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TECHNOLOGY FOR CREATING A DEVICE FOR LAMINAR FLOW OF WATER IN PIPES

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Abstract: The article discusses the mathematical modeling of the movement of viscous incompressible fluids through a bundle of tubes located inside the outer pipe. The laminar and turbulent modes of this movement are considered, and the physical meaning of their occurrence is also analyzed. The fluid flow through n tubes of length L and radius r located inside the outer tube is considered. Calculation formulas are derived for calculating the maximum velocity of this flow, the volume of fluid passing through the cross section of the tube, the coefficient of resistance to friction in the tube along the length of the flow, and also the maximum value of the tangential stress. The results of the study of the relationship of the coefficient of resistance to friction in the tube with the Reynolds number are presented. A description is given of a device created according to the results of a study that brings the disordered flow of liquids into a laminar state.

Keywords: Reynolds number, laminar flow, turbulent flow, parabolic flow, friction force, integral, coordinate, pipe, viscosity, density, main flow velocity, average speed, maximum speed, radius, Hooke, Gegin, Poiseuille, Darcy-Weisbach, fluid volume, drag coefficient.

The motion of real fluids is often very different from that of laminar flow. They have a special property called turbulence. As the Reynolds number increases in real fluid flows in pipes, channels, and boundary layers, the transformation of a laminar-shaped flow into a turbulent flow is clearly observed. This transition of laminar flow to turbulent flow is sometimes called turbulence, which is fundamental in the whole field of hydrodynamics. Initially, such a transition was observed in the flow of straight pipes and channels.

Information on the forces acting on a fluid for flow in a cylindrical tube is given in the article [2; pp. 36-47].

Consider the motion of a tube of constant diameter along its entire length and the flow of fluid through n tubes of length L and radius r placed inside the tube. In real liquids, the liquid sticks to the walls of the tubes and exerts a repulsive stress on the flowing surface. This creates a force called internal friction, which is the viscosity of liquids. Viscosity is the property of gases and liquids to resist the action of external forces that cause the fluid to move. The presence of experimental stresses and the adhesion of the fluid to solid walls cause the real fluids in motion to be qualitatively different from ideal fluids. We now calculate the forces acting on the fluid in the pipe, taking into account the n tubes. Due to the adhesion, the velocity in the tube wall is zero, and the velocity between the tubes reaches its maximum value. Some concentric layers move so that the velocity is axial everywhere and the flow is laminar. At a sufficiently long distance from the starting point of the tubes, the velocity distribution of the flow in the tube does not depend on the longitudinal coordinates along the radius.

The movement of the fluid in the tube is due to the fact that the pressure decreases along the axis of the tube, but the pressure does not change in the cross section perpendicular to the axis of each tube. The motion of each element of the fluid accelerates due to the pressure drop and slows down due to the shear stress caused by friction [3; pp. 36-38]. The pressure p is assumed to be constant, i.e., across the entire tube section [4; pp. 59-60].

There are compressive forces and effects on the cylinder along the main axis, which correspond to the inlet and outlet bases of the cylinder, respectively, and there is an actuating force acting on the side surface of the cylinder. It is necessary to determine the maximum flow rate in this cylinder, the volume of liquid flowing through the cross section of the pipe, the coefficient of frictional resistance of the pipe along the length of the pipe, and the maximum value of the test voltage.

By balancing the forces acting on the fluid in the tube (Figure 1), we obtain the following equation as a condition of equilibrium in the direction of motion:

$$\sum_{i=1}^{n} p_0 \pi y^2 = \sum_{i=1}^{n} p_l \pi y^2 + \sum_{i=1}^{n} 2\pi y L \tau \cdot \quad (1)$$

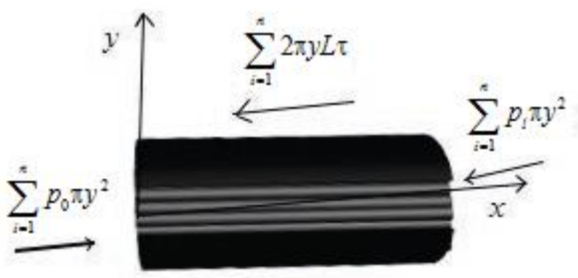

Figure 1. N tubes are placed inside the tube

The projection of the internal friction force is obtained with a positive sign because the velocity gradient is negative (the flow velocity of the layer decreases with increasing coordinate).

