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Prediction of Cavitation. Current Understanding of the Cavitation Mechanism

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Abstract

Cavitation is the process of formation, growth and subsequent collapse of vapor bubbles with the local creation of a high energy density per unit volume of a substance. For the development of technologies based on the application of cavitation effects, it is extremely important to find a parameter that allows predicting the cavitation threshold and its intensity. The dimensionless cavitation number currently used for these purposes is not able to accurately predict the onset of cavitation for different types of liquids and devices. This paper discusses the limitations of using this parameter and demonstrates, based on the analysis of the research literature, that it cannot be considered sufficient and the only one for predicting the onset and development of cavitation in a fluid flow. Theoretical analysis of the scientific literature has shown that the threshold for creating cavitation is sensitive to changes in various liquid parameters that are not taken into account in the dimensionless cavitation number, including surface tension, concentration of dissolved salts, the presence of mechanical impurities and gas inclusions. The absence of these parameters in the existing expressions for the dimensionless cavitation number leads to a situation where, for the same cavitation number, the parameters of the cavitation itself will differ significantly in different liquids.

***Keywords**: Cavitation; Cavitation number; Cavitation properties of liquids.*

1. Introduction

Cavitation has found application in the food industry [1], wastewater treatment [2], biomedical fields [3], liquid hydrocarbon processing [4-6]. The high popularity of the use of cavitation in various industries is explained by the possibility of creating high energy density in the local areas of the space of processed liquid raw materials, creating conditions for the occurrence of chemical reactions.

The processing of liquid hydrocarbons is of particular interest in the application of cavitation. In some way, cavitation was created for the processing of oil and petroleum products. Oil, especially crude oil, is a complex heterogeneous liquid with a complex fractional composition. Due to its effect, cavitation can carry out the destruction of molecular compounds, which predetermined a large number of studies to find the possibilities of using cavitation in the processing of oil and oil products. The main directions of existing research completely repeat the problems of processing heavy grades of oil inherent in traditional methods and methods of oil refining, or rather, they are aimed at reducing the viscosity of oil and the amount of sulfur compounds in it, as well as increasing the yield of light fractions. The high prevalence of this scientific direction among scientists from different countries, a large number of patents and publications, which record the successful results of cavitation effects on petroleum products, suggests that the use of cavitation in this area is promising. At the same time, the decrease in the reserves of deposits of “light” oil grades and the increase in the share of “heavy” oil grades in the total world volume of oil produced predetermine the high relevance of research aimed at finding new technologies for processing crude oil. Cavitation can turn out to be the energy impact method that can effectively replace or supplement a number of existing oil refining processes in the processing of "heavy" grades of oil, increasing both the quality of oil products and the energy efficiency of refineries, and reducing the overall cost of refining.

At the same time, long-term studies of cavitation did not allow moving from laboratory copies of cavitation generators to industrial implementation. For many industrial applications, it is important to be able to accurately estimate the intensity of the cavitation created for various liquids and the technological equipment used and, accordingly, predict the processing efficiency. Unlike any other characteristics, cavitation has no parameters that accurately describe and predict the threshold of its occurrence and intensity for various technological processes. Often, the so-called dimensionless cavitation number is used by the scientific community to evaluate these parameters.

In most cases, the cavitation number reflects the ratio of the difference between the ambient pressure and the vapor pressure, or the ratio of the pressure difference at the inlet and outlet of the device. The following expression has become the most widespread:

$$\sigma = \frac{P_a - P_v}{0{,}5\rho v_e^2} \quad (1)$$

where Pa - ambient pressure; Pv - fluid vapor pressure; ρ - fluid density; ve - average spouting velocity.

Nevertheless, there are other expressions in the scientific literature for calculating the dimensionless cavitation number:

$$\sigma = \frac{\mathrm{P_{вх}} - \mathrm{P_v}}{\mathrm{P_{вх}} - \mathrm{P_{вых}}} \quad (2)$$

$$\sigma = \frac{\mathrm{P_{вых}} - \mathrm{P_v}}{\mathrm{P_{вх}} - \mathrm{P_{вых}}} \quad (3)$$

$$\sigma = \frac{\mathrm{P_{вх}} - \mathrm{P_{вых}}}{\mathrm{P_{вых}} - \mathrm{P_v}} \quad (4)$$

$$\sigma = \frac{\mathrm{P_{вх}} - \mathrm{P_{вых}}}{0{,}5\rho v_e^2} \quad (5)$$

where $P_{вх}$ and $P_{вых}$ - pressures at the inlet and outlet of cavitation reactors, respectively.

