MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
"KHARKIV POLYTECHNIC INSTITUTE"

METHODICAL INSTRUCTIONS

to perform laboratory work

in the course

"Mechanics of Viscous Fluid and Drilling Fluids"

for full-time and part-time students

in the specialty "Sectoral Engineering",

educational program "Sectoral Engineering"

Kharkiv

NTU «KhPI»

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Methodical instructions to perform laboratory work in the course "Mechanics of Viscous Fluid and Drilling Fluids" for full-time and part-time students in the specialty "Sectoral Engineering", educational program "Sectoral Engineering"/ compiled by Andrii Rogovyi, Evgeniy Krupa, Kseniya Rezvaya, - Kharkiv: NTU "KhPI." - 2025. - 24 p.

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LABORATORY WORK 1.
Instruments for measuring the pressure of the liquid

Purpose of work - study of devices for measuring pressure in the liquid, verification of technical manometer with a tubular spring and determine the accuracy of pressure measurement manometer.

Hydrostatic pressure p is the direction of compression in a liquid

$$p = \lim_{\Delta S \to 0} \frac{F}{\Delta S},$$ (1.1)

where F is the force acting on the selected area in the fluid ΔS.

Pressure at any point of the liquid acts normal to the elementary area and does not depend on its orientation [1, 2].
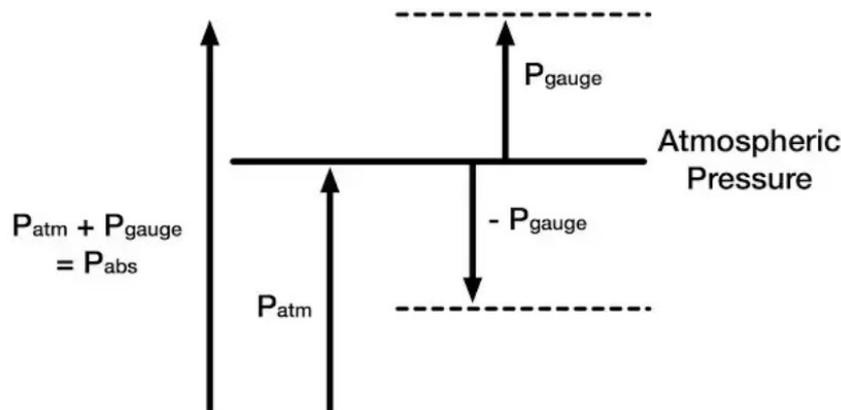

Figure 1.1 - Schematic diagram of pressure reporting systems

Two reference systems are used to measure pressure (Fig. 1.1). In one, the pressure is counted from absolute zero and is called absolute pressure p_{abs}. In the other, atmospheric pressure p_{atm} is taken as the starting point. Then the measured positive pressure is called gauge pressure p_g and represents the excess of absolute pressure over atmospheric pressure [3].

$$p_g = p_{abs} - p_{atm} \quad \text{if} \quad p_{abs} > p_{atm}$$ (1.2)

Negative overpressure is called vacuummetric, or vacuum, and is the lack of absolute pressure to atmospheric pressure

$$p_{vac} = p_{atm} - p_{abs} \quad \text{if} \quad p_{абс} < p_{атм.} \qquad (1.3)$$

Classification of instruments

Instruments for measuring fluid pressure are very diverse and are classified according to various features - the principle of operation, the kind of measured value, accuracy class, and range of the measured value [4].

The instruments are divided into 4 groups according to the type of the measured value:

1. Barometers - instruments for measuring atmospheric pressure.

2. Manometers and vacuum gauges - devices for measuring positive overpressure and vacuum-negative overpressure took with a positive sign. Instruments that measure both of these pressures are called manovacuum gauges.

3. Differential manometers are instruments for measuring pressure differences.

4. Instruments for measuring small values of excess pressure or vacuum - micromanometers.

Pressure measuring instruments have the following accuracy classes: 0.005; 0.02; 0.05; 0.1; 0.2; 0.4; 0.5; 1.0; 2.0; 2.5; 4.0; 6.0. Instruments with accuracy classes 0,005 ... 0,4 are used as reference instruments and the rest - as working (or technical).