From formula (1) we can determine the test voltage

$$\tau = \frac{p_0 - p_l}{L} \cdot \frac{y}{2} \quad (2)$$

In this case, the flow rate decreases with increasing coordinate and becomes zero due to the viscosity. Therefore, we can say that according to Newton's law of $\tau = -\mu \frac{du}{dy}$ friction.

Substituting this expression into (3), we get:

$$-\mu \frac{du}{dy} = \frac{p_0 - p_l}{L} \cdot \frac{y}{2}$$

Henceforth

$$\frac{du}{dy} = -\frac{p_0 - p_l}{\mu L} \cdot \frac{y}{2} \quad (4)$$

Now, assuming that when $y = r$, it is $u(y) = 0$, we integrate Equation (4) with this initial condition to form the following equation

$$u(y) = -\frac{p_0 - p_l}{4\mu L} y^2 + C, \quad (5)$$

To find the constant C in Equation (5), we use the condition that the velocity is $y = r$ when $u(r) = 0$ i.e.

$$u(r) = -\frac{p_0 - p_l}{4\mu L} r^2 + C$$

henceforth

$$C = \frac{p_0 - p_l}{4\mu L} r^2 \quad (6)$$

we find that Set this value of the constant to (6)

$$u(y) = -\frac{p_0 - p_l}{4\mu L} y^2 + \frac{p_0 - p_l}{4\mu L} r^2$$

equation and so on

$$u(y) = \frac{p_0 - p_l}{4\mu L} (r^2 - y^2) \quad (7)$$

we have the equation

Thus, we have a parabolic distribution of velocities along the radii of the tubes (Figure 2). This velocity reaches its maximum value in the middle of the tube (y=0) and has the following maximum value:

$$u_{\max} = \frac{p_0 - p_l}{4\mu L} r^2 \quad (8)$$

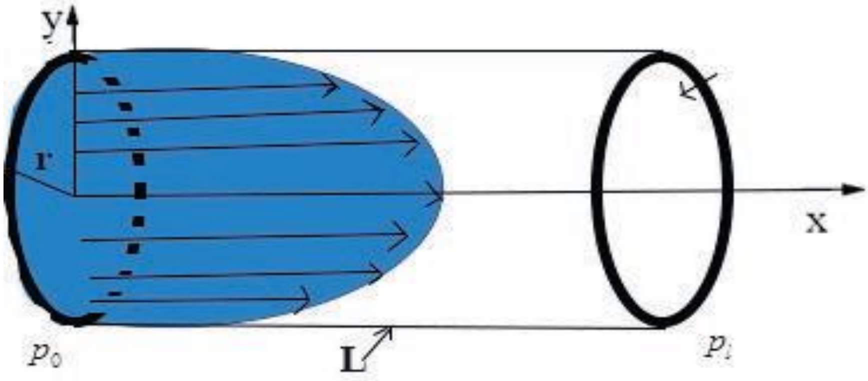

Figure 2. Flow motion for a single tube

The total fluid flow (fluid flow) through the tube section is defined as the circulating paraboloid volume (Figure 2) and is defined as follows.Equation (7) we have the following formula:

$$u(y) = \frac{p_0 - p_l}{4\mu L} r^2 (\frac{r^2 - y^2}{r^2}) = u_{\max}\left(1 - \frac{y^2}{r^2}\right) \quad (9)$$

Using the Gagen-Poiseuille formula for the total flow of fluid through a tube with a circular cross section, we determine:

$$Q = \int_0^r u(y) 2\pi y dy = 2\pi u_{\max} \int_0^r \left(y - \frac{y^3}{r^2} \right) dy = 2\pi u_{\max} \left[\frac{y^2}{2} - \frac{y^4}{4r^2} \right] \Bigg|_0^r$$

that is, we have a formula for the flow rate

$$Q = \frac{\pi (p_0 - p_l) r^4}{8\mu L} \quad (10)$$

Enter the average flow velocity across the cross section of the tube:

$$\bar{u} = \frac{Q}{\pi r^2} \quad (11)$$

Given formula (10), we write (11) as follows

$$\bar{u} = \frac{(p_0 - p_l) r^2}{8\mu L}$$

Comparing the function $\bar{u}(y)$ with $u_{\max}$ defined by formula (8), the average velocity for the motion $\bar{u}(y) = \frac{1}{2} u_{\max}$ is half the maximum velocity.

