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THEORETICAL ASPECTS OF FORMATION AND DEVELOPMENT OF CAVITATION PROCESSES IN TECHNOLOGICAL ENVIRONMENT

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Summary. The operation of a technological process under cavitation as a way of processing a dispersed environment. It is determined that the physical properties of the process medium have a decisive influence on the optimal modes of a technological process and conditions for the spread of vibrations carried through rheological properties. Features of signs of the environment of processing are called the loading mode to the emitter, the physical characteristics and conditions of impact on the emitter. It is assumed that electrical energy is converted into acoustic oscillations and radiation energy. The working environment must be such so that the radiator has to ensure the most efficient input of energy in coordination with the forces of resistance in this environment. This reaction is a response to the power operation system. Depending on the degree of absorption at the wave reflected from the boundaries of the volume occupied by the environment, and the environment itself, and the number of reflections and phase shifts the reaction to the emitter can be different. Is necessary to agree actual load of the process fluid to the radiator, which is performed on the basis of a solution of the contact problem of the interaction of these subsystems, which are subject to a single wave of the process through the use of a mathematical model that adequately reflects the cavitation treatment of the environment.

Analytical dependence made it possible to evaluate and formulate the principles of rational conditions and environment interactions of a cavitation system, improving performance parameters and energy.

Key words: pressure, absorption coefficient, energy, cavitation processing, rheological properties, technological environment.

INTRODUCTION

At the time of cavitation processing the technological environment, energy density of the sound field contact the zone of the "cavitation machine – environment" which is transformed into the high density energy of bubbles which are formed inside and around them, which eventually slam into each other.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

In general energy is expended on the formation of shock waves, heat, local electrification bubbles, sonoluminescence excitation, and the formation of free radicals [1]. Electrical energy is converted into acoustic oscillations and radiation energy. The working environment must be such so that the radiator has to ensure the most efficient input of energy in coordination with the forces of resistance in this environment. This reaction is a response to the power operation system.

The rheological properties are determined by changing technological environment that occurs during cavitation processing, which is tough, ductile and elastic [2] due to choice model [3–13], which takes into account these changes and methods of presentation in the mathematical description of the process of cavitation under which the bubbles are formed, their oscillation, followed by slamming development.

This process is accompanied by a complex transfer of heat and mass and [14] cavitation in the current field. It is clear that an accurate description of this process is too complex a task, but the undeniable fact is that the key parameter of the evolution of gas and air bubbles in the acoustic field is the energy components which are pressure, time and rate of occurrence of cavitation process. Such statements determined the main task of this study.

OBJECTIVES

The main objective is to establish the most influential parameters for the cavitation process from inception to slamming the volume of the bubbles to access the impact of the course of the process to determine these parameters.

THE MAIN RESULTS OF THE RESEARCH

The first objective study was to agree to terms on what grounds should conduct a classification machining environments. Signs of the environment of processing are called the loading mode to the emitter, the physical characteristics and conditions of impact on the emitter. So under these rules, the load on the radiator are divided into: unlimited acoustic environment with constant physical parameters, environment with constant dimensions with permanent physical parameters, unlimited acoustic environment with variable physical parameters, environment with variable dimensions or have variable physical parameters. In terms of physical characteristics: fluids, dispersed environment, solid medium. Under the impact of the emitter: neutral environment, chemically aggressive, temperature and aggressive.

An acoustically unlimited environment with constant physical parameters (whose values remain unchanged in the ultrasonic treatment) are characterized by the fact that the value of the input resistance of the medium, ie the load applied to the radiator remains constant and does not depend on the size of the object processing. In order for this technological object to satisfy this requirement, the size and magnitude of acoustic energy absorption per unit volume should be sufficient to neglect the reaction of the reflected waves on the radiator.

For the acoustically unrestricted fluid environment radiation resistance is the input resistance of the environment, is defined by its parameters, frequency, type and size of the radiator. For a limited acoustic environment with constant physical parameters and a constant size, the value of the input resistance depends on the size, as reflected waves in response emitter, depending on their amplitude and phase, determines the input resistance. Depending on the degree of absorption at the wave reflected from the boundaries of the volume occupied by the environment, and the environment itself, and the number of reflections and phase shifts the reaction to the emitter can be different. It may be that, because of the relatively small (compared with the surface of the walls) Square emitter and significant absorption of reflected waves, their reaction is so small that the input impedance can almost be defined as unrestricted acoustic environment. The efficacy of acoustic vibrations in unrestricted and restricted environments can be achieved by matching the input impedance value of the oscillation source (transmitter) and a waveguide system. For environments with variable parameters may change the absorption coefficient and the velocity of the waves, which is characteristic of a developed cavitation regimes.