According to the principle of operation, there are liquid, spring, piston, electric, combined, etc. instruments [5].

Due to the simplicity of the device, high accuracy of pressure measurements and stability of ensuring this accuracy over time, liquid instruments have become widely used in laboratory practice, and also as reference instruments for verification and calibration of the scales of other pressure measuring devices.

Practically, the accuracy of pressure measurement by liquid instruments is determined mainly by height measurement accuracy.

Errors in the density determination values and scale graduation inaccuracies are usually insignificant.

The disadvantages of liquid devices include their fragility, lack of transportability, narrow range of measured pressures, not exceeding 0.4 MPa for mercury manometers, and bulky. When using mercury and other heavy liquids, the vapors of which are poisonous, it is necessary to take precautions to prevent contact of these liquids with the atmosphere and release into it.

Spring devices

Their work is based on the use of Hooke's law when deforming under the action of pressure of other elements of devices - springs, which can be made in the form of a curved tube, diaphragm, bellows, etc.
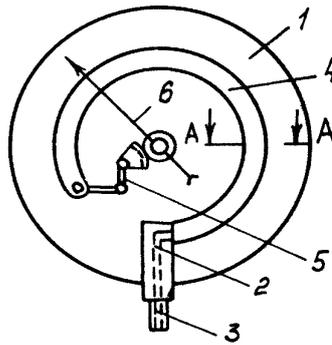
Figure 1.2 - Schematic diagram of a manometer with a tubular spring

A manometer with a single coil tubular spring (Fig. 1.2) is placed in the body 1 curved circumferential tube 4 with an oval shape in the cross-section. One tube end is sealed and connected to the arrow 6 through the transmission mechanism 5. The second end is fixed on holder 2 with connector 3, with the help of which the device is installed in the place of pressure measurement.

At positive overpressure, the tube under its influence is partially straightened, and its deformation is transmitted to the arrow, which is rotated by some angle proportional to the measured pressure [6].

In a vacuum gauge, under the influence of atmospheric pressure, a greater internal pressure bends the tube.

Some tubular instruments, called mano-vacuum gauges, measure positive overpressure and vacuum.

Depending on the elastic element's material, shape, and size, general-purpose tubular manometers have scales with limits from 0.05 to 1000 MPa.
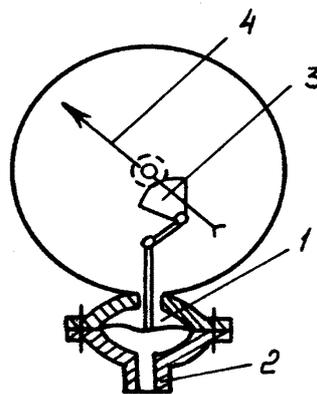
Figure 1.3 - Diagram of a pressure gauge with a diaphragm

In instruments with diaphragm springs (Fig. 1.3), the elastic element - diaphragm - is a corrugated, metal, round plate 1, pinched between the flanges.

Under the action of the pressure of the liquid coming through connection 2, the membrane deflects, and its deformation is transmitted to the pointer 4 of the device. Diaphragm instruments are used for measuring vacuum and overpressure not exceeding 2.5 MPa.

Valuable qualities of spring devices are portability, versatility, simplicity of device and application, and huge range of measured pressures. The main disadvantages of these devices include instability of their readings, called residual deformations of the elastic element and changes in its mechanical characteristics, wear of the transmission mechanism, etc., which makes it necessary to verify the spring devices periodically.

Laboratory setup and procedure for calibration of pressure gauges

For technical instruments, the purpose of verification is to confirm the accuracy class established for them, indicated on the dial, and for laboratory instruments - to determine the values of pressure corrections Δp, compensating the systematic error at different values of pressure. In this case, the result of verification is presented in the form of a graph of dependence $\Delta p = f(p)$.

