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The rise of the liquid due to the relative velocity of the phases with different densities, as well as a complex of gas bubbles

Depending on how deeply and correctly the physical essence of the process of liquid lifting is understood, it is possible to formulate the main directions for its study and requirements for practical implementation. Despite a huge amount of work in the theory and practice of lifting fluid from wells, researchers do not have a single point of view on the physical nature of this process. Therefore, we will briefly discuss the existing points of view about the main reason for the rise of liquid in vertical pipes.

D. Versluis (1930) believes that "some source of energy is needed for lifting, and this source of energy is the expansion of the gas in the lifting tube. We will not touch here on the question of how the work done by the expanding gas causes the liquid and gas to rise; we will only assume that the expansion of the gas when it is raised from the bottom to the mouth is the main source of energy that causes the mixture to rise."

Indeed, when gas is compressed in a compressor, part of the energy is lost irrevocably, while the other part is spent on changing the volume of gas (compression). The expansion of the compressed gas will occur at the expense of the energy spent on its compression, that is, the energy of the compressed gas can be spent on its expansion.

The other side of the question is what phenomena can occur in the system in which the compressed gas is located during its expansion? Based on the point Of view of D. Versluis, it follows that if there is no expansion of the gas when it rises from the bottom to the mouth, then the main source of energy that causes the mixture to rise also disappears. Moreover, liquid lifting is also impossible when using other incompressible working agents (for example, liquid or solid).

Let's say there is a pool of water with a density of p. The vertical pipe A is lowered to a depth of h1, (figure 1). With this immersion h1, under the level: h1= const, and the pressure in the cross section is 1-1

$$P_1 = h_1 \rho g . \qquad (1.1)$$

Let an incompressible, insoluble liquid with a density of P1 be fed through the tube B in section 1-1 to the tube A $\rho_1 < \rho.$

At a certain flow rate of a liquid with a density of p, the average density of the mixture PCM in the pipe A (figure 1 b) will be so much less than P1 that the mixture rises to a height of HP to a cross section of 2-2. Considering the friction losses of the mixture to be negligible, we can write the following condition:

$$P_1 = \rho_{см} g \,(h_1 + h_{п}). \qquad (1.2)$$

With a further increase in the flow rate of liquid with a density of P1, the mixture begins to pour out of the pipe A in section 2-2, located above the water level in the pool at a height of HP. In the example considered, the water is raised to the height HP without using the energy of the expanding gas. This convinces us that the working agent can serve as an incompressible insoluble liquid of lower density than the lifted one.

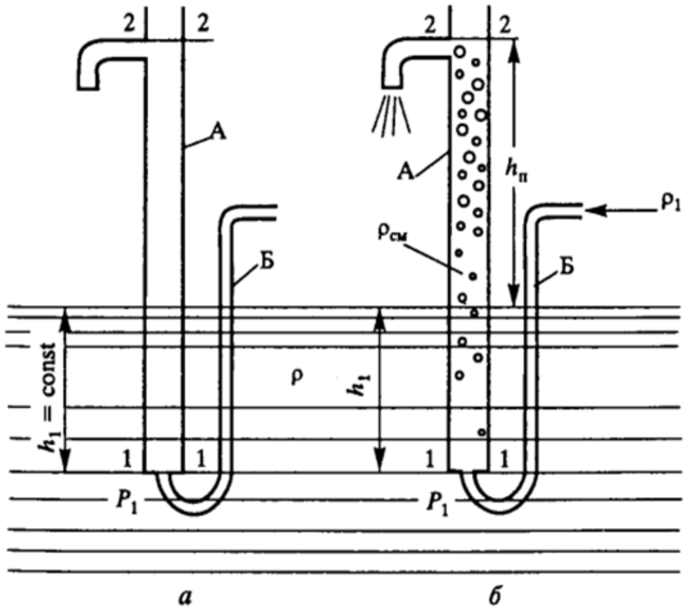

Figure 1.1. Physical essence of the liquid lifting process

The effect of lifting the liquid to the height HP can be obtained in the case of using a solid body with a density P2 < p instead of liquids (for example, solid polyethylene balls of small diameter). Reasoning similarly to the above, we come to the conclusion that the process of lifting the liquid can also be carried out by a solid working agent.

Thus, the rise of the liquid can be produced by a liquid or solid working agent, which does not allow us to consider the energy of the expanding gas as the main reason for the rise of the liquid in any case. If compressed gas is used as the working agent, then when it expands, the volume of the liquid-gas system in the lifting pipes increases, which leads to a decrease in the density of the mixture and its rise to a certain height.

Indeed, air, mixing in unlimited proportions with the liquid in the form of separate large and small bubbles, in the form of foam, and finally in the form of saturated steam, is an excellent means for using it in lifts to reduce the specific weight of the liquid. For the air used, it is only necessary to compress it to the required pressure and bring it to the base of the lifting tube, where it will enter it and mix with the liquid, reducing its specific gravity. The air lift is built on this principle."

$$V = \frac{\pi d^2}{4} h. \quad (1.3)$$

Let's introduce a working agent into the liquid by volume (the working agent can be gaseous, liquid, or solid). The introduction of the working agent is associated with the displacement of the liquid in the volume, i.e. the liquid rises by an amount, and:

$$\Delta h = \frac{4V_{\Lambda}}{\pi d^2}. \quad (1.4)$$