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**TO THE THEORY OF CAVITATION REACTOR**

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This work defines the role of cavitation reactor with a harmonious wave energy source among processes and devices for cavitation treatment of liquids. It is shown, that in a cavitation field an interference effect takes place with respect to a total pressure pulse which arises at superposition of fields of separate bubbles. Therefore cavitation energy allocated in a reactor is always distributed non-uniformly. It is shown by the example of the mathematical model of a cavitation field. With the purpose of model testing exothermal effect of reaction of autohydration of water is investigated. Sufficient coincidence is obtained. The observable phenomenon is the result of “epithermal” change of thermodynamic balance of water treated with cavitation.

There is a specialist opinion in the field of acoustic cavitation, that the total pressure pulse generated by ensemble of cavitation bubbles in a multibubble reactor, can be increased by augmentation of the pulse generated by each separate bubble, synchronization of a collapse of bubbles among themselves and increase of hydrostatic pressure [1]. With respect to the first it can be made by synchronization of a collapse with the end of a half-cycle of harmonic pressure compression. Remaining raises the doubts. As bubbles in cavitation field are dispersed in space, an interference effect takes place with respect to total pressure pulse originating at a superposition of fields of separate bubbles.

The mathematical model of a cavitation reactor describes allocation of an average cavitation energy density $w$ [J/m$^3$] on a reactor section, which makes it possible to control cavitation process. In [3] combinatorial functions are utilized for this purpose. In conditions considered here an expression of cavitation energy allocated during harmonic pressure period in a point of a reactor space with $n$ cavitation fields looks like:

$$w = \frac{N^2 \lambda^2}{a^2 \rho^2} \frac{\beta}{2} \left( \frac{\rho}{\lambda} - \left\lfloor \frac{n}{2} \right\rfloor \right)^2 - \left( \frac{\rho}{\lambda} + \left\lfloor \frac{n}{2} \right\rfloor \right)^2,$$

where: $a$ - average harmonic value of distances between the arbitrary point and all points of surfaces of crests of pressure visual from it; $\rho$ - average arithmetical distance between the arbitrary point and all surfaces of all crests of harmonic pressure visual from it; $\beta$ - adiabatic compressibility of fluid $r_0,p_0$ - equilibrium radius of a bubble and pressure on its border, accordingly.

As shown in [2], when a bubble collapse contemporizes with the end of a half-cycle of harmonic pressure compression, cavitation effect practically does not depend on total energy alterations spread in a reactor. That is, at a variation of harmonic pressure voltage a significant kinetic energy variation and little significant potential energy variation occurs. Therefore it is possible to consider, that the amount of energy necessary and sufficient for fluid impact in these conditions depends only on duration of action $\tau_1$ and a relaxation time of a non-steady state of this fluid $\tau_c$.

As the mechanism of power transmission, for example, in water at cavitation impact has an epithermal character, therefore, for example, dissociation degree of the electrolytes dissolved in it will increase as contrasted to thermodynamic balanced water which is determined by hydration ability of water in standard conditions. Generated “exuberant” ions, gaining sheaths of solvent molecules from not structured water, become complex that hinders their fast recombination and allows water to reserve and save energy for some time.

If we consider electric conductivity as a standard of mineralization level of water, increase of dissociation degree of molecules of salts under cavitation energy impact should appear as apparent temporal augmentation of $\Delta C$ level. The degradation of a parameter $\partial C = \Delta C/C$ in solutions of electrolytes has been investigated experimentally with the help of the conductometric canal of an Anion 7051 device (INFRASPAK, the Russian Federation). By approximation of processing effect of solutions of salts of $A^+B^–$ type with an ionic bonding at processing frequency of 22 $kHz$ the following expression was obtained:
where: \( a \) - a constant depending on initial salt content; \( \alpha \) - a vector, which dimension \( k \) and \( j \) elements values depend on initial salt content and selected error of approximating.

Point set of experimental dependences, for: \( \tau_1 = 3 \text{ sec.} \), \( \tau_1 = 10 \text{ sec.} \), \( \tau_1 = 30 \text{ sec.} \) and \( \tau_1 = 90 \text{ sec.} \) and approximating degradation functions \( \partial C = f(\tau, t) \) are shown in Figure 1 (lines 1, 2, 3 and 4, accordingly).

It is possible to suppose, that function \( \partial C \) shows with adequate accuracy, how should the level of electrolyte be reduced in water solutions treated with cavitation during period of time \( \tau_1 \) so that after period of time \( \tau_2 \) this level corresponds to the given level of electrolyte on electrical conductivity.

Sonoluminescence phenomenon as researchers of sonoluminescence [4] report is stipulated by gas-vapor reactions in cavitation bubbles. A surveyed phenomenon of cavitation dissociation of electrolytes, as well as dissociation of water molecules on ions which results, for example, in hydrogen dioxide synthesis, can originate completely in a fluid phase. Dissociation energy of water molecules is 57 kJ/moles, and energy of vaporization is 44 kJ/mole.