When verifying any manometer (call it working), its readings are compared with the readings of a reference, the upper limit of the measured pressure should be higher than that of the working, and the maximum absolute systematic error should be lower by at least four times. As a reference gauge, it can be a piston, spring, or (at low pressures) liquid manometer.

Installation for verification of spring pressure gauges includes a reference piston and spring gauges, a tank with oil, a verifiable working gauge, and a press device, which is used to create the necessary pressure in the system.

Each unit is connected to the oil system by means of a corresponding valve. All devices are placed on a stand having levels and legs made in the form of micrometer screws.

In the piston pressure gauge, the force of oil pressure on the shank of the movable piston, the tightness of which is ensured only by the accuracy and purity of manufacture, is balanced by the weight of the piston and reference weights 2, placed on its load-receiving plate.

At known values of the piston cross-sectional area and weight of the weights, determining pressure does not cause difficulties. To reduce the friction force of the piston, it should be driven into rotation at a speed of 0.5 ... 2 r/s.

Weight piston pressure gauges are devices of high accuracy (classes from 0.005 to 0.2) and are used mainly for verification of spring pressure gauges, graduation of their scales, calibration of sensors and so on.

In this laboratory work we will not use it, and as the true values of pressure we will take the readings of an exemplary spring manometer.

Conditions and order of work performance

When verifying the mechanical pressure gauges must fulfill the following conditions:

- the installation should be located in an area free from vibration and with the help of micrometer screws aligned horizontally on the levels;
- the ambient temperature should be within 17...23 ^{0}C;
- the readings of each device should be taken after light tapping on it with a bent finger;
- when counting, the observer's beam of vision should be perpendicular to the dial of the device and pass through the index end of the hand;
- instrument readings are counted to the nearest 0.1 scale division.

The pressure gauge is verified in the following sequence

1. Write down the number, State Standard, accuracy class and scale limit value of the manometer to be verified.

2. Assign verifiable points of the scale of the device, which should be evenly distributed on it. The number of verifiable points depends on the accuracy class of the gauge. Manometers class 4 ... 6 verify in three points, (1 ... 2.5) - in five, classes 0.5 and above - in ten points.

3. Close the valves on all gauges.

4. Fill the cylinder with oil, for which to set the piston (with an open tank valve) first in the leftmost position, then slowly rotate the flywheel to the rightmost position.

5. Open the valves of spring pressure gauges and record the initial reading on their scales in the protocol.

6. Close the cistern valve and create a piston piston successively at intervals, first smoothly rising, then smoothly falling pressure within the entire scale of the working manometer and record the pressure readings verifiable and reference manometers in the protocol.

7. Repeat the last two points.

Processing of measurement results

Calculate the arithmetic mean of the readings of the gauge under verification at the given pressure

$$p_{cp} = \frac{p_{н} + p_{p} + p_{н}^1 + p_{p}^1}{4},$$ (1.4)

where $p_{н}$ is readings of the manometer under verification when dialing the pressure; $p_{н}^1$ is the same after tapping on the dial; p_{p} is readings of the manometer under unloading; p_{p}^1 is the same after tapping on the dial of the manometer under verification.

Calculate the absolute systematic error of measurement at each value of p_0

$$\Delta p = p_{cp} - p_0;$$ (1.5)

$$\delta = \frac{\Delta p}{p_0} \cdot 100\%.$$ (1.6)

Determine the accuracy class of the gauge to be verified

$$K = \frac{\Delta p_{max}}{N} \cdot 100,$$ (1.7)

where N is upper limit of the instrument scale.

The results of calculations are recorded in Table 1.1

Table 1.1 - Measured and calculated values

Measurement number	Measured values					Calculated value		
	p_0	p_H	p_P	p_H^1	p_P^1	p_{cp}	Δp	δ
	MPa					MPa		%
1								
2								
3								
4								
5								

Report

Your report should include the following:
- the title
- objective
- table of raw data
- table of results
- conclusions.

Control questions
1. What is absolute, gauge, and vacuum pressure?
2. Explain the advantages and disadvantages of mechanical manometers.
3. What is the accuracy class of the device?
4. Explain the purpose of instrument verification.

