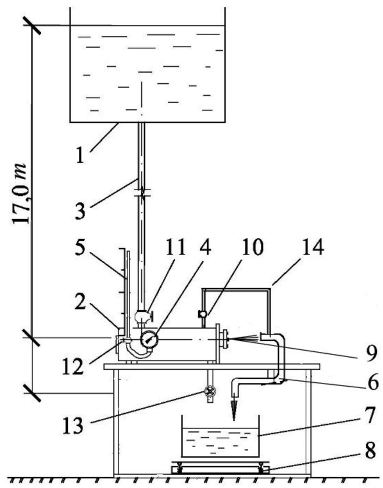

Fig. 1. Schematic diagram of experimental bench: 1 – reservoir with water; 2 – pressure tank with fragment of investigated PD; 3 – joining pipeline; 4 – pressure gauge; 5 – piezometer; 6 – water draining pipe; 7 – water receiving tank; 8 – electronic balance; 9 – jet outflowing from PD though investigated nozzle; 10, 11, 12 – taps

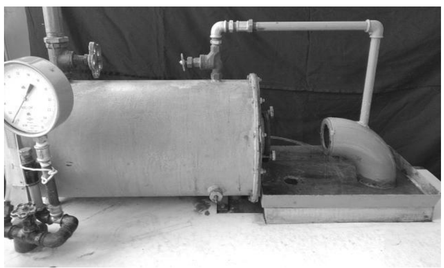

Fig. 2. Pressure tank

The values of head which were less 2.2 m were measured by means of a piezometer accurate to 2.2 mm . The values of head which were greater than 2.2 m were measured by МТИ pressure gauge accurate to 0.02 $\kappa g/\mathrm{cm}^2$ whose class of accuracy was 0.6.

The investigated nozzles were installed on inner surface of the butt lid of the cylindrical tank (see item 2 in Fig. 1). For simulation of the conditions under which the outlet cylindrical nozzle with lateral inlet in PD operates, the outlet end of the nozzle was fixed in the pipe branch, which operated as PD

(Fig. 3–5). In Fig. 3, the fixation of the segment PD with a nozzle built-in is show form external and internal sides of the butt lid of the pressure tank 2. In order to bather understand the schematic diagram of fixation, it is depictured axonometrically. And in Fig. 4, axonometric presentation of a section of the fixation of PD with a nozzle is given; in Fig. 5 parts of the fixation.

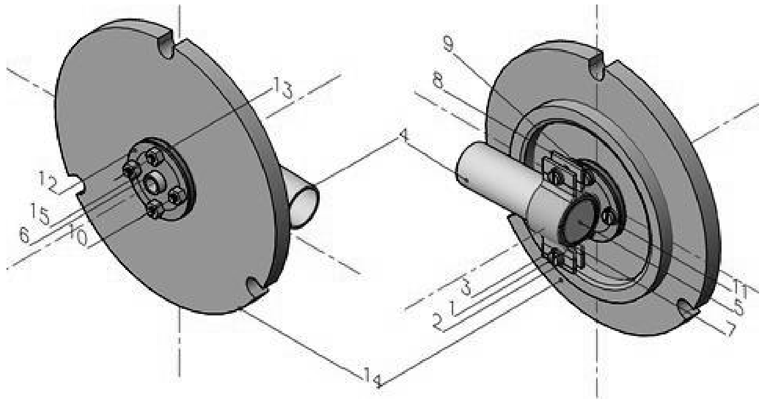

Fig. 3. Fixation of segments of PD with investigated nozzle fixed on butt lid of pressure tank:
1, 10 – bolts; 2, 11, 12 – washers; 3, 8 – installation yokes; 4 – segment of PD; 5 – blind on butt;
6 – outlet nozzle; 7, 13 – rubber gasket; 9, 15 – nuts; 15 – lid of pressure tank

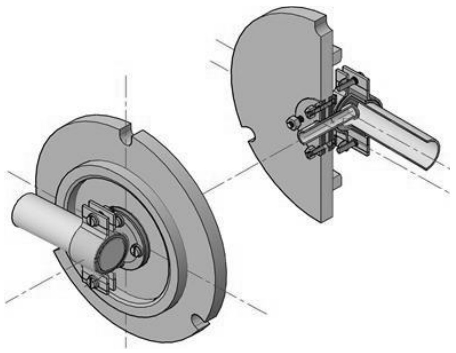

Fig. 4. Axonometric section of assembly of fixation (on butt lid of pressure tank) of segment of PD with investigated nozzle