We determine the pressure difference $(p_0 - p_l)$.

$$p_0 - p_l = \frac{8\mu L \bar{u}}{r^2}$$

Henceforth

$$p_0 - p_l = \frac{8\mu L\bar{u}}{r^2} = \frac{32\mu\bar{u}}{2r}\cdot\frac{L}{2r} = \frac{32\mu\bar{u}}{D}\cdot(\frac{L}{D}) \quad (12)$$

where $D = 2r$ the diameter of the tube.

The pressure lost along the length of the flow is found by the Darcy-Weisbach equation [5-9]. Summarizing the above formula for one tube for -ta tubes, we obtain the following formula

$$p_0 - p_l = \sum_{i=1}^{n}\frac{\lambda_i}{2}\rho\bar{u}^2(\frac{L}{D}) \quad (13)$$

Substituting the value of $p_0 - p_l$ from formula (4.34) into (13) we obtain the following formula

$$\lambda_n = \frac{32\mu\bar{u}}{D}\cdot\frac{L}{D}\cdot\frac{2}{\rho\bar{u}^2}\cdot\frac{D}{n\cdot L} = \frac{64\mu}{\rho\bar{u}D\cdot n}$$

or more

$$\lambda = \frac{64}{n\cdot \mathrm{Re}} \quad (14)$$

where n is the number of tubes, the coefficient of resistance decreases with increasing number of tubes $\mathrm{Re} = \frac{\rho\bar{u}D}{\mu}$.

Above (14), we present the results obtained on the basis of the formula (Fig. 3).

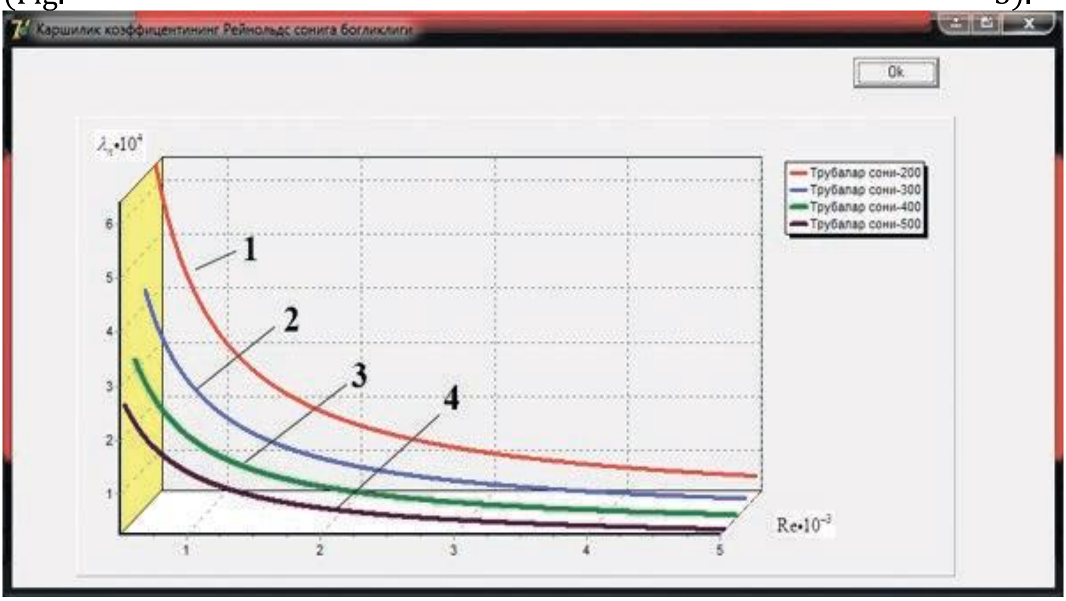

Figure 3. The dependence of the coefficient of resistance in a smooth pipe on the number of tubes n and Re:

1) n=200; 2) n=300; 3) n=400; 4) n=500.

Figure 3 shows the results of calculations showing that the resistance coefficient λ_n for a smooth n tube depends on the Rnolds number Re. A comparison of the results shows that the theoretical formula (14) is valid for all values of the number Re. At larger values of the number Re, the resistance decreases due to the active activation of the turbulence mechanisms.

In the computational experiment, the characteristic parameters Reynolds number Re and λ_n of the coefficient of resistance are studied in the following quantities:

$\mathrm{Re} = 500 \div 5000$, $\lambda_n = 0.0001 \div 0.0007$. The figure shows that as the number of tubes increases, the coefficient of resistance decreases.