LABORATORY WORK 2.
Study of relative rest of liquid in a rotating vessel

Purpose of work is experimental determination of the free surface of the liquid in a rotating vessel.

The liquid in a cylindrical vessel rotating at a constant angular velocity ω, is at rest relative to the vessel. This is because the walls of the vessel, due to frictional forces, entrain the liquid, which begins to rotate with the vessel with the same angular velocity. Since the coordinate axes rotate with the vessel, in relation to the rotating coordinate axes, the liquid will also be in relative equilibrium [7]. Consequently, for the study of a rotating fluid, it can be used Euler equations, reduced to the form

$$dp = \rho\left(Xdx + Ydy + Zdz\right) \qquad (2.1)$$

where X, Y, Z are projections of acceleration of volume forces, related to the mass unit.

For a surface of equal pressure, when $p = const$,

$$Xdx + Ydy + Zdz = 0 \qquad (2.2)$$

Projections of centrifugal forces on coordinate axes, related to the unit of mass,

$$X = \omega^2 x; \quad Y = \omega^2 y; \quad Z = -g.$$

Substituting in equation (2.2) instead of projections of volume forces their values, we obtain

$$\omega^2 xdx + \omega^2 ydy - gdz = 0 \qquad (2.3)$$

By integrating equation (2.3) we obtain the equation of the paraboloid of rotation

$$\frac{\omega^2 r^2}{2g} = z \qquad (2.4)$$

where ω is the angular velocity; r is distance from the given point of the free surface to the axis of rotation.

The free surface of the fluid is a surface of equal pressure ($p_0 = p_{atm}$), hence it also takes the form of a paraboloid [8].

Equipment Description

The free and forced vortex apparatus consists of a transparent cylindrical tank with a diameter of 250 mm and a depth of 180 mm. It is fitted with two pairs of diametrically opposed inlet tubes, measuring 9.0 mm and 12.5 mm in diameter. The larger 12.5 mm inlets are angled at 15° to the tank's diameter, generating a swirling flow during free vortex experiments (see Figure 2.1). A central outlet at the bottom of the vessel is equipped with interchangeable orifices of 8, 16, and 24 mm, allowing control over the outlet size and the formation of vortices with different dimensions. The vortex surface profile is determined using a caliper mounted on a bridge, which measures the vortex diameter at various heights. These data points are used to plot the free vortex profile.
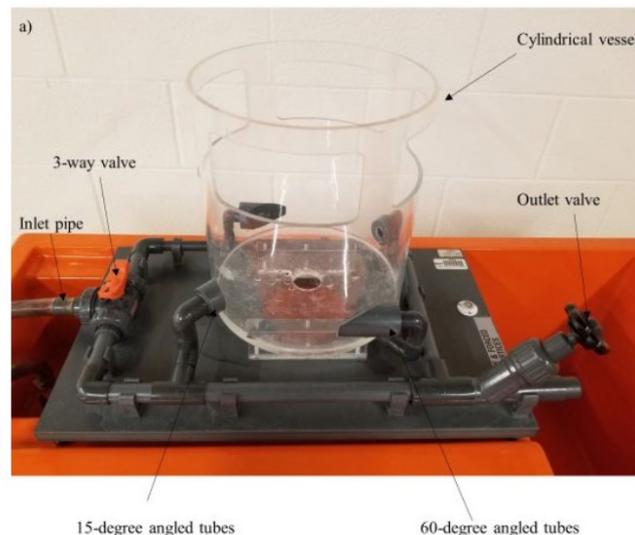

Figure 2.1: P6238 CUSSONS free and forced vortex apparatus

The forced vortex is created by inserting a bushed plug into the central opening of the vessel and directing water through 9 mm inlet tubes positioned at a 60° angle to the diameter. The incoming water strikes a two-blade paddle mounted on a vertical shaft, which is supported by the bushed plug, causing it to rotate. The water then exits the vessel through the 12.5 mm angled tubes, which also serve as the inlets for the free vortex experiment. A bridge positioned over the vessel holds a set of needles used to measure the coordinates of the forced vortex surface profile. A three-way valve controls the flow direction, allowing water to be diverted through the 12.5 mm inlets for free vortex formation or through the 9 mm inlets for generating the forced vortex.