Scientific research idea has accepted the position that the efficiency of formation of cavitation energy is determined by the structure and interaction of the basic elements of ultrasonic technological equipment, which are:

- Electric generator,
- Fluctuations in the electrical transformer speakers,
- The radiator,
- Technological device where the facility processing.

But the effectiveness of the introduction of acoustic vibrations in the vehicle manufacturing environment depends on a number of conditions to ensure:

- The maximum possible extraction of energy from the power fluctuations,
- Minimum energy dissipation in the elements of the design process apparatus,
- The greatest application of acoustic energy is introduced into the work environment to ensure the flow of the process,
- Maximum stability parameters of acoustic apparatus to predefined values of their technology and acoustic modes of the device.

So based on the above, the following hypotheses were formulated, the implementation of which will enable to achieve the desired result in the creation of a new or improvement of existing acoustic device.

1. Convert electrical energy into acoustic oscillations and radiation energy in the working environment must be such so that the radiator had to ensure the most efficient input of energy into the work environment in coordination with the forces of resistance in this environment, as a reaction to power system operation.

2. Is necessary to agree actual load of the process fluid to the radiator, which is performed on the basis of a solution of the contact problem of the interaction of these subsystems, which are subject to a single wave of the process through the use of a mathematical model that adequately reflects the cavitation treatment of the environment.

To determine the approach to the implementation hypotheses defined algorithm (Fig. 1), which will consider the physical aspects of the sequence of cavitation research process.

This approach will allow more intelligently and with less error to take a mathematical model for the studied environments, develop, or out of necessity, improve the methodology of research results are reliably determined by the levels of the difficulty of the cavitation process (Fig. 2), the distribution zones and areas developed cavitation considering changes physical properties of the dispersion environment, which is the density, impedance, absorption coefficient and others.

On the first level of the model is considered the physics of the formation and determination of dependencies radius individual cavitation bubbles *R* of time *t*, the intensity of ultrasonic vibrations *I* and rheological properties of the medium in particular, the density *ρ*, the coefficient of viscosity *ν*, the module of elasticity *E* which is linear materials, pseudo plastic and dilatant [3]:

$$R = f(t, I, \rho, \nu, E). \qquad (1)$$

The dependence of the radius of the cavitation bubbles in accordance with (1) a precondition for the average level of detail model of cavitation field. Realization of this research can be used depending on the analytical studies [14–18] for some clarification numerical values of acoustic parameters and system environments. Because of this set allowable range of numerical values of intensity ultrasonic vibrations, which implemented slamming bubbles. At the secondary level (Fig. 2) are defined by a set of cavitation bubbles in the size of *L*, which is less than the length of the ultrasonic wave *λ*, but is much larger than the radius of the cavitation bubbles *R*:

$$\lambda >> L >> R. \qquad (2)$$

Adopted condition (2) makes it possible to establish dependent volume content of cavitation bubbles (3) and concentration (4) the intensity of ultrasonic vibrations *I*, time t and rheology liquid *ρ*.

$$V_b = \frac{4}{3}\pi R^3 n, \qquad (3)$$

$$n_b = g(t, I, \rho, \nu, E) \qquad (4)$$

where: n_b – the estimated concentration of cavitation bubbles, m^{-3}, V_b – volume content of bubbles, *R* – instantaneous radius of the bubble, which is defined on the lower level model city.

The third level is determined by the total volume and shape of the cavitation field, set the intensity of the ultrasonic action, under which conditions provided intensive mode of developed cavitation as completed stage of the process.

So mathematical model of manufacturing environment is a continual system [12] with three levels of implementation and taking into account the changes in its rheological properties.