Based on the above results, it is possible to create a device that allows the regulation of water flows. The device can be implemented in the manufacturing process, it can be used to regulate the flow in water fountains.

The proposed device allows you to make the fountains look beautiful and enrich them with different colors.

The main purpose of the device is to maintain the flow of water in the form of a uniform laminar flow with the help of its working bodies.

The device can be explained by the following diagrams, its working elements are shown, Figure 4 shows the internal section of the device, where the base legs holding the device at an acute angle and the device is firmly attached to it, 2 tube-shaped housing, 3 -cylindrical section with inlet and outlet holes mounted vertically from top to bottom, 4 small-diameter tubes, which serve to convert the tubular flow into laminar flow, and 5-distributor, which serves to evenly distribute the flow to small-diameter tubes by reducing the flow rate, 6 -network holding small-diameter tubes, which in turn serves for the orderly movement of the flow.

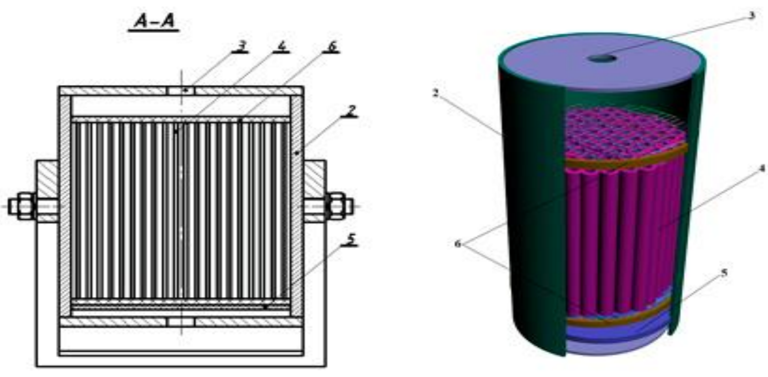

Figure 4. Device interior

The device that converts the flow to a laminar view works as follows: the flow from the inlet 3 is directed to the flow 5, which reduces the flow rate and the flow is evenly distributed in the small diameter tubes, the current passing through the small diameter tubes 4 becomes laminar and It is shot in a laminar view through 3 outlet holes.

The experimental study found that the optimal length for a set of tubes placed inside a tube was 12–16 cm, and that the resistance coefficient decreased as the tube set increased, resulting in a device for converting chaotic flows into laminar flows.

The proposed device is an in-depth analysis of laminar flow in the movement of incompressible viscous fluids in the pipe, which is important in technical applications, when it is necessary to convert turbulent (chaotic) flows into laminar (layered, ordered) flows, including in parks. They can be used when there is a need to effectively control the flow of water, that is, to create a variety of pleasant and colorful streams of water in the installed fountains, to give people an aesthetic pleasure. Laminarization of water flows in the pipe is very useful and cost-effective, ie it saves water.

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Compensation for moral damage caused by violation of the author's right

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Abstract: Nowadays, there are many cases of using works protected by copyright without obtaining the appropriate permission of the author or the owner of such rights. The most common types of copyright infringement include copying, distribution of the work, mass demonstration, mass execution of works in concert halls, theatrical productions, translation of the work into other languages, processing of the work (plagiarism), etc. As a result of committing such an illegal act, not only material damage, but also moral damage can be caused to the author of the work. In this article, the issue of compensation for moral damage caused by violation of the rights of the author has been studied.

Keywords: copyright law, intellectual property, moral damage, material damage, mental calmness, anguish, feeling uncomfortable.

With the development of modern information and communication technologies, the illegal users of literary works (literary-artistic, scientific, educational, publicist and other works), dramatic and scenario works, works of text and non-text music, musical-dramatic works, choreographic works and pantomime, audiovisual works, painting, sculpture, graphics, design works and other fine arts, works of landscape-applied and stage decoration art, architecture, urban planning and garden-park development works of art, photographic works and works created in similar ways to photography are often encountered. As a result of this, personal non-property and property rights of the author are violated.

We can say that our main laws aimed at protecting copyright are the Civil Code of the Republic of Uzbekistan and the law of the Republic of Uzbekistan "On copyright and related rights", the Criminal Code of the Republic of Uzbekistan and other normative-legal acts. The result of the reforms carried out in this area was the signing of the law of the Republic of Uzbekistan "On the Accession of the Republic of Uzbekistan to the Treaty of the World Intellectual Property Organization on Copyright (Geneva, December 20, 1996)" on February 2, 2019.