For acoustic cavitation, a cavitation number has also been developed, presented in [7] and having the following form:

$$\sigma = \frac{2(P_\infty - P_v(T_\infty))cA_d}{\pi^2 P} \quad (6)$$

where P_∞ - ambient pressure; P_v – fluid vapor pressure at ambient temperature T_∞; c – sound speed in the investigated liquid; P – average power of ultrasonic homogenizer; A_d – horn tip area, defined by:

$$A_d = \pi \frac{d^2}{4} \quad (7)$$

where d – horn diameter.

According to the basic postulates, the cavitation number is a critical number that determines the possibility of creating cavitation in the liquid under study using appropriate equipment [8]. At the same time, the results of experimental studies published by different scientific teams show a certain inconsistency in the use of the cavitation number as the only parameter for estimating the intensity of cavitation. In the work [9], scientists conducted research on the treatment of hydrodynamic cavitation in a Venturi tube of a dye. According to the results obtained, hydrodynamic cavitation is observed at the value of the cavitation number from 0.13 to 0.18. In the work [10], when decomposing an aqueous solution of KI by hydrodynamic cavitation, the optimal cavitation number found by scientists was in the range from 0.15 to 0.25. In the work [11], the optimal number of cavitation for the implementation of the process of degradation of insecticides is 0.067. However, in the work [12], hydrodynamic cavitation treatment becomes possible with a cavitation number of 0.4. In the work [13] the cavitation number is selected in the range of 0.1-1. And in the work [14] it is stated that cavitation can occur only when the cavitation number is equal to 1.

2. Materials and methods

An attempt to characterize cavitation by a single parameter showing both the probability of cavitation creation and its intensity is an important step towards further research on the way to the introduction of devices directly into industrial spheres and requires a detailed theoretical study to find the main parameters of the liquid that affect cavitation, including its creation and maintenance.

However, cavitation, regardless of whether acoustic or hydrodynamic, is a complex physical phenomenon, the intensity and efficiency of which within the framework of the implemented technological processes is strongly dependent on the physical parameters and characteristics of the initial liquid raw materials. The main properties of liquid raw materials include its density, viscosity, surface tension, the amount of dissolved gases and the presence of mechanical impurities. Real liquids, which are supposed to be treated by cavitation as part of the implementation of technological processes in industry, are often complex multi-dispersed systems with a high and unpredictable content of mechanical impurities and gas inclusions.

The purpose of the theoretical study is to inform researchers that in its current form it is impractical to use a dimensionless cavitation number as the only parameter for estimating the intensity of cavitation. The parameters of cavitation, including its intensity, and, consequently, the efficiency created by the same device, will differ significantly in different liquids. In some liquids, cavitation may not be created at the same system parameters. Thus, the cavitation properties of liquids are of great importance in the design of any cavitation generators and the development of a new single parameter for assessing the intensity of cavitation. In this work, a detailed theoretical study of the influence of various parameters on the mechanism and intensity of cavitation was carried out.

In the presented work, some scientific publications related to the study of the influence of individual fluid parameters on the threshold of cavitation creation and its intensity are selected. The data were collected and studied to assess the degree of influence of the parameters of liquid raw materials on cavitation.

3. Results

A large number of combinations of the same parameters in the expression of the cavitation number only confirms the complexity of its application as the only parameter of the cavitation intensity. A striking example is the work [15], where the authors estimated the number of cavitation during measurements in various parts of the Venturi tube under study. The result of this study was a range of dimensionless cavitation number, varying from 1.2 to 168, which showed how much the number of cavitation depends on the location of the working chamber of the device where measurements are made.

In the work [8] an estimated comparison of the numerical prediction of the cavitation number with the results of experimental studies was carried out. Numerical analysis of cavitation was carried out using the most common model of the Navier-Stokes equations averaged by Reynolds in the Ansys software package. The main disadvantage of the existing expressions for determining the cavitation number, reflected in this study, is the lack of consideration of the geometry of the reactor working chamber. In this work [8], it was confirmed that there is no regularity in the change in the cavitation number with a change in the geometry of the tubes under study. In this case, cavitation was observed both at a cavitation number equal to 1 and at a cavitation number equal to 5. It was also shown in this work that the temperature dependence of cavitation differs for each tube geometry. In general, the conclusions of the experimental study [8] only confirm the impossibility of using the cavitation number as the only parameter for predicting the occurrence of cavitation.