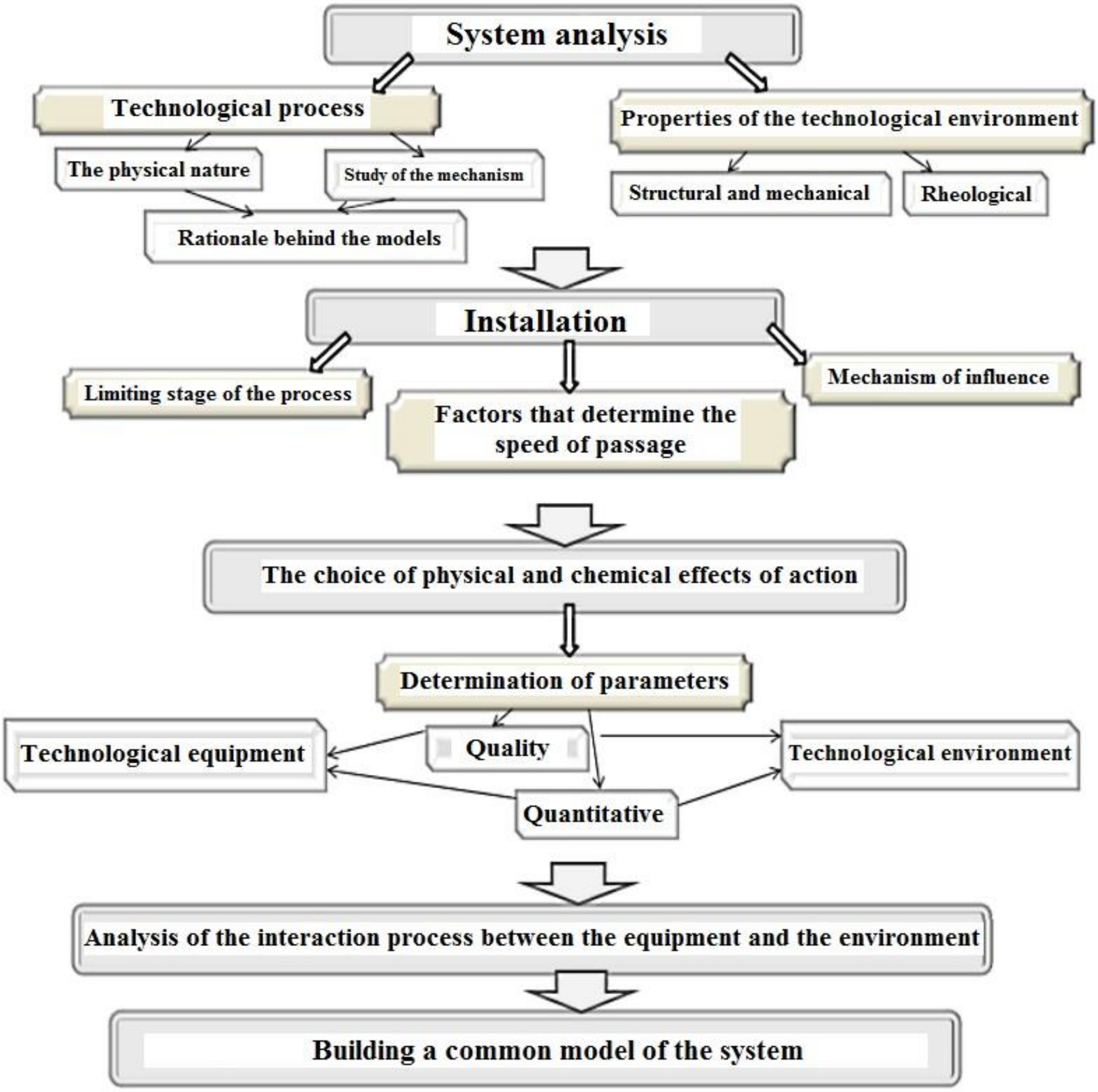

Fig. 1. The algorithm of conduct research

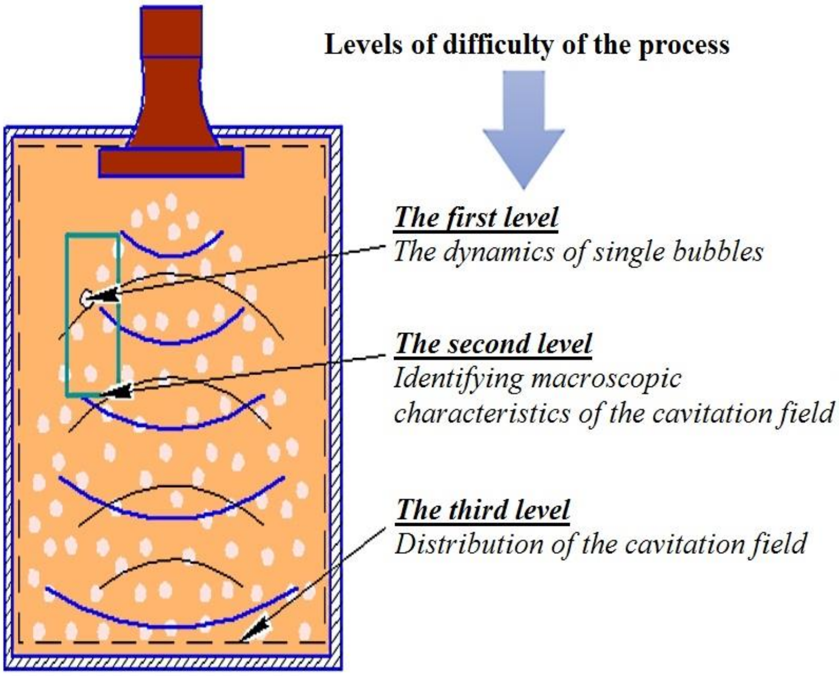

Fig. 2. Difficulty levels forming cavitation field

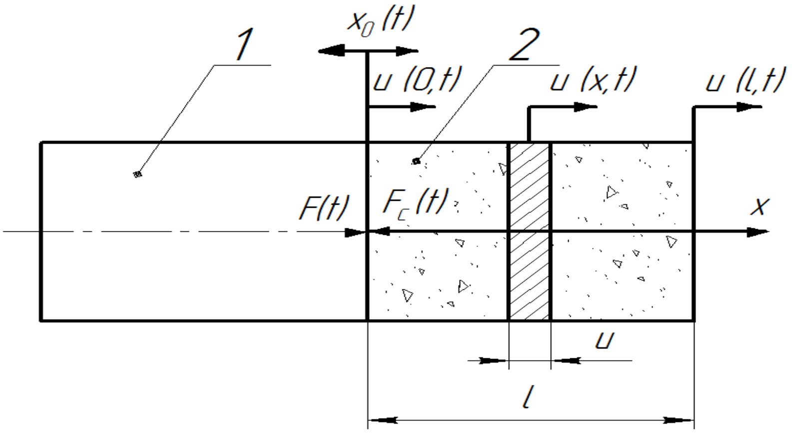

Fig. 3. Diagram of the system "cavitation machine - environment": 1 – cavitation device, 2 – environment, *u* – moving vehicle, *F (t)* – periodic forcing cavitator strength in the contact zone of the manufacturing environment, *u (x, t)* – longitudinal displacement current environment section treated with fluctuations, this movement depends on the location sectional /coordinates *x*/ and from time *t*, $F_c = 0$ – the reaction medium in section $l = 0$, $R \mid x = l$ – a reaction medium treated in section $x = l$.

The next task is to describe a model to determine the specific power of shock waves (P_n) per unit volume cavitation field, impedance environment ($\rho_c c_c$) and absorption coefficient (k_e).

Power (5) can be represented as

$$F_c = -E_e \cdot S \left.\frac{\partial u}{\partial x}\right|_{x=0}, \tag{6}$$

where: E_e – modulus environment, $\frac{\partial u}{\partial x}$ – deformation of the medium in the contact zone.

In shock movement is an important characteristic acceleration.

Therefore, on the other hand can contact force with some approximation to determine how

$$F_c = m'_e \ddot{x}\big|_{x=0}, \tag{7}$$

where: m'_e – mass medium, determining inertial properties at accelerating the contact zone of "cavitation machine – environment".

So determining the contact force needs of the deformation $\partial u/\partial x$ or acceleration $\ddot{x}$.

