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THE PLACE AND SIGNIFICANCE OF NON-VISUCOUS FLUID DYNAMICS IN TEACHING THE SCIENCE OF HYDRAULICS

Eshev Sabir Samatovich;
Professor of Karshi Engineering - Economics Institute

Nazarov Odil Omankulovich;
Senior Teacher of Karshi Engineering - Economics Institute

A B S T R A C T	K E Y W O R D S
Looking back over the years, we have a deeper understanding of the value of our independence. We are going through a period of complete renewal in education, a real transition to a new process and adaptation to it. The subject of non-viscous fluids is very important in teaching hydraulics to students. Non-viscous fluids do not experience internal friction. A non-viscous fluid is a fluid model, an idealized environment that is not found in nature or technology. However, this idealized environment is of great importance in the study of the laws of dynamics.	Hydraulics, viscosity, fluid dynamics, fluid motion, hydromechanics, fluid motion methods, Euler method, etc.

Introduction

Fluid dynamics is a branch of hydromechanics that studies the laws of fluid motion in relation to forces applied to it.

Problems of fluid dynamics under given external forces, kinematic parameters and stresses of movement from any point of the fluid at any instant of time, and hydrodynamic forces of the current acting on the body are determined.

In the movement of non-viscous fluids, internal friction forces do not occur, so there are no stress in the flow.

Normal stresses in non-viscous fluid motion have the properties of fluids at rest, i.e., their values at the considered point do not depend on the direction of action. Accordingly, the stress state of the moving non-viscous fluid can be characterized by the value of the normal stress at any point. Since this value does not depend on the direction of action, it is called pressure, just like a liquid in equilibrium.

A non-viscous fluid is a fluid model, that is, an idealized environment that does not occur in nature and technology. However, this idealized environment is of great importance in studying the laws of dynamics.

The use of solutions to some problems in the laws of non-viscous fluid motion in the calculation of real phenomena gives the results of an accurate representation of real phenomena. In addition, in some cases, the equations of non-viscous fluid dynamics serve as the starting source for deriving the equations of viscous fluid motion.

Differential equations of non-viscous fluid motion and their integration ρ having density, we look at the movement of a non-viscous liquid. Inside it are the edges of the coordinate axes dx, dy, dz, distinguish a parallelepiped parallel to dz (Fig.1). Proportional to the mass of liquid in the volume of the parallelepiped $\rho dxdydz$ mass forces and x we consider the action of surface forces of the burning liquid along the internal normal of the side of the parallelepiped along the axis.

According to the equilibrium conditions (§ 2.2) to this particle from the left side $pdydz,$ from the right side

$$-\left(p+\frac{\partial p}{\partial x}dx\right)dydz$$

pressure forces and $\rho dxdydz\cdot X$ are affected by mass forces.

In these expressions: p- pressure in the center of the left side; X – x acceleration of mass forces x projection on the axis.

Algebraic sum of projections of forces acting in the case of fluid movement, particle mass, its du_x/dt should be equal to the product of the projections of the acceleration of the movement, equal to the projections of the forces of inertia. Considering this,

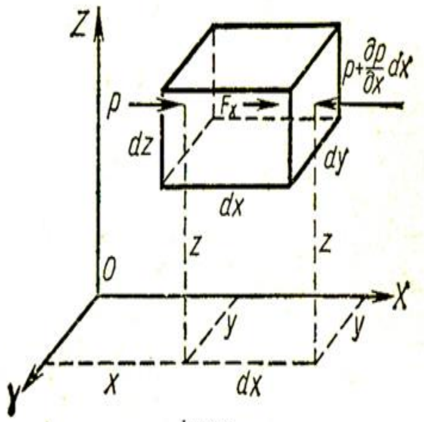
$pdydz-\left(p+\frac{\partial p}{\partial x}\right)dy\partial z+\rho dxdydzX=\rho dxdydz\frac{du_x}{dt}$ or after simplification

$$-\frac{\partial x}{\partial x}+\rho X=\rho\frac{du_x}{dt}$$ it is formed.