Order of execution and processing of experimental data
1 .Switch on the electric motor using the toggle switch.

2. Adjust the vessel's rotational speed using the regulator, monitoring the speed with the dial indicator.

3. Position the measuring needle so that its axis aligns with the vessel's vertical axis (mark 0 on the horizontal scale).

4. Turn the handle to lower the measuring needle until its tip touches the liquid's free surface, then record the reading from the vernier scale.

5. Raise the needle, shift it horizontally by 1 cm (either to the left or right of the vessel's center), lower it again until it contacts the liquid surface, and take a new reading from the vernier.

6. Repeat this process for 7–8 points along the vessel's radius.

7. After completing the measurements, switch off the electric motor using the toggle switch.

Processing of research results

Calculate the angular velocity ω of rotation of the vessel by the formula

$$\omega = 2\pi\frac{N}{t} \tag{2.5}$$

where N is the number of revolutions.

Calculate the theoretical height of the free surface using the formula:

$$H = \frac{\omega^2 r^2}{2g} \tag{2.6}$$

Measurement data and calculation results are summarized in Table 2.1.

Table 2.1 - Results of measurements and calculations

	Forced Vortex											
Distance from center, r (mm)	N = 10			N = 20			N = 40			N = 50		
	ω (rad/s)	H (calculated) (mm)	H (measured) (mm)	ω (rad/s)	H (calculated) (mm)	H (measured) (mm)	ω (rad/s)	H (calculated) (mm)	H (measured) (mm)	ω (rad/s)	H (calculated) (mm)	H (measured) (mm)
0												
30												
50												
70												
90												
110												
125												

Report

Your report should include the following:
- the title

- objective
- table of raw data
- table of results
- graph of measured and calculated water surface profiles
- conclusions.

Control questions
1. What forces act on a liquid in a vessel that rotates about a vertical axis?
2. What is the shape of the free surface of the liquid in a vessel that rotates?

LABORATORY WORK 3.
Modes of fluid motion

The aim of the work is to familiarize with the modes of fluid flow. Learn to find Reynolds numbers, at which we can expect laminar or turbulent modes of fluid motion.

Observations show that there are two modes of fluid motion in nature: laminar and turbulent [9, 10].

If the liquid moves in such a way that its jets do not mix with each other, then such motion is called laminar mode (from Latin Lamina - layer). If the jets are mixed with each other, such motion of the liquid is called turbulent (from Latin Turbulentus - vortex).

The motion mode is determined by the ratio of inertia and viscous forces. The Reynolds number expresses the ratio of these forces [11].

$$\mathrm{Re} = \frac{Vd}{\nu} \qquad\qquad (3.1)$$

The dimensionless number Re comprises the average fluid velocity V, pipeline diameter d and kinematic viscosity ν.

The critical number $\mathrm{Re}_k = 2320$ is the limit of transition from one regime to another. When $\mathrm{Re} < \mathrm{Re}_k$ the motion is laminar, when $\mathrm{Re} \geq \mathrm{Re}_k$ - turbulent.

Considering the working processes, which are based on the flow of liquid or gas, the engineer first of all needs to establish which mode takes place in a particular case.

Determination of the mode of motion in the flow is of significant practical importance, because the head losses depend on it [12]. Consequently, in the laminar regime the head losses are proportional to the first degree of velocity, while in the turbulent regime the degree ranges from 1.75 to 2.