In any case, you must take the equation of the medium and on this basis to determine the contact force, and then the parameters included in the equation of the medium in the contact zone.

Wave equation environmental fluctuations take the form:

$$\frac{\partial^2 u}{\partial x^2} = \frac{\rho}{(E' + iE'')} \cdot \frac{\partial^2 u}{\partial t^2}, \tag{8}$$

where: *u (x, t)* – move current layer protection section in the direction of the force, which depends on coordinates *x* and time *t*, ρ – density of the medium, E', E'' – the complex modulus, *i* – the imaginary unit, indicating a shift in the angle $\pi/2$ between E' and i.

The physical meaning of complex components is their compliance with elastic (E') and not resilient (E'') properties, $\partial^2 u/\partial t^2$ – acceleration contact layer technology environment. If we take into account that:

$$\ddot{x}_{x=0} = \left.\frac{\partial^2 u}{\partial t^2}\right|_{x=0} \tag{9}$$

the equation (8) can be written as:

$$\frac{\partial^2 u}{\partial t^2} = \ddot{x}\big|_{x=0} = \left(\frac{E' + iE''}{\rho}\right)\left.\frac{\partial^2 u}{\partial x^2}\right|_{x=0}. \tag{10}$$

If we substitute the expression for acceleration (10) (7) and taking into account (6), we have that

$$m'_e = \frac{-E \cdot S \left.\frac{\partial u}{\partial x}\right|_{x=0}}{\left(\frac{E' + iE''}{\rho}\right)\left.\frac{\partial^2 u}{\partial x^2}\right|_{x=0}}. \tag{11}$$

Thus the problem of determining m'_e is to find strain $\frac{\partial u}{\partial x}$ and acceleration $\frac{\partial^2 u}{\partial x^2}$ values taken at A medium - density ρ and module *E*.