Likewise, y va z it is possible to create equations for the axes as well. Then the equations take the following form:

$$\left.\begin{aligned} X-\frac{1}{\rho}\frac{\partial p}{\partial x}&=\frac{du_x}{dt}\\ Y-\frac{1}{\rho}\frac{\partial p}{\partial y}&=\frac{du_y}{dt}\\ Z-\frac{1}{\rho}\frac{\partial p}{\partial z}&=\frac{du_z}{dt}\end{aligned}\right\} \qquad (1)$$

These are differential equations of non-viscous fluid motion. These are differential equations L.Eyler These are differential equations of non-viscous fluid motion. These are differential equations



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(1) there are four unknowns in the equations: p, u_x, u_y ,u_z . It follows that another equation is needed to solve this system, more precisely, a continuity equation. To integrate the Euler equation, it is necessary to make the following substitutions. These substitutions x let's look at the example of the equation for the axis. Given that velocity is a coordinate function of time and space in general, x We write that the

complete differentiation of the velocity projections on the axis is as follows:

$$du_x = \frac{\partial u_x}{\partial x}dx + \frac{\partial u_x}{\partial y}dy + \frac{\partial u_x}{\partial z}dz + \frac{\partial u_x}{\partial t}dt.$$

$\frac{dx}{dt} = u_x,\quad \frac{dy}{dt} = u_y,\quad \frac{dz}{dt} = u_z$ considering that they are, x for the bullet

Eyler equation

$X - \frac{1}{\rho}\frac{\partial p}{\partial x} = \frac{\partial u_x}{\partial t} + u_x\frac{\partial u_x}{\partial x} + u_y\frac{\partial u_y}{\partial y} + u_z\frac{\partial u_z}{\partial z}$ we create

$\frac{\partial u_x}{\partial y}$ va $\frac{\partial u_x}{\partial z}$ (2) components of the aggregate using special derivatives $\frac{\partial u_x}{\partial y} = \frac{\partial u_y}{\partial x} - 2\omega_z;$

$\frac{\partial u_x}{\partial z} = \frac{\partial u_z}{\partial x} + 2\omega_y;$ can be expressed by Then Eq

$$X - \frac{1}{\rho}\frac{\partial p}{\partial x} = \frac{\partial u_x}{\partial t} + \left(\frac{\partial u_x}{\partial x}u_x + \frac{\partial u_y}{\partial y}u_y + \frac{\partial u_z}{\partial z}u_z\right) + 2(\omega_y u_z - \omega_z u_y)$$

takes the form.

(3) Given the formula,

$\frac{\partial u_x}{\partial y} = \frac{\partial^2 \varphi}{\partial x dt}$ and change the expression in the parentheses above:

$$\frac{\partial u_x}{\partial x} + \frac{\partial u_y}{\partial x}u_y + \frac{\partial u_z}{\partial x}u_z = \frac{\partial}{\partial x}\left(\frac{u_x^2}{2} + \frac{u_y^2}{2} + \frac{u_z^2}{2}\right) = \frac{\partial}{\partial x}\left(\frac{u^2}{2}\right).$$

In it

$$X - \frac{1}{\rho}\frac{\partial p}{\partial x} = \frac{\partial^2 u_x}{\partial x dt} + \frac{\partial}{\partial x}\left(\frac{u^2}{2}\right) + 2(\omega_y u_z - \omega_z u_y)$$

will be.

$X = -\frac{\partial E_p}{\partial x}$ (§ 2.2 see), assuming that y and z we write the equations for the axes in the last form:

$$\left.\begin{aligned}
&\frac{\partial}{\partial x}\left(-E_p - \frac{p}{\rho} - \frac{u^2}{2} - \frac{\partial \varphi}{\partial t}\right) = 2(\omega_y u_z - \omega_z u_y);\\
&\frac{\partial}{\partial y}\left(-E_p - \frac{p}{\rho} - \frac{u^2}{2} - \frac{\partial \varphi}{\partial t}\right) = 2(\omega_z u_x - \omega_x u_z);\\
&\frac{\partial}{\partial z}\left(-E_p - \frac{p}{\rho} - \frac{u^2}{2} - \frac{\partial \varphi}{\partial t}\right) = 2(\omega_x u_y - \omega_y u_x)
\end{aligned}\right\} \quad (4)$$

Eyler equation I.S.Gromeka changed by, (4) displayed. In this form of the equation, the presence or absence of collective action is shown. [4]

The first equation to integrate Gromeka's equation dx, the second dy, the third dz to we multiply and add them by reversing the previous signs:

$$d\left(E_p+\frac{p}{\rho}+\frac{u^2}{2}+\frac{\partial\varphi}{\partial t}\right)=-2[(\omega_y u_z-\omega_z u_y)dx+(\omega_z u_x-\omega_x u_z)dy+$$
$$+(\omega_x u_y-\omega_y u_x)dz].$$

