IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 4, April 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Fluid Hydrodynamics in Nano-Systems With Regard To Quantum-Mechanical Effects

Gabil Garibkhan oglu Aliyev
Doctor of physic-mathematical sciences, Professor

Head of the department of "Applied mathematics"
Tel.: (99455) 767-74-34 (моб),
Institute of Mathematics and Mechanics
Azerbaijan National Academy of Sciences
www.imm.az

Azad Gabil oglu Aliyev
Doctor of Economical sciences (PhD), **Assistant Professor ,**
Tel.: (99470) 316-32-59 (моб),
Azerbaijan State Oil and Industry University (ASOIU)
www.asoiu.edu.az

ABSTRACT

Mechanism of the parietal physical field effect existing between a solid and fluid in a lower-dimensional (nano-type) system is revealed; the dependence of the variability of the density of ideal fluid on the function of the electronic field in depth in a nano-type tube is suggested; the determining equations of hydromechanics of ideal fluid with regard the parietal physical field effect in lower-dimensional systems (nano-type) are established; the generalized Bernoulli equation with respect to parietal physical field effect is given; the essential quality and quantity effect of parietal physical field phenomenon on ideal fluid hydrodynamics in low dimensional systems was shown.

In the last decade in the world there is a great breakthrough in the field of nanotechnology and in development of electron-physical instrument engineering that allow to carry out extensive scientific studies of physical processes in molecular and atomic level. The problem of impact of physical fields on real media (liquid, gaseous, solid) is related to such a problem. This is dictated by the fact that there are such problems in natural science that they can not be described within classical physics and mechanics. In particular, the problem of hydromechanics of ideal and viscous liquid in nanosystems ($10^{-9}\,м \leq h \leq 10^{-4}\,м$) is related to quantum-mechanical effects that hold on the boundary of the contact "solid-liquid" and and its action impenetrated into liquid. They are: the phenomenon of formation of blank space Δ in the form of physical field in the boundary between a solid and liquid; the phenomenon of "adhesion-slipping" of liquid along the solid; the phenomenon of variability of physical-mechanical properties of liquid (density and viscosity) under the action of physical pole intensity $\tilde{E}(x)$ arising on the boundary of "solid-liquid".

In the paper we establish causality of the phenomenon of transubstantiation of homogeneous liquid into nonhomogeneous one in nanosystems that is connected with the quantity of density of action of impenetrated physical field intensity $\tilde{E}(x)$. A physical-mathematical model of dependence of variability of mechanical characteristics of the density $\rho(x)$ and viscosity $\mu(x)$ on the physical pole intensity $\tilde{E}(x)$ in a nanosystem is suggested in the form [1,2]:

$$\rho(x) = \rho_0[1 - \tilde{E}(x)], \quad \mu(x) = \mu_0[1 - \tilde{E}(x)] \tag{1}$$

where

$$\tilde{E}(x) = \frac{E(x)}{E_0}, \quad x_0 \le x < \frac{h}{2} - \Delta, \quad 0 \le \tilde{E}(x) < 1$$

Taking the above quantum-mechanical effects into account, a theory of hydrodynamics of ideal and viscous liquid in nanosystems ($10^{-9}\,м \le h \le 10^{-4}\,м$) was created.

On quality and quantity action of physical field intensity arising on the boundary of "a solid-liquid" in hydromechanics problems in nanosystems

Let us consider a nanotube of radius R_0 filled with liquid of volume V_0. We define the height to which the liquid in the pipe is elevated and also, how the characteristics of the mass of liquid changes at the expense of blank space between a solid and liquid and influence of variability of the density of liquid.