To solve this problem, we assume that the motion of "cavitation machine - environment" is:

$$u(x,t) = \left(A_1 \cdot e^{ikx} + A_2 \cdot e^{-kx}\right) \cdot e^{i\omega t}, \tag{12}$$

where: A_1 i A_2 – constant determined from the boundary conditions, *k* – complex wave number:

$$k = \omega/c \cdot (\eta + i\chi), \tag{13}$$

where: η i χ – factors that are by substituting (12) to (8):

$$\eta = \sqrt{\frac{\sqrt{1+\gamma^2} - 1}{2\left(1+\gamma^2\right)}}; \qquad \chi = \sqrt{\frac{\sqrt{1+\gamma^2} + 1}{2\left(1+\gamma^2\right)}}. \tag{14}$$

Dependence (14) obtained on condition that the complex modulus has the expression:

$$E^* = E' + iE = E \cdot (1 + i\gamma), \tag{15}$$

where: γ – loss factor which determines the ratio of energy dissipated volume in the environment *ΔW* of the period of oscillation to the potential energy *W*:

$$\gamma = {}^{1}\!/_{2\pi} \cdot \left({}^{\Delta W}\!/_{W} \right). \qquad (16)$$

Dependence (13) can be somewhat simplified if we take into account that in practical terms the cavitation process numerical values of resistance to environmental matters $\gamma \le 0{,}4$, then after the adoption of the conditions obtain:

$$\eta = {}^{\gamma}\!/_{2}; \quad \chi = 1. \qquad (17)$$

This complex wave number (13):

$$k = {}^{\omega}\!/_{c} \cdot \left({}^{\gamma}\!/_{2} + 1 \right). \qquad (18)$$

It is now possible to determine the required values deformation and its derivative. With (12) determine the deformation:

$$\left. \frac{\partial u}{\partial x} \right|_{x=0} = {}^{\omega}\!/_{c} \cdot \left({}^{\gamma}\!/_{2} + i \right) \cdot \left[A_1 - A_2 \right],$$

considering that the wavelength is small, we get:

$$\left. \frac{\partial u}{\partial x} \right|_{x=0} = 0,$$

Then $A_1 \cdot e^{l(\eta + i\chi)} - A_2 \cdot e^{-l(\eta + i\chi)}$.

Where:

$$\frac{A_1}{A_2} = e^{-2l(\eta + i\chi)}, \qquad (19)$$

where: $\frac{\omega}{c} \cdot \left(\frac{\gamma}{2} \right) = \eta; \;\; \frac{\omega}{c} = \chi$.

It is necessary to consider the second component pressure according to the relationship (15). That is, in general, the contact pressure is twofold – first (purely inertial) determined by the dependence (7) and dissipation:

$$\left| F_k \right| = \left| F_k^p \right| + \left| F_k^a \right| = -m_e q \ddot{x} \big|_{x=0} - m_e j \dot{x} \big|_{x=0}. \qquad (20)$$

The coefficients *q* and *j* determine reactive and active components of resistance.

The energy lost in the process of cavitation flow is determined from the dependence:

$$E_e = \psi_e \frac{\left(\frac{\partial u}{\partial x} \right)^2 E}{2}. \qquad (21)$$

To determine the strain $\partial u / \partial x$ use the resulting dependence (19), which takes into account the real value ratios η and χ (15). As seen contact problem, the dependence (12) as the ultimate expression of deformation (19) can be simplified by writing the equations of motion (12) as:

$$u(0,t) = x_k c l \varphi \frac{x}{l} \left({}^{\gamma}\!/_{2} + i \right) e^{i\omega t}, \qquad (22)$$

where: x_k – the amplitude of the contact zone, $\varphi = \frac{\omega l}{c}$.

Then deformation $\frac{\partial u}{\partial x}$:

$$\frac{\partial u}{\partial x} = \frac{\varphi \left({}^{\gamma}\!/_{2} + i \right)}{l} \cdot \frac{sh \varphi \frac{x}{l} \left({}^{\gamma}\!/_{2} + i \right)}{ch \varphi \left({}^{\gamma}\!/_{2} + i \right)} x_k \qquad (23)$$

and expression $\left(\frac{\partial u}{\partial x} \right)^2$:

$$\left(\frac{\partial u}{\partial x} \right)^2 = \frac{\varphi^2}{l^2} \cdot \frac{ch\left(\varphi \frac{x}{l} \right) - \cos\left(2\varphi \frac{x}{l} \right)}{ch \gamma \varphi + \cos 2\varphi} x_k^2. \qquad (24)$$

Substituting (24) in (21) we obtain

$$E_e = \frac{\psi_e}{2} x_k^2 \omega^2 \rho k_E, \qquad (25)$$

where: k_E expresses the ratio of energy distribution

$$k_E = \frac{ch\left(\varphi \gamma \frac{x}{l} \right) - \cos\left(2\varphi \frac{x}{l} \right)}{\cos \gamma \varphi + \cos 2\varphi}. \qquad (26)$$

While the specific impact power:

$$\overline{P}_e = \frac{E_e \omega}{2\pi\rho} = \frac{\gamma}{2} x_k^2 \omega^3 k_E. \qquad (27)$$

In the end, a power value for cavitation processing environment:

$$P_e = \frac{m_e}{2} x_0^2 \omega^3 j, \qquad (28)$$

where:

$$j = \frac{sh(\varphi\gamma) - \frac{\gamma}{2} \sin 2\varphi}{\varphi(\cos 2\varphi + ch \varphi\gamma)}. \qquad (29)$$

Thus dependences (5) – (28) make it possible to assess the energy cost of "cavitator – environment". Installed the maximum total power generated shock waves will provide a measure of the efficiency of cavitation effects.