Laboratory installation

Laboratory installation for determining the modes of water movement in the pipe consists of a pressure tank 3 (Fig. 3.1), which is connected to glass tube 7 with a valve 8. Above the tank is vessel 4 with colored water, through a thin tube 6 enters the inlet section of the glass tube.
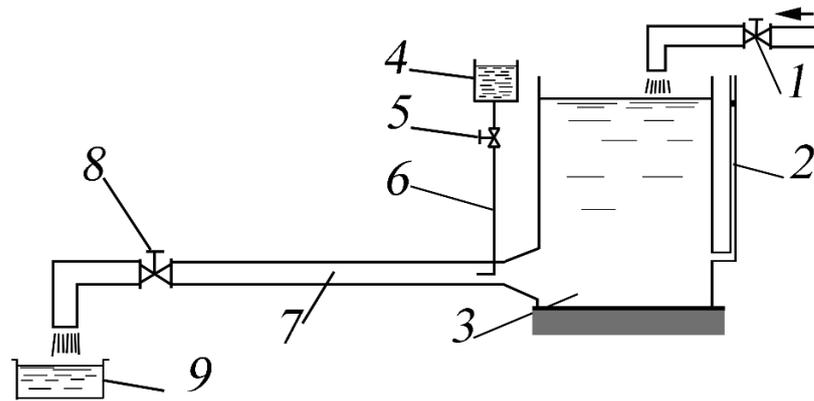
Figure 3.1 - Schematic diagram of the laboratory setup

Procedure

1. Open valve 1 and fill tank 3 with water, watching the water level in the piezometer 2.

2. With the help of valves 8 and 5 to achieve that the jet of colored liquid throughout the glass tube 7 looks like a stretched thread, that is, to establish a laminar mode of motion.

3. Measure the filling time t of the measuring tank 9 and the temperature of the water T.

4. Use valve 8 to achieve complete movement of the colored liquid, that is, to establish a turbulent mode of motion.

5. Adjust the valve 1 flow rate, entering the liquid in tank 3, and set a constant pressure.

6. Measure the filling time t of the measuring tank 9 and the temperature of the water T;

7. Close valves 1,5 and 8.

Processing of research results

Determine water flow rate

$$Q = \frac{1000 \cdot W}{t} \tag{3.2}$$

where W is the measuring tank capacity, t is the measuring tank filling time.

Use the Poiseuille formula to find the kinematic viscosity

$$v = \frac{0.0178}{1 + 0.0337 \cdot T + 0.000221 \cdot T^2}, \text{ cm}^2/\text{s} \tag{3.3}$$

where T is the water temperature, °C.

Determine the Reynolds number

$$\mathrm{Re} = \frac{Vd}{\nu},$$

where $V = Q/w$ is the mean velocity of fluid; w is the cross-sectional area; d is the diameter of a tube.

The obtained Reynolds number should be compared with the critical Reynolds number $\mathrm{Re}_k = 2320$: when $\mathrm{Re} < \mathrm{Re}_k$ the flow regime is laminar, when $\mathrm{Re} \geq \mathrm{Re}_k$ the flow regime is turbulent.

Measurement data and calculation results are recorded in Table 3.1.

Table 3.1 - Results of measurements and calculations

Measured and calculated values	Experiment number	
	1	2
1. Diameter of the glass tube d, cm		
2 Live section area w, cm^2		
3 Volume of water in the measuring tank W, l		
4. Time of filling the measuring tank t, s		
5. Water flow rate Q, cm^3/s		
6. Average velocity V, cm/s		
7. Water temperature T, °C		
8. Kinematic viscosity ν, cm^2/s		
9. Reynolds number Re		
10. Mode of motion		

Report

Your report should include the following:
- the title
- objective
- table of raw data
- table of results
- conclusions.

Control questions
1. Define the laminar mode of fluid motion.
2. How can the critical Reynolds number be used to determine the modes of fluid motion?

LABORATORY WORK 4.
Fluid flow in a channel of variable cross-section

The aim of the work is to find the regularity of the steady-state motion of real liquid in a channel of variable cross-section and to illustrate the Bernoulli equation for the flow.

At the steady-state motion of a real droplet liquid along a pressure pipeline (channel) of variable cross-section, there is a transformation of one form of its energy into another depending, for example, on the change of the cross-sectional area of the channel. Thus, with its decrease in the direction of fluid flow, the velocity head will increase, and the piezometric head will decrease (with unchanged or increasing geometric head). In addition, part of the energy of the fluid flow will be spent on overcoming hydraulic resistances. Therefore, its total energy does not remain constant, but decreases from section to section in the direction of fluid flow.