At the expense of influence of parietal physical field, the radius R_n of the liquid, the size of the blank space between the wall and liquid Δ, and also variability of the density of liquid will be equal to [1-4]:

$$\frac{R_{ж}}{R_0} = 0{,}88\,, \quad \Delta = R_0 - R_{ж} = 0{,}12 \cdot R_0, \quad \rho(x) = \rho_0[1 - \tilde{E}(x)] \tag{2}$$

Under these conditions we established the following new mechanical effects:

- at the expense of only blank space, the height of elevation of liquid in the tube will be $\Delta\ell_0 = 0{,}2913 \cdot \ell_0$, and the appropriate extruded mass will be $\Delta m_0 = 0{,}23 \cdot m_0$,
- the hight of elevation of liquid in the tube, arising only at the expense of variation of the density of liquid, will be $\Delta\ell_3 = 0{,}9685 \cdot \ell_0$, and appropriate extruded mass of liquid will be equal to $\Delta m_3 = 0{,}375 \cdot m_0$.

Thus, at the expense of total influence of quantum-mechanical effects, elevation of liquid along the length of the nanotube will be $\Delta\ell_{gen} = 1{,}2598 \cdot \ell_0$, and appropriate extruded mass will be equal to $\Delta m_{общ} = 0{,}605 \cdot m_0$.

Determining equations of viscous liquid hydrodynamics with regard to quantum-mechanical effects in nanosystems.

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 4, April 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Taking into account quantum-mechanical effects that hold between solid wall and liquid and their impenetrability into the liquid, the following generalized Navier-Stocks equations of motion of viscous liquid in nanosystems were suggested [1-2]:

- equations of motion of compressible viscous liquid in Cartesian coordinates:

$$\begin{cases} \frac{d\upsilon_x}{dt} = X - \frac{1}{\rho_0(1-\tilde{E})}\cdot\frac{\partial p}{\partial x} + \nu_0\cdot[\Delta\upsilon_x + \frac{1}{3}\cdot\frac{\partial div\vec{\upsilon}}{\partial x}] + + \frac{2}{3}\cdot\frac{\nu_0}{(1-\tilde{E})}\cdot\frac{\partial\tilde{E}}{\partial x}\cdot(div\vec{\upsilon} - 3\frac{\partial\upsilon_x}{\partial x}) \\ \frac{d\upsilon_y}{dt} = Y - \frac{1}{\rho_0(1-\tilde{E})}\cdot\frac{\partial p}{\partial y} + \nu_0\cdot[\Delta\upsilon_y + \frac{1}{3}\cdot\frac{\partial div\vec{\upsilon}}{\partial y}] - \frac{\nu_0}{(1-\tilde{E})}\cdot\frac{\partial\tilde{E}}{\partial x}\cdot(\frac{\partial\upsilon_x}{\partial y} + \frac{\partial\upsilon_y}{\partial x}) \\ \frac{d\upsilon_z}{dt} = Z - \frac{1}{\rho_0(1-\tilde{E})}\frac{\partial p}{\partial z} + \nu_0\cdot[\Delta\upsilon_z + \frac{1}{3}\frac{\partial div\vec{\upsilon}}{\partial z}] - \frac{\nu_0}{(1-\tilde{E})}\cdot\frac{\partial\tilde{E}}{\partial x}\cdot(\frac{\partial\upsilon_x}{\partial z} + \frac{\partial\upsilon_z}{\partial x}) \end{cases} \quad (3)$$

-a continuity equation of the form:

$$\frac{\partial\rho_0}{\partial t} + \rho_0\cdot[div\cdot\vec{\upsilon} - \frac{1}{1-\tilde{E}(x)}\cdot\frac{\partial\tilde{E}(x)}{\partial x}\cdot\upsilon_x] = 0, \text{ for } x_0 \le x \le \frac{h}{2} - \Delta, \quad 0 \le \tilde{E}(x) \le 1 \quad (4)$$

Here, for $x = x_0$, $\tilde{E}(x) = 0$; for $x_0 \le x \le \frac{h}{2} - \Delta$, $\tilde{E}(x)\big|_{x\to\frac{h}{2}-\Delta} = 1$; $\tilde{E}(x)$ is an experimentally given linear function; $\nu_0 = \frac{\mu_0}{\rho_0}$ is the coefficient of kinematic viscousity of liquid.