Under the influence of ultrasonic harmonic oscillations in medium pressure varies according to the law:

$$p(t) = A\omega\rho_c c_c \cos(\omega t - kr), \qquad (30)$$

where: ρ_c and c_c – density and sound velocity in a cavitating environment, ω – circular frequency sound wave, $k = \frac{\omega}{c}$ – wave number, *A* – amplitude of the radiator, then the amplitude of sound pressure P_m:

$$P_m = A\omega\rho_c c_c, \qquad (31)$$

where: $\rho_c c_c$ – impedance environment because it, as follows from formula (31), determines the speed of oscillation at a given acoustic pressure.

On Cavitation parameters significantly impact a number of other factors, including:

- speed of sound in the cavitation region,

- distance from the cavitation device that transmits energy environment,
- temperature and gas content liquid,
- the composition and concentration of dissolved impurities,
- the number of bubbles that are involved in the process of cavitation.

In practice, for convenience assess the cavitation bubbles substitute index numbers by a factor of cavitation index *K*, which is the average time the volume concentration of bubbles:

$$K = \frac{\sum_i V_i}{V_f + \sum_i V_i}. \tag{32}$$

where: V_f – the volume of fluid without bubbles, V_i – the average amount of cavitation bubbles, i = 1, *N*, *N* – number of bubbles.

The number of bubbles can be expressed through cavitation index:

$$N = \rho V_f, \tag{33}$$

where: $n = \frac{3K}{4\pi R_{cp}^3}$ – the concentration of bubbles, R_{ar} – average radius of the bubble.

Then the wave resistance cavitating advisable environment represented as a relationship:

$$\rho_c c_c = \rho_0 c_0 \left[\frac{1}{1 + \frac{K\beta_n}{\beta_0}} \right]^{1/2} \tag{34}$$

where: $\frac{\beta_n}{\beta_0}$ – the ratio of compressibility of vapor bubbles in the mixture to the compressibility of fluid water $\frac{\beta_n}{\beta_0} = 10^4$ [15, 16].

Bubbles, having high compressibility, take on the action of external forces in the sound waves, thus reducing the bulk modulus E_e and the speed of sound $c_c = \sqrt{\frac{E_e}{\rho_c}}$ [19]. Effect parameters on the occurrence of cavitation process considered in [11–19]. Thus, the dependent impedance environment of cavitation index (Fig. 4) shows that the index of cavitation only 0,2% impedance, and hence the amplitude of the current bubble in the sound pressure is reduced almost five times.

Another important parameter is the absorption coefficient in cavitating environments to determine the magnitude of which can use the equation [20], which describes the distribution of acoustic fields in the technological environment of cavitation bubbles filled with steam or gas:

$$\Delta p - \frac{1}{c_0^2} \cdot \frac{\partial^2 p}{\partial t^2} = -\rho_0 \frac{\partial^2 \overline{V}}{\partial t^2}, \tag{35}$$

where: *t* – time s, ρ_0 – equilibrium density of the medium, kg/m^3, *p* – instantaneous pressure environment, Pa c_0 – the speed of sound in the liquid phase, m/s, $\overline{V}$ – instant volume content of bubbles.

Unlike (8) in equation (35) takes into account the contribution of higher harmonics in which case the instant pressure and volume content of bubbles conveniently represented as a Fourier series [21]. Expansion in Fourier series in complex form in accordance with the classical theory [21] is:

$$\overline{p}(r,t) = \sum_{n=1}^{\infty} \overline{V}_n(r) e^{-in\omega t}, \tag{36}$$

$$\overline{V}(r,t) = \sum_{n=1}^{\infty} \overline{V}_n(r) e^{-in\omega t}, \tag{37}$$

where: ω – circular oscillation frequency acoustic device, which interacts with the environment, s^{-1} , r – radius vector of the point of the medium, m, *n* – number of harmonics.

After substituting (36) and (37) in the wave equation (35) it is transformed into the equation for each harmonic:

$$\Delta \overline{p}_n + \frac{n^2 \omega^2}{c_0^2} \overline{p}_n = n^2 \omega^2 \rho_0 \overline{V}_n, \tag{38}$$

Wave equation (35) for the 1st harmonic:

$$\Delta \overline{p}_1 + \frac{\omega^2}{c_0^2} \left(1 - \frac{\rho_0 c_0^2 \overline{V}_1}{\overline{p}_1}\right) \overline{p}_1 = 0. \tag{39}$$

In this form it is known Helmholtz equation [21]:

$$\Delta \overline{p}_1 + (k + ik_e)^2 \overline{p}_1 = 0, \tag{40}$$

where: *k* – the effective wave number cavitating environment, m^{-1}, k_e – effective absorption coefficient cavitating environment, m^{-1}.

