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Study of Gas-Liquid Displacement in a Pipeline with a Swirled Flow

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ABSTRACT: In the article the question of studying the swirling flow in the technological pipeline. Studied the nature of the flow of swirling flow. The experimental velocity distribution and the pressure inside the pipe with a swirling flow in graphical and tabular form. Scope - displacement of the liquid and gas to the purification of natural waters by means of ozone and chlorine.

KEY WORDS: wirling flow, natural water treatment, axial and rotational speeds, radial gradient of static pressure, overpressure.

I.INTRODUCTION

The swirling of the flow at the inlet to the pipe leads to the appearance of a rotational component of the flow velocity and the formation of a field of centrifugal mass forces, which have a significant effect on the flow structure[1].

An analysis of the axial V_z profile and rotational V_φ velocity shows that swirling flows in the pipe are a complex structure with a continuous character of changing local parameters along the pipe section. Such a flow contains simpler elements of the structure of water movement - the region of the near-wall flow, the near-axis region of the reverse flow and the zone of circulation flow located between them[2].

The maximum values of the axial and rotational velocities in the region where the flow swirl intensity is significant are located in the peripheral region of the pipe and are 2-3 times higher than the average flow rate V_{cp},tab.1,fig.1. With an increase in X to 1.9 m (the X is the distance from the swirl to the measurement point) due to the action of friction forces, a decrease in the twist intensity occurs, which leads to the transformation of local parameters. The axial and total velocities with decreasing swirl in the peripheral region decrease and increase in the axial region, the reverse flow region gradually degenerates, transforming into a "dip" characteristic of the flow behind a poorly streamlined body. Thus, there are simultaneously flow regions in the pipe with negative (in the peripheral zone) and positive (in the axial region) longitudinal velocity gradients. The interaction of regions of the opposite gradient is manifested in the continuous "suction" of the gas mass from the peripheral zone of the flow to the near-axis.

The profile of the rotational velocity is characterized by sharply expressions of growth in the region of the near-wall flow, a monotonic increase to a maximum value at a certain radius, and a decrease to zero on the channel axis. As the swirl attenuation decreases, the rotational speed decreases, and in the initial sections, the decrease is more pronounced in the peripheral region of the pipe, and further in the central region, which leads to the gradual degeneration of the maximum rotational speed. With a decrease in the spin intensity, the radius of the maximum value of the rotational speed decreases in absolute value, reaching a value equal to $\bar{r}$=0,35÷0,37, and then it completely degenerates.

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Table1

Change in v_z and v_φ along the radius of the pipe at Q = 40 l/min, d = 50 mm, X = 1.0 m

The distance from the pipe wall to the measuring point, mm	Pressure P, МПa	Reynold's number, R_l $1 \cdot 10^4$	Axial speed v_z, m/s	Rotational speed v_φ, m/s	Average speed v_{cp}, m/s
2	0,41	7,0	1,38	1,37	1,38
4	0,38	7,2	1,49	1,45	1,51
6	0,32	7,5	1,71	1,72	1,75
8	0,37	7,25	1,51	1,53	1,55
10	0,36	7,3	1,54	1,52	1,54
12	0,40	7,1	1,43	1,40	1,50
14	0,35	7,33	1,58	1,56	1,59
16	0,37	7,25	1,51	1,50	1,56
18	0,33	7,47	1,62	1,65	1,66
20	0,39	7,15	1,47	1,42	1,52
22	0,40	7,1	1,43	1,33	1,44
25	0,41	7,1	1,38	1,37	1,41

A distinctive feature of the interaction of the three flows is the appearance of a radial gradient of static pressure, Fig. 1, which is associated with the appearance of the rotational velocity component. With a significant swirl of the flow, there are areas of positive and negative overpressure and a significant pressure drop is observed between the pipe wall and its

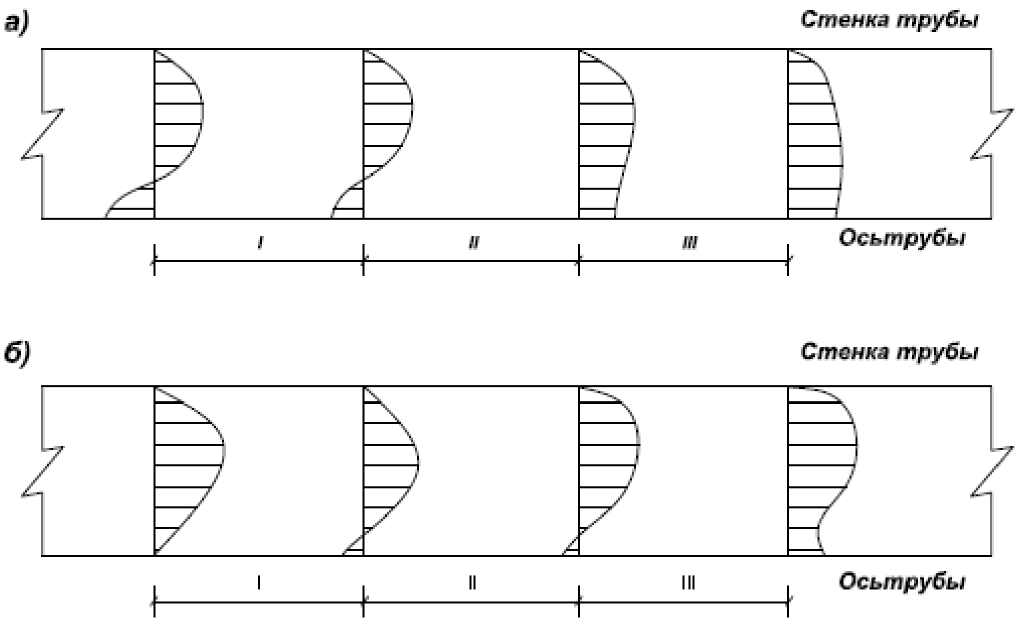

*Рис. 1 Распределение осевой (а) и вращательной (б) скорости по радиусу трубы, при d= 50 мм, Re= 1,2 * 10⁵*

axis.

When the swirl attenuation, the excess static pressure in the peripheral region of the pipe decreases, and in the axial increases, the radius of its zero value is gradually shifted to the axis of the pipe, which leads to equalization of the pressure profile.

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Thus, a direct gas flow with opposite longitudinal gradients of static pressure is formed. Unlike axial flows, the signs of the velocity and pressure gradients correspond to each other.

The nature of the transformation of the total overpressure shows that when the swirl attenuation decreases, the value of P at the pipe surface decreases, P = 0.11-0.2 MPa, and in the near-axis region it increases to 0.25 MPa, while the region of an approximately constant value of P continuously expands.

The swirling flow in the pipeline can be divided into three sections, Fig. 1, the first of them directly adjoins the tangential water supply zone. The flow structure in this section is determined.

A characteristic feature of the second section is that the flow structure is practically independent of the type of swirl and is determined only by the intensity of the swirl, which decreases as the section under consideration moves away from the swirl.

In the third zone, features caused by swirl disappear in the flow, and it turns into a normal axial flow with a developed velocity profile. Therefore, the total length of the zones can be considered as the hydrodynamic initial section of the swirling flow.

Thus, in the apparatus for displacing liquid and gas [3], the presence of an additional swirl chamber allows one to intensify the mixing of liquid and gas, create a stable gas-liquid phase for the time necessary for almost complete saturation of the liquid with gas, which is necessary when processing natural waters.

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