For any two cross sections 1-1 and 2-2 of the real droplet fluid flow at steady-state motion, the Bernoulli equation has the following form

$$Z_1 + \frac{p_1}{\rho g} + \frac{\alpha_1 V_1^{\ 2}}{2g} = Z_2 + \frac{p_2}{\rho g} + \frac{\alpha_2 V_2^{\ 2}}{2g} + \sum h_{1-2}.$$

Here Z_1 is the specific potential energy of position or geometric head of liquid flow in the corresponding section, equal to the height of location of its center of gravity of the section relative to the selected plane of comparison; $Pi/\rho g$ is the specific potential energy of state or piezometric head in the corresponding section, equal to the height of rise of liquid relative to its center of gravity in the piezometric tube installed in this section; $\dfrac{\alpha_i V_i^{\ 2}}{2g}$ is the specific kinematic energy or velocity head of the flow in i-th section; $\sum h_{1-2}$ is the total head losses between the selected plane of comparison. ρ is the density of the fluid, assumed unchanged; α_i is the dimensionless coefficient of kinetic energy, taking into account non-uniform distribution of velocity along the cross-section. For laminar mode $\alpha = 2$, turbulent mode $\alpha = 1$; V_i is the average cross-sectional velocity of the fluid.

The left part and the sum of the first three terms of the right part of the Bernoulli equation are the total specific energies or total heads of the fluid flow in the selected cross-sections, i.e., the energy loss between any two cross-sections

of the fluid flow is equal to the difference of the total heads in them. This relationship can be represented in the following form

$$(Z_1 - Z_2) + \frac{p_1 - p_2}{\rho g} + \frac{\alpha_1 V_1^2 - \alpha_2 V_2^2}{2g} = \sum h_{1-2},$$

from this, it is possible to conclude that at possible components of total heads in cross-sections of signs of differences of homonymous components of total heads in cross-sections, the sum of these differences should always be positive.

Bench for the study of fluid motion in a channel of variable cross-section

The bench includes (Fig. 4.1) drain 1 and pressure 2 tanks, pump 3, pipeline 4 and 5, overflow tube 6, horizontal channel of variable cross-section 7, Venturi tube 8, shut-off 9 and control valves 10 and 11, piezometers 12 and full head (Pitot) tubes 13.

In channel 7, with a rectangular cross-sectional shape of variable height and constant width, seven cross-sections are allocated, in each of which the piezometric head and total head are measured respectively by a piezometer with a Pitot tube. The latter is installed along the axis of the channel and measures the total head at maximum liquid velocity.

The water flow rate in pipeline 5 and channel 7 is determined by the readings of differential piezometer 14 connected to the Venturi tube 8.

When the bench is operating, the water of pump 3 is supplied from drain tank 1 to pressure tank 2, from which it flows through pipeline 5 through regulating valve 10 and Venturi pipe 8 into the channel of variable cross-section 7. Then, it flows through the pipeline and the control valve 11 into drain tank 1.
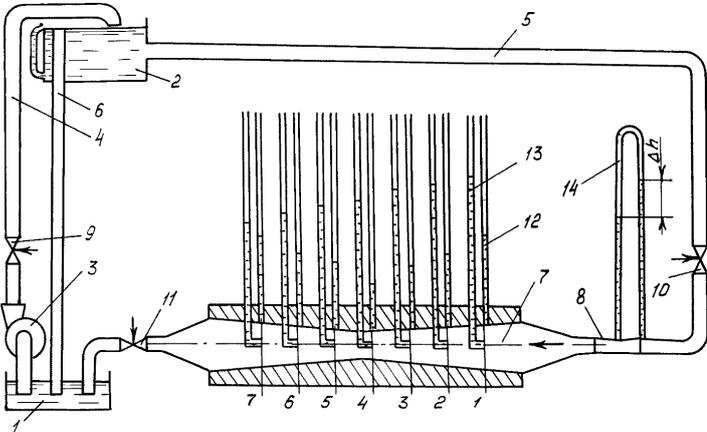

Figure 4.1 - Schematic diagram of the stand for investigation of fluid flow in a channel of variable cross-section

Sequence of operation

Turn on pump 3, open valve 9 (valves 10 and 11 are closed) and fill pressure tank 2 with water. By means of control valves 10 and 11 set the required water flow rate through the channel of variable cross-section. Measure the readings of piezometers and full-head pipes and record them in the table. Close valves 9, 10, 11 and switch off the pump.