Even less power-intensive metamorphosis of water - its declustering (molecular hydrogen bond opening) - was investigated with the help of Brookfield LVDV-III rheometer (Br. Eng. Lab., USA). Thus water was considered as a disperse system which medium is not structured amounting, a phase - structured. It was necessary also, that at temperature of vaporization in adiabatic conditions all volume of water is declustered, and within the temperatures range 0°C ... +4°C water contains a maximum of the structured phase. Then, if dependence of viscosity \( \eta \) on an interrelation of volumes of a phase and medium submits to the Einstein-Smolukhovsky equation [5], with implying from this equation immobilization quotient value for water equal to 0,4 (\( \eta_{\text{max}} / \eta_{\text{min}} - 1 \) \( \approx \) 2), it is possible to note expression for the contents of not structured phase depending on a temperature of water:

\[
C_i = 1,2 - 0,2\eta_i / \eta_{\text{min}} \tag{4}
\]

The obtained quotient 2 shows that each molecular of water immobilizes another molecular, that is, they remain bound to each other by a hydrogen bond even at maximal temperature of water in liquid state.

Brookfield LVDV-III rheometer does not have an automatic temperature compensation. Therefore for distillate of water with electrical conductivity of \( 1,5 \times 10^{-3} \text{ Cm/m} \) in volume of a reactor the performance of an inverse relation of the mechanical moment on a measuring spindle to temperature \( f^{-1}(t_{M}) \) has been found by practical consideration. As a hydrogen bond opening provides two active centers: a donor and an acceptor, with consideration of immobilizing quotient, mass water content, capable to react hydrations, is evaluated from the expression:

\[
C = 4(C_{\text{max}} - C_i) \tag{5}
\]

Where: \( \Delta t = t_{M} - t_{M_0} \); \( M_0 \) - the mechanical moment on a measuring spindle in water at a thermodynamic equilibrium. Data and evaluations obtained with formulas (5-6) of autohydration of water in the above reactor after cavitation treatment during 10 sec., 30 sec. and 90 sec. (curves 1, 2 and 3, accordingly) are given in Figure 2. According to (2) it is possible to calculate values of potential
cavitation energy dissipated in distilled water \((r_0 < 1 \mu m)\) amounting ~ 5, 15 n 45 kJ, accordingly. Water in experiments was heated up no more than by 1,5…2,0°C which can serve as an acknowledgement of epithermal mechanism of energy transmission.

With the purpose of checking the obtained outcomes by the law of conservation of energy heat effect of reaction of autohydration of water has been investigated. For this purpose at an ambient temperature of a room \(t_{\text{min}} = +18,0^\circ\text{C}\) water in a reactor by means of the conductive heating accompanying with cavitation impact of different duration and without it, was lead up to temperature \(t_{\text{max}} = +35^\circ\text{C}\), and then exposed to spontaneous refrigerating in equal thermodynamic conditions of heat convection with air up to +18,1°C. The trend of temperature was measured with accuracy 0,1°C.

Parameters \(\Delta t = (t - t_0)/t_0\) were evaluated, where \(t, t_0\) - current value of temperature of a sample of water subjected to cavitation treatment, and water heated without cavitation treatment, accordingly. Using a known dependence of a calorific capacity of water at constant pressure \(c_p\) from its temperature, values of “excess” energy discharged by water during reaction of autohydration were computed as:

\[
W = \left(\frac{t}{t_0} - 1\right)m \int_{t_{\text{min}}}^{t_{\text{max}}} c_p \, dt,
\]

where: \(m\) – water mass in a reactor. They amounted to: 5 kJ for the sample treated with cavitation during 10 sec., 18 kJ the sample treated with cavitation during 30 sec. n 24 kJ for the sample treated with cavitation during 90 sec. Considering the established immobilization it corresponds to 12, 33 and 42 per cent of water by mass in samples, involved in hydration reaction.

Apparently, the concurrence of outcomes to the conforming outcomes of viscosity valuation researches (Figure 2) appeared accurate enough, in spite of the fact, that owing to methodical difficulties and the limited periodicity of viscosity measurements, measurements were taken only a minute later the end of cavitation treatment. The values obtained from the equation (2) are less as they are valid only for isothermal conditions and do not take into account dissipation of energy on a reactor body, however nevertheless they are close to empirical. The disproportion of energy and time of action in the experimental conditions, distinguishing it from the model, is also illustrated by \(p_0\) value alteration accompanied by change of water temperature. Pictorial interpretation of the investigated process is given in Figure 3 where curves 1, 2 and 3, and also smoothed point cloud correspond to a 10 sec., 30 sec. and 90 sec. cavitation treatment of heated water near to temperature \(t_{\text{max}}\).

Interpreting the outcomes of the above researches the author decided to write this paper which can help understand some information published on this issue, which sometimes has a pseudoscientific character.

The polemic publications devoted to “hydrodynamic heat-generator” do not descend from the periodical press. This generator, on an intention of its originator, was designed for use in the capacity of a heater in the hot-water
heating with low temperature of the heat-transfer medium. The sensation has arisen as a result of detection of apparent disharmony of amounts of energy expended on water heating and energy returned by water into hot-water heating. Improper interpretation of a phenomenon has induced its discoverer to vain searches of traces of thermonuclear processes, as if accompanying conversion of cavitation energy and even has generated imaginations about any mysterious energy ostensibly made in water or in bubbles.

In fact an observable phenomenon is only at outcome of water properties variation as of a heat-transfer medium owing to processes of regeneration of the thermodynamic equilibrium dislocated by epithermal impact of cavitation energy on cluster structure of water formed by hydrogen bonds.

REFERENCES

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