Then from equations (39) and (40) we obtain the absorption coefficient cavitating environment:

$$k_e = -\frac{\omega}{c_0} \ln \frac{\rho_0 c_0 \overline{V}_1}{\overline{p}_1}, \tag{41}$$

It follows from (41) the absorption coefficient depends on complex amplitude of sound pressure in cavitating environments and complex amplitude volume content of cavitation bubbles. A convenient size for assessing energy performance ultrasonic cavitation is intensity oscillations (Fig. 5).

This is due to the fact that the intensity is related to the amplitude of sound pressure unambiguous relationship:

$$I = \frac{p^2}{2\rho_c c_c}. \tag{42}$$

Given (42) Absorption Rate (41) was presented in the form of:

$$k_e = -\frac{\omega}{c_0} lm \frac{\rho_0 c_0 \overline{V}_1}{(\sqrt{2\rho_c c_c I} e^{i\varphi})};$$

$$I = \frac{|\overline{p}_1|^2}{2\rho_c c_c};$$

$$\overline{p}_1 = |\overline{p}_1| e^{i\varphi}, \tag{43}$$

where: φ – phase shift ultrasonic pressure $\overline{p}_1$ councils.

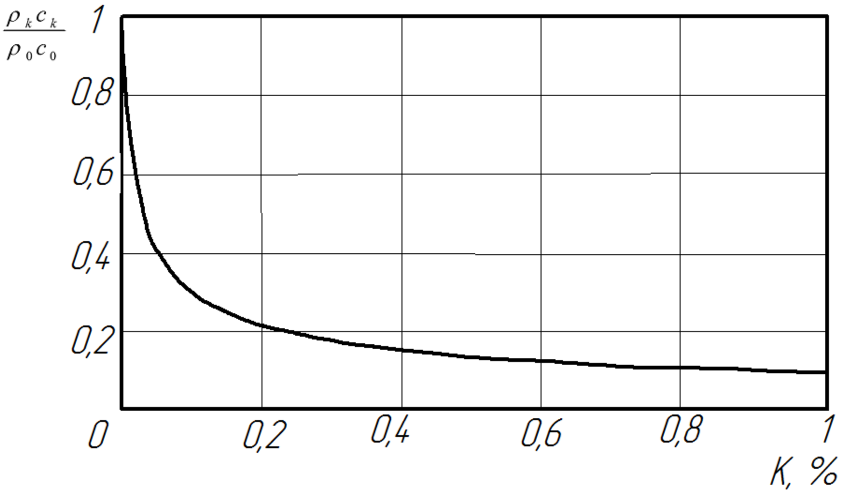

Fig. 4. Dependence of change of impedance protection from cavitation index.

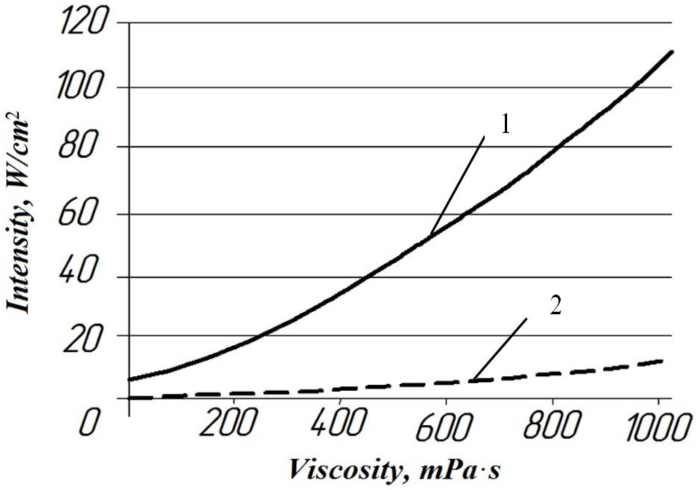

Fig. 5. Scope changes the intensity of cavitation processing of dispersed linear viscous process fluids: 1 – maximum intensity, 2 – low intensity.

