The content of undissolved air in the water ducts

Arifdjanov A.M.
Abdujapparov S.К.
D.of.S., professor

Annotation
The water supplied through the pressure ducts always contains a certain amount of undissolved gases, a mixture of which is conventionally called the general term “air". This air enters the ducts through leaks in the pipe connections in the suction line to the pumps or in separate siphon sections operating under vacuum. Air is also sucked through the pump seals on the suction side, remains in the pipes when they are initially filled with water or when filling the pipes after repairs. A lot of air enters the water ducts together with water through water intakes, especially on rough mountain rivers. In addition, it is known that a large amount of gases contains groundwater.

Keywords: pressure pipeline; hydraulic calculation; air bags; critical water flow velocity; absolute pressure

It is very difficult to determine the volume of undissolved air in the water of the aqueducts accurately enough, since it depends entirely on local specific conditions. In addition, the volume of undissolved air along the length of the conduit is constantly changing, since, depending on the pressure in the pipes and the temperature of the water, it contracts or expands, dissolves in water or vice versa is released from the water.

The literature provides data on the amount of undissolved air in the water of water ducts, but they are, as a rule, extremely contradictory.

Depending on the mode of operation of the conduit, the profile of its laying and the speed of water flow, the undissolved air in the conduit may be in different positions. In the horizontal sections of the conduit, the undissolved air, both during the flow of liquid and in the absence of flow, is mainly in the form of small bubbles in the upper part of the pipe.

Of the greatest interest is the study of the positions of undissolved air in pipes with water on rough terrain in the presence of elevated tipping points of the profile. In the absence of water flow, air accumulates on the peaks. When water flows at a relatively low speed (less than the so-called “critical”), air collects in clusters (air bags), which can be located both on the tops of profile fractures and on the descending branches of pipelines. At water flow rates exceeding critical values, air accumulations move along with the water and are carried out of the pipes by the water flow.