Processing of the measurement results

On the basis of the measured values calculate the parameters necessary to find the full design heads in the sections of the channel 7.

Liquid flow rate through the channel, m^3 / s

$$Q = 1{,}1 \cdot 10^{-5} \sqrt{\Delta h} ,$$

where Δh is the reading of the differential piezometer installed on the Venturi pipe, mm.

Average velocity in each cross-section of the channel, m/s

$$V_i = \frac{Q}{S_i} ,$$

where S_i is the cross-sectional area, m².

To determine the velocity heads, it is necessary to know the values of coefficients α, i.e. Reynolds number and, respectively, the modes of fluid motion in the cross-sections.

The Reynolds number is found from the expression

$$\mathrm{Re}_i = \frac{V_i D_{ri}}{v} ,$$

where $D_{ri} = \dfrac{4S_i}{\Pi_i}$ is the hydraulic diameter of the rectangular section of the channel width $b = 1 \cdot 10^{-2}$ m; $\Pi_i = 2(b + h)$ is the perimeter of the cross-section; $h = \dfrac{S'}{b}$ is the height, $v = 1 \cdot 10^{-6}$ is the water kinematic viscosity, m²/s.

If the regime in the first or seventh cross-section is turbulent, it is possible to take for all cross-sections $\alpha \approx 1$.

When the plane of comparison passes through the axis of the channel, Zi=0 and the expression of the total design head in the cross-sections is as follows

$$H_i = \frac{p_i}{\rho g} + \alpha_i \frac{V_i}{2g}$$

According to the results of measurements and calculations recorded in the table, plots of changes in piezometric, velocity and total head (measured H' and calculated H) along the length of the channel, starting from the first section, as shown in Fig. 4.2, rationally choosing the scale of variables. 4.2, rationally choosing the scale of variables.
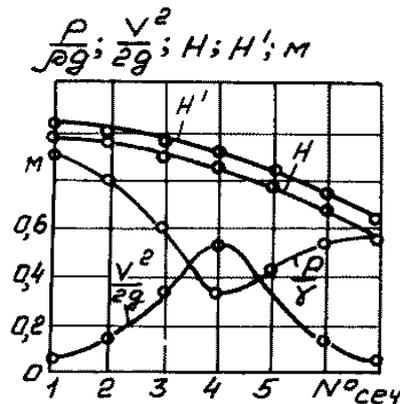

Figure 4.2 - Variations of velocity, piezometric and total head along the channel length

Table 4.1 - Measured and calculated values

cross-section number	Measured values							Calculated values				
	$S \cdot 10^4$	$\frac{P}{\rho g}$	H	Δh	Q	V	П	Re	α	$\alpha \frac{V^2}{2g}$	$H = \frac{P}{\rho g} + \alpha \frac{V^2}{2g}$
	m^2	m	m	mm	m³/s	m/s	m			m	m
1	2,75										
2	2,0										
3	1,2										
4	0,7										
5	1,2										
6	2,0										
7	2,75										

Report

Your report should include the following:
- the title
- objective
- table of raw data

- table of results
- graph of heads
- conclusions.

Control questions

1. Should pump 3 be running when taking measurements?

2. Can the total head in a subsequent section be greater than in the previous section?

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FOR NOTES

Навчальне видання

Методичні вказівки до лабораторних робот з навчальної дисципліни
«Механіка в'язкої рідини та бурильних розчинів (англійською мовою)»
для студентів денної та заочної форми навчання
за спеціальністю «Галузеве машинобудування»
освітня програма «Галузеве машинобудування»

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