Complex amplitude volume content of cavitation bubbles may be determined by direct Fourier transform:

$$\bar{V}_1 = \frac{\omega}{2\pi}\int_0^{\frac{2\pi}{\omega}} \frac{4}{3}\pi R^3(t)\bar{V}_\infty e^{-i\omega t}\partial t, \qquad (44)$$

where: *R(t)* – functional dependence of cavitation bubble radius (m) from the time detected by analyzing the third level of complexity (Fig. 1), $\bar{V}_\infty$ – fixed concentration of cavitation bubbles (m^{-3}) set based on the analysis of the second level of complexity of the process of cavitation. In its final form using dependencies (43) and (44) the formula for determining the absorption coefficient becomes:

$$k_e = -\frac{\omega}{c_0} lm \frac{\rho_0 c_0^{\,2} \frac{\omega}{2\pi}\int_0^{\frac{2\pi}{\omega}} \frac{4}{3}\pi R^3(t)\bar{V}_\infty e^{-i\omega t}\partial t}{(\sqrt{2\rho_c c_c l})e^{i\varphi}}, \qquad (45)$$

Analysis of the relationship (45) shows that the absorption coefficient at a certain intensity of the ultrasonic action in the formation, development and cavitation bubbles slamming area corresponds to the maximum effectiveness of cavitation process. Fig. 6 shows the dependence of absorption cavitating liquid on the intensity of exposure to different coefficients of viscosity.

The value of the absorption coefficient can serve as a measure of the efficiency of cavitation effects. The confirmation of this finding may be the relationship of the absorption coefficient of specific power shock waves through consideration of the local area treated medium volume *ΔSΔx*. So, using the law of conservation of energy, we find that the power density shock wave can be determined according to the following expression:

$$P_{dens} = \frac{\Delta Sl}{\Delta x \Delta S} = \frac{\Delta S(I - Ie^{-k\Delta x})}{\Delta x \Delta S} = \\ = \frac{(I - Ie^{-k\Delta x})}{\Delta x} = K\frac{I(1-e^{-k\Delta x})}{K\Delta x} \approx KI, \qquad (46)$$

where *ΔI* – change the intensity of this wave as a result of acquisitions, W/m^2.

Since (46) implies that the specific energy shock waves generated per unit time is the product of the absorption coefficient and the initial intensity ultrasound waves. Thus, the absorption coefficient is a measure of the effectiveness of ultrasonic cavitation, that determines the ratio of useful energy created in the form of shock waves and cavitation necessary for the implementation of process energy.

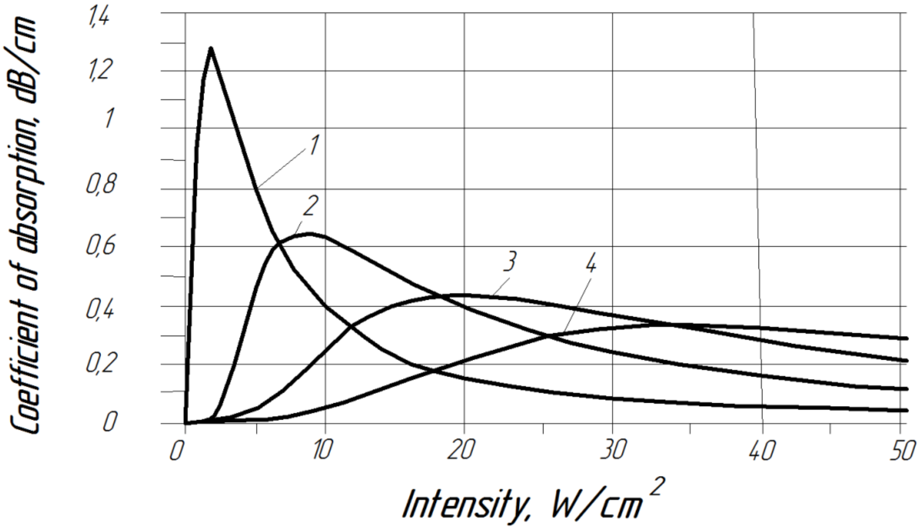

Fig. 6. The dependence of the absorption coefficient cavitating liquid in the intensity of the impact of different viscosity: 1 – 1 mPa·s, 2 – 200 mPa·s, 3 – 400 mPa·s, 4 – 600 mPa·s.

CONCLUSIONS

1. The exact description of cavitation processing technology dispersed environments is a difficult task, but the undeniable fact is that the key parameter of the evolution of bubbles in the acoustic field is the energy components which are pressure, absorption coefficient of energy, time and speed the flow of the process.

2. Revealed that featured machining environments that can be used to determine the rational model of the process are: load mode for the emitter, physical characteristics and conditions influence the radiator.

3. Scientific research idea was accepted position that the efficiency of formation of cavitation energy determined by the structure and interaction of the basic elements of ultrasound technology equipment technological environment. Necessary approvals real burden technological environment of the transmitter, based on solving the contact problem of interaction between these subsystems that conquered single wave processes through the use of mathematical models with distributed parameters, which adequately reflects the cavitation treatment of the environment.

4. Done description adopted mathematical model, which made it possible to get analytical dependence of power density shock waves per unit volume cavitation region, the wave resistance of the medium and the absorption coefficient. The absorption coefficient is a measure of the effectiveness of ultrasonic cavitation, that determines the ratio of useful energy created in the form of shock waves and cavitation necessary for the implementation of process energy.

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