Another explanation for the large number of expressions for determining the number of cavitation and contradictions in the values obtained is the lack of uniform standardization in the development and design of hydrodynamic cavitation devices. Since cavitation technologies have not yet advanced beyond laboratory research, each research team carries out the design of the installation guided by its own vision of the effectiveness of a particular design. Each laboratory installation of each individual team is unique, in addition, the application of the developed installation is carried out for some specific liquid raw materials, the parameters and characteristics of which are often unknown to a wide range of scientists.

The difficulty in developing an expression reflecting the number of cavitation is also introduced by the spread to replace stationary cavitating reactors with installations with moving internal working parts, including vortex reactors, rotary installations and devices with a discrete secondary part, for which previously developed expressions are not applicable.

Nevertheless, even on the example of well-studied Venturi tubes, there is a significant inconsistency in the application of the cavitation number. The work [15] carried out a detailed study of the parameters that influence the intensity of the generated cavitation, using the example of liquid treatment in a Venturi tube. In the study, the authors noted that several factors influence the likelihood of cavitation bubble formation, including the geometry of the tube constriction, the temperature of the medium, the density of the liquid, and the size of the cavitation nuclei. While maintaining hydrodynamic conditions and a slight change in the geometry of the narrowing of the tube, a significant change in the intensity of cavitation was observed. The effect of thermal cavitation delay has been noted [16], according to which, along with an increase in the temperature of the raw material, the vapor density increases. With the growth of the cavitation bubble through the vapor, a decrease in the temperature of the liquid and a local drop in the evaporation pressure are observed. With the destruction of the bubble, a sharp recovery of the temperature is observed, which eventually exceeds the initial one. Then, at a lower pressure, the formation of the next cavitation bubble is initiated, which increases to a smaller size [15]. Also in the work [15], a study of the effect of the amount of cavitation nuclei content on the intensity of cavitation was carried out. With the same parameters of the dimensionless number of cavitation, flow velocity and visually identical cavitation in the treated liquid containing a smaller number of cavitation nuclei, significantly low pressure fluctuations were observed, indicating a lower aggressiveness of cavitation.

Several mechanisms for the formation of cavitation bubbles can exist simultaneously in a liquid. Cavitation is divided into two categories depending on its occurrence: homogeneous cavitation of vapor bubbles in a metastable pure liquid [17] and heterogeneous cavitation due to impurities such as solid particles and non-condensing gas nuclei [18].

Based on these assumptions, cavitation will be more intense in contaminated liquids or in monodisperse systems, for example, such as oil and petroleum products, and less intense in distilled or deonized water. At the same time, it is problematic to evaluate the influence of certain parameters on the threshold of formation and the intensity of cavitation in a real environment due to the large number of independent parameters that affect cavitation. This fact predetermined the need to evaluate individual characteristics of liquid raw materials on the threshold of cavitation creation.

The simplest in the development of predictive factors was water, including distilled water. In a liquid in which mechanical impurities and gas inclusions are practically absent, the formation of cavitation bubbles is difficult and is predominantly homogeneous, and is created by separating liquid molecules [19]. According to the results of work [20], in pure deionized water, the threshold for the formation of cavitation bubbles at room temperature is -60 MPa. However, in water with gas inclusions and mechanical impurities, the threshold for the formation of cavitation bubbles according to the results of the work [21] is 0.1 MPa. In turn, the dynamics of bubbles is also associated with many different factors, including surface tension and viscosity.

The classical theory of origin is not able to accurately predict the magnitude of the negative pressure at which cavitation bubbles are generated in water. According to this theory, the calculated strength of water is -1600 to -1300 atm [22-24], while the results of experimental studies show the maximum strength of water in the region of -300 atm. The tensile strength of water is extremely high, it is obvious that the tensile strength of water is determined by the presence of gas and mechanical inclusions. Briggs [25] was able to increase the maximum tensile strength of water by providing the necessary purity of water and using distilled water with a low gas content. The main reason for the discrepancy between theoretical and experimental results was the impossibility of controlling the purity of water and its inevitable contamination in the course of experimental studies.

In the work [26], it was assumed that the phase transition of a liquid is influenced by the surface activity of gases forming nuclei. In the work [22], a hypothesis was put forward about the dependence of the probability of the formation