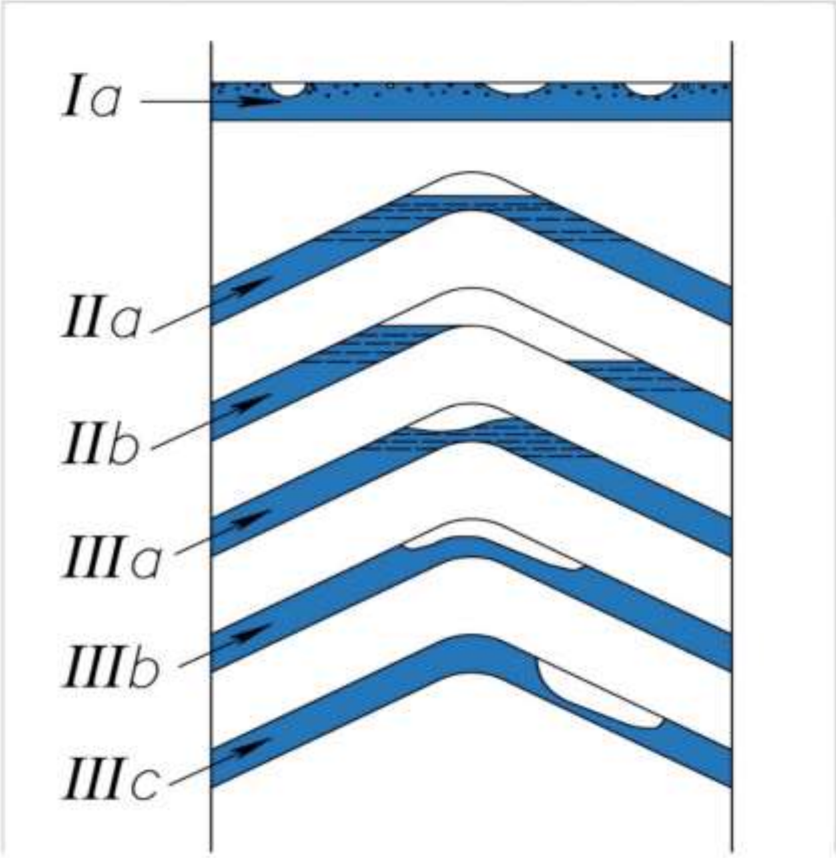

Fig. 1. The positions in which the undissolved air in the water in the water ducts is located: in horizontal with the flow of liquid (I); in rough terrain at elevated tipping points of the profile in the absence of flow (II a and II b); in rough terrain and the flow of liquid at a low speed (IIIa and IIIb); then the same with high speed - an air cluster on the descending branch (III c)

Thus, one of the main tasks of the study is to determine the critical velocity of water flow under different conditions, when exceeding which air accumulations lose their equilibrium on the tops or descending branches of pipelines and are removed from them by flowing water.
The question arises, what kind of damage is caused by the presence of undissolved air in the pipelines. It depends primarily on the condition of the air.
If the air is transported through the conduit in the form of small bubbles and is not collected in clusters, i.e. the water flow rate is less than critical, then its presence has little effect on the operation of the conduit. If there are air bubbles in the water, the water supply through the conduit is reduced by the amount Q, which can be determined by the formula:

$$Q = b_1 M_a \%, \qquad (1)$$

where b1 is the coefficient of reduction of water supply through the conduit, determined on the basis of hundreds of experiments in the laboratory and is on average from 70 to 100;
Ma is the number of volumes of air in water at absolute pressure in the pipeline, per volume of a mixture of water and air at the same pressure,

$$\mathrm{M}_a = \frac{q_1}{Q_1+q_1} \qquad (2)$$

q 1 - air flow at absolute pressure in the pipeline q1 = qa/Pa;
qa - air flow at atmospheric pressure;
Pa is the absolute pressure in the pipeline, i.e. taking into account atmospheric pressure, ata;
Q 1 - water flow in the pipeline.
Calculations using the formula (1) show that the reduction in the flow rate of the supplied water due to the presence of air at its content of no more than 5% does not exceed 2-3%, i.e. taking into account this circumstance has no practical significance, since the determination of the flow rates in the ducts is made with an accuracy of 5%.
Pressure losses in water ducts in the presence of air bubbles in the water can be determined by the formula of V.I. Gotovtsev :

$$\frac{h_{\text{см}}}{h_{\text{см}}} = 1 + \frac{1{,}11 m_a}{1-0{,}11 m_a} \qquad (3)$$

где $h_{см}$ - потери напора в трубопроводе при наличии в воде воздушных пузырьков, м.вод.ст.;
$h_{вод}$ - то же при течении одной воды, м.вод.ст.;
m_a- воздухосодержание, т.е. расход воздуха q_a, принятый при атмосферном давлении и отнесенной к расходу воды в трубопроводе q_1.
Расчеты по этой формуле также показывают, что увеличение потерь напора при малых воздухосодержаниях очень незначительно и не имеет практического значения.

Conclusions
Thus, the presence of small air bubbles in the water pipes does not essentially affect the operation of the conduit. moreover, it is shown below that undissolved air significantly reduces the speed of propagation of waves of hydraulic shock, and, consequently, reduces the amount of additional pressure that occurs with such a formidable phenomenon as hydraulic shock.

Literature
1. Dikarevsky V.S. On the effect of undissolved air on water consumption and energy loss in pressure ducts. / Collection of works of LIIZhT. Water supply, sewerage, hydraulics, issue 185. Under the general editorship of Prof. A.A.Surin. - L.: LIIZhT, 1962. - pp. 106-122.
2. Dikarevskiy V.S. Vodovody, 1997.-pp.40-43.
3. Dikarevskiy V.S. Removal of air accumulations from pipelines by flowing liquid. / Sat. Liizhta. issue 158. Questions builds. and operation. railways. - M.: Transzheldorizdat, 1958. - pp. 47-54.