The right-hand side of this expression can be expressed as a qualifier:

$$d\left(E_p+\frac{p}{\rho}+\frac{u^2}{2}+\frac{\partial\varphi}{\partial t}\right)=-2\begin{vmatrix} dxdydz \\ \omega_x\omega_y\omega_z \\ u_x u_y u_z \end{vmatrix} \qquad (5)$$

The right-hand side of this expression can be expressed as a qualifier: $\left(E_p+\frac{p}{\rho}+\frac{u^2}{2}+\frac{\partial\varphi}{\partial t}\right)$ represents the law of change, that is, it connects the pressure, speed, and acceleration of the mass force with the acceleration of movement. (5) equation (4) you don't sleep like ($\omega_x=\omega_y=\omega_z=\omega=0$) and sloppy ($\omega\neq 0$) stable ($\partial\varphi/\partial t=0$) it will be appropriate for action. Unstable ($\partial\varphi/\partial t\neq 0$) in motion these equations are velocity potential and its $\partial\varphi/\partial t$ can only represent motion without friction when there is a derivative. The general integral of equation (5) is much easier to find for cases of non-viscous fluid movement when the right side of this equation is zero.

In it

$$E_p+\frac{p}{\rho}+\frac{u^2}{2}+\frac{\partial\varphi}{\partial t}=const \qquad (6)$$

and this expression Lagranj is called an integral. In private $\partial\varphi/\partial t=0$ in steady motion

$$E_p+\frac{p}{\rho}+\frac{u^2}{2}=const \qquad (7)$$

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This expression was introduced in 1738 by Daniil Bernoulli, an academician of the St. Petersburg Academy of Sciences, and is called Bernoulli's equation or integral. In particular, if only the force of gravity affects the acting mass forces, then $X=Y=0;$ $\qquad Z=-g=\frac{\partial E_p}{\partial z}.$

In it $\partial E_p=-gdz$ va $E_p=-gz+C.$

Taking these into account, Bernulli s equation takes the following form: $Z+\frac{p}{\rho g}+\frac{u^2}{2g}=C$.

(8)

(6), (7) and (8) expressions are appropriate only in cases where the right side of equation (5) is equal to zero, i.e.

$$\begin{vmatrix} dxdydz \\ \omega_x\omega_y\omega_z \\ u_x u_y u_z \end{vmatrix} = 0 \quad (9)$$

This condition is fulfilled in special cases, when some series or some two series of the determinant are proportional to each other. We will consider these cases separately.

1. Members of the first and third rows are proportional, i.e

$dx/u_x = dy/u_y = dz/u_z$

when the condition is fulfilled, the Bernulli equation is appropriate. This condition is fulfilled in streamlines. Accordingly, Bernulli s equation is appropriate along the flow line. The constant value of equation (7) is generally different for different streamlines.

2. Members of the first and second rows are proportional, that is, Bernulli s equation

$dx/\omega_x = dy/\omega_y = dz/\omega_z$

it is appropriate when the condition is fulfilled. This equation will be a set of cumulative lines. It follows that, $C_1, C_2, \ldots C_n$ Equation (8) is also valid for any number of constant lines.

3. The members of the second and third rows are proportional:

$\frac{\omega_x}{u_x} = \frac{\omega_y}{u_y} = \frac{\omega_z}{u_z} = a = const.$

Of these proportions

$$\omega_x = u_x a; \qquad \omega_y = u_y a; \qquad \omega_z = u_z a.$$

This is a line drawing of expressions

$$dx/\omega_x = dy/\omega_y = dz/\omega_z$$

by putting into the equation, the streamline equation

$dx/u_x = dy/u_y = dz/u_z$ we create In this view, the velocity and angular velocity vectors (their directions coincide) are parallel. Such movement is called screw movement. In the screw movement, particles move along the flow line (since the movement is stable, the flow line and the particle trajectory coincide), and at the same time, they are considered drift lines. The Bernoulli equation (7) can be applied in the screw movement of liquid at an arbitrary point.

4. The members of the second row of the determinant are equal to zero

$$\omega_x = \omega_y = \omega_z = 0$$

condition indicates that the action is non-static (potential).

For all points of the potential movement zone (7) Bernulli equation will be appropriate.

5. The third line of the determinant is equal to zero

$$u_x = u_y = u_z = 0$$

condition corresponds to the equilibrium state of the liquid. [2]

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