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ACOUSTIC CAVITATION AND ITS EFFECT ON HEAT EXCHANGE

Heat exchangers the most common devices in all forms and types of energy and mass transfer systems. Heat exchangers are widely used in many fields of energy, commercial, aerospace, chemical, oil refining, food processing, refrigeration and cryogenic technology, heating, hot water and air conditioning. Therefore, it is necessary to strive for the heat exchanger to provide, if possible, the highest heat transfer parameters.

Currently, there are two main directions of intensification of heat exchange through the wall: the development of the heat transfer surface and the increase of thermodynamic characteristics of the coolant. However, it is not always possible to increase the heat transfer area.

The main thermodynamic characteristics of the heat carrier, which determines the efficiency of the heat transfer, include: temperature and velocity near the heat transfer surface. Their increase also makes it possible so increases the heat flux. However, as in the case of ribs, this direction of intensification of heat exchange has a number of limitations.

One of the promising ways to intensify heat exchange may be the use of ultrasound [1].

Ultrasound is oscillation, the frequency of which lies above the threshold of hearing of the human ear, that is, above 20 kHz [2].

Under the action of ultrasound in the liquid, there are the following effects: heating due to scattering of acoustic energy, acoustic cavitation, acoustic currents, acoustic source and sputtering.

The two main effects affecting heat transfer are cavitation and acoustic streaming [3].

Cavitation represents the process of unstable change in the size of the vapor-gas bubbles at the alternating pressure in the liquid [4]. Let's consider in detail the process of cavitation in a liquid, which is depicted in Figure 1 [5].

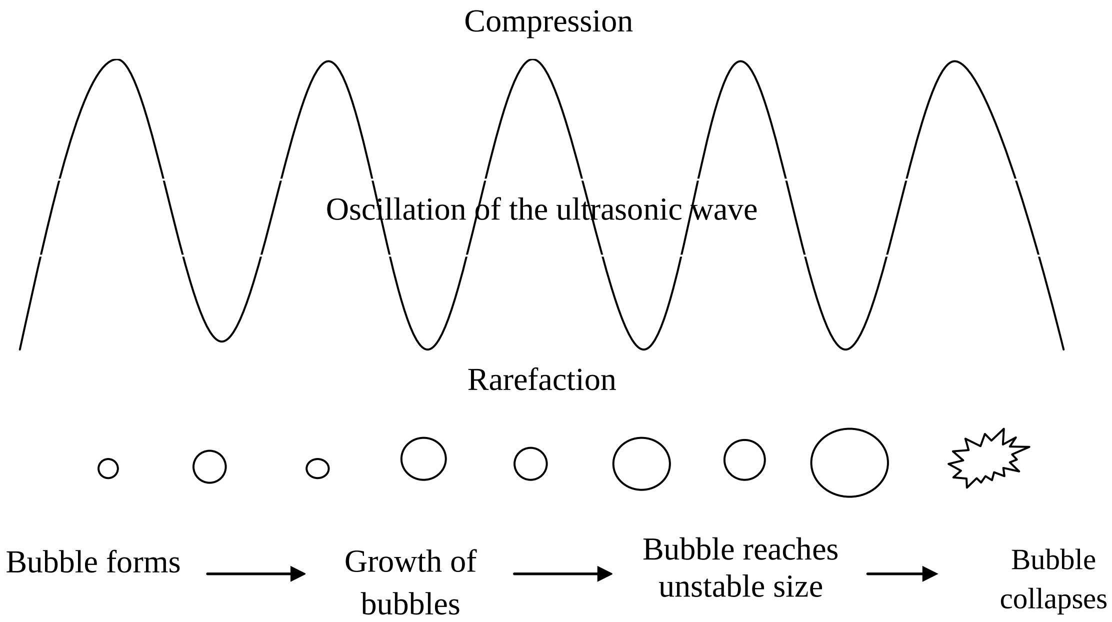

Figure 1 – Formation, growth and closure of bubbles

The liquid operates ultrasound of low intensity. Ultrasonic wave, passing through the liquid, creates zones of compression and a zone of discharge, which changes in places every half-wave of a wave.

With an increase in intensity up to 10000 W / m^2 there will be a violation of the homogeneity of the liquid. In the phase of discharge (low pressure) in the most "weak" places begins the allocation of dissolved gases with the formation of bubbles [6]. These "weak" places are called cavitation's embryos.

Existing bubbles under negative pressure begins to waver. The instantaneous pressure is reduced to such an extent that bubbles cannot remain stable, so they increase their volume to a new equilibrium value. When fluctuation bubble size increases and grows until, then grow until it reaches a critical size known as its resonance size. The resonance size of a bubble depends on the frequency of the ultrasound.

The resonance radius of the bubble can be found by the formula

$$R_p = \sqrt{\frac{3 \cdot \gamma \cdot p}{\rho \cdot \omega^2}}, \qquad (1)$$

where $\gamma = \frac{c_p}{c_v}$ – the specific heat of gas inside the bubble;

p – pressure of the liquid, Pa;

ω – angular ultrasound frequency, c^{-1} [5].

There are two possibilities, after the bubble has reached resonant size: the bubble continues to oscillate within the resonant size (stable cavitation) or the bubble is slamming (unstable cavitation) [7].

When the cavitation bubble is closed, a shock wave arises that creates a huge pressure. If a shock wave encounters an obstacle on its way, it destroys its surface [8].

Consequently, this explains why cavitation is an important phenomenon for the intensification of heat transfer through ultrasound. Clogging the bubble near the boundary between the solid surface and the liquid destroys the thermal and high-speed boundary layers that prevent the transfer of heat from the liquid to the wall, thereby reducing the thermal resistance and creating microturbulence.

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