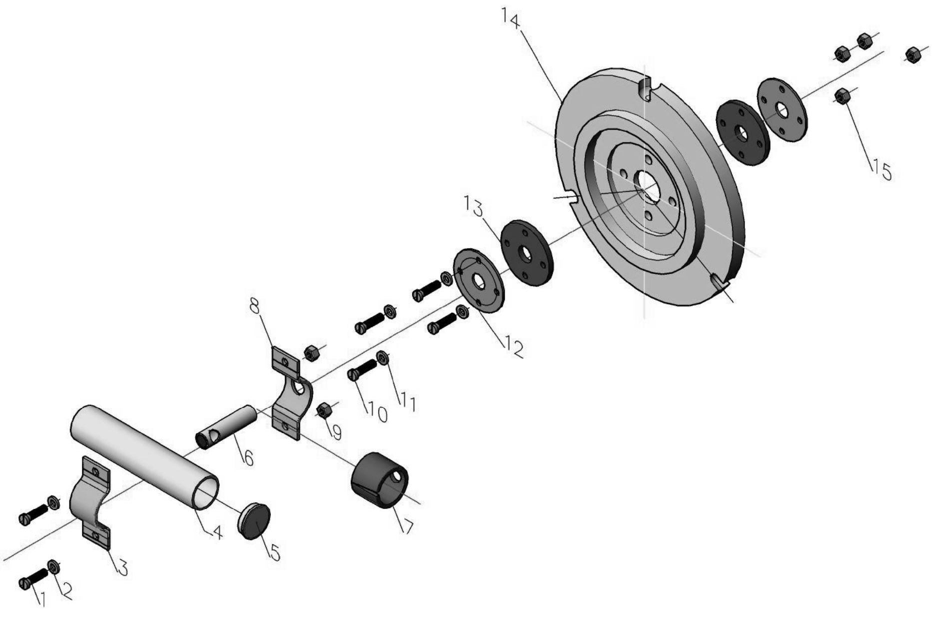

Fig. 5. Parts of fixation of segment of PD with investigated nozzle:
1,10 – bolts; 2, 11, 12 – washers; 3,8 – installation yokes; 4 – segment of PD; 5 – blind on butt of PD;
6 – outlet nozzle; 7, 13 – rubber gaskets; 9, 15 – nuts; 14 – butt lid of pressure tank

The cylindric nozzles with lateral inflow of stream-lines (Fig. 6, *a*) are fixed in a pressure PD provided the possibility of rotation about their longitudinal axes (Fig. 6, *b*).

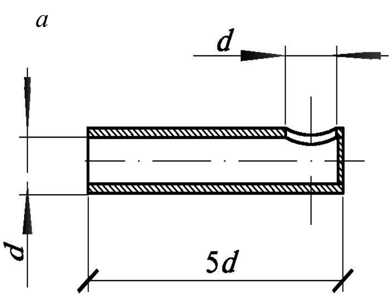

Fig. 6. Cylindric nozzles with orthogonal lateral inflow: a – schematic diagram; b – general view (in center, segment of PD with built-in nozzle)

In the course of the experiments, the angle β between the direction of water stream in PD and the direction of the outflow jet were assigned the values within the range of $0^0 \ldots 360^0$ (see the Table and Fig. 7).

Geometric characteristics of the manufactured distributive pipe-lines

Diameters, *mm*		Ratio of cross-section areas of nozzle and PD, $(d/D)^2$
Distributive pipelines, D	Nozzles, d	
20.18	6.01	0.0887
26.01	8.99	0.119
20.18	8.02	0.158
11.28	4.83	0.183
16.13	8.08	0.250

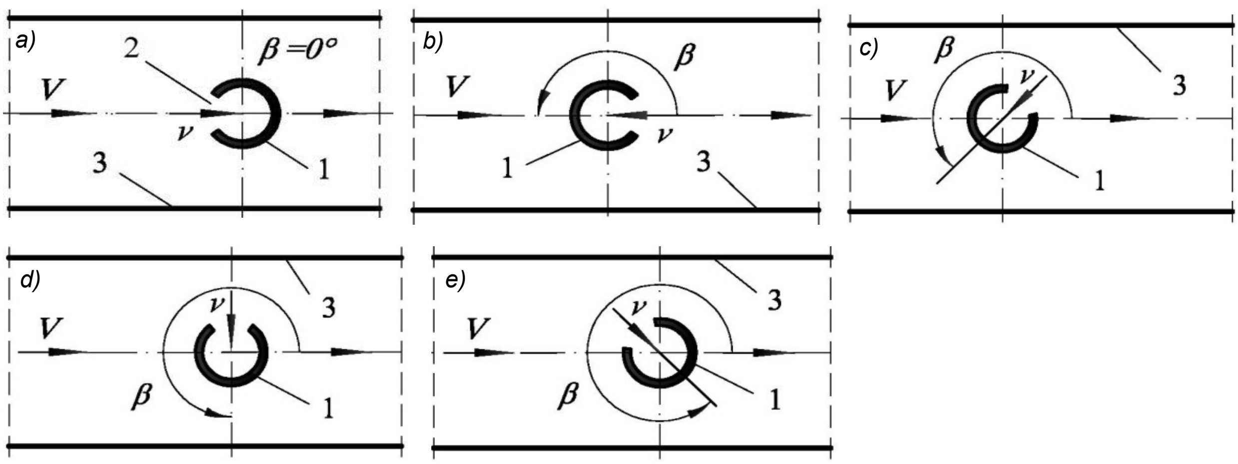

Fig. 7. Schematic diagrams of reference of angle β between direction of water stream in PD and direction of outflow jet: a – β=0 ⁰; b – β=180 ⁰; c – β=225 ⁰; d – β=270 ⁰; e – β=315 ⁰; 1 – cylindrical nozzle with lateral orthogonal inlet (cross-section); 2 – outlet of nozzle; 3 – wall of PD; V is the mean speed of stream in PD; ν ditto for stream-line which inflows into nozzle from PD

Conclusions. An experimental investigational bench for evaluation of the coefficient of flow rate for outlet cylindric nozzles with lateral orthogonal inflow of stream-line has been manufactured. The nozzles were fixed in the wall of a distributive pipeline so that they can be rotated about their longitudinal axes. This ensures the possibility to regulate the value of the angle β between the direction of the water stream in the distributive pipeline and the direction of the jet which outflows from the pipeline through this nozzle.

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