Motion of incompressible viscous liquid between two parallel plates in nanosystems.

A boundary value problem of laminar flow of incompressible viscous liquid between two fixed parallel plane walls that located at the distance h one from another ($10^{-9}\,м \le h \le 10^{-4}\,м$) will be in the form [2]:

$$\frac{d^2\upsilon_z(x)}{dx^2} - \frac{1}{1-\tilde{E}(x)}\cdot\frac{d\tilde{E}(x)}{dx}\cdot\frac{d\upsilon_z(x)}{dx} = -\frac{1}{\mu_0}\cdot\frac{1}{1-\tilde{E}(x)}\cdot\frac{\Delta p}{\ell}, \text{ for } x_0 \le x < \frac{h}{2} - \Delta \quad (5)$$

$$\frac{d^2\upsilon_z}{dx^2} = \frac{1}{\mu_0}\cdot\frac{dp}{dz}, \quad \text{for } 0 \le x \le x_0 \quad (6)$$

The boundary conditions:

$$\upsilon\big|_{x\to\pm(\frac{h}{2}-\Delta)} = L\cdot\frac{\partial\upsilon}{\partial x}\Big|_{x\to\pm(\frac{h}{2}-\Delta)}, \quad \upsilon_к^+ = \upsilon_к^- \text{ for } x = \pm x_0 \quad (7)$$

In this case, distribution of velocity of motion of viscous liquid in the slot of width h between two plane plates of thickness h will be in the form :

- in the thin layer ($0 \le x \le x_0$) in the form:

$$\upsilon(x) = \frac{\Delta p}{2\mu_0 \cdot \ell} \cdot h^2 \cdot [\frac{x_0^2 - x^2}{h^2} + 0,3881 \cdot (1 - 2,27 \cdot \frac{x_0}{h}) \cdot (1 + 2,27 \cdot \frac{x_0}{h} + 2,27 \cdot \frac{L}{h})] \quad (8)$$

- in the thin layer ($x_0 \le x < 0,44 \cdot h$) in the form:

$$\upsilon = 0,1941 \cdot \frac{\Delta p}{\mu_0 \cdot \ell} \cdot h^2 \cdot (1 - 2,27 \cdot \frac{x_0}{h}) \cdot (1 + 2,27 \cdot \frac{x}{h} + 2,27 \cdot \frac{L}{h}), \quad (x_0 \le x < 0,44 \cdot h). \quad (9)$$

Hence it is seen that the flow of viscous liquid in the slot is a flow of stratified liquid. The character of distribution of height velocity was established in the form:

$$\upsilon(x_0) = 0.8573 \cdot \upsilon(0) < \upsilon(0) < \upsilon(0,44h) = 1,1434 \cdot \upsilon(0). \quad (10)$$

Secondly, it was established that quantum-mechanical effects in nanoslot twice increase the mean velocity of the motion of liquid compared with its classic value, i.e. $\tilde{\upsilon} = 2,049 \cdot \tilde{\upsilon}_{кл}$.

References:

1. Aliyev G.G. Theoretical principles of hydrodynamics in low- with regard to influence of equembum-mechanical effects dimensional systems. LAMBERT Akademic Publishing, ISBN 978-3-659-93313-4, Germany, 260 стр. 2016 г.

2. Aliyev G.G, Aliyev A.G. «Fundamentals of Hidromechanics of Ideal Fluid in Nanotupe Systems». Internation Journal of Applied and Fundamental Recearch -2016-№4,Deutschland/Германия. URL: www. science-sd. com/466-25058.

3. Lauga E., Brenner M.P. Store H.A. Microfluidics: the no-slip boundary condition / Springer in Handbook of Experimental Fluid Mechanics (edited dy Tropea C.,Yarin A.L., Foss J.F.). New York: Springer, 2007. -1557 p.

4. Kotsalis E.M., Walther J.H. Koumoutsakos P. Multiphase water flow inside carbon nanotubes. Internation Journal of Multiphase Flow, 30, 2004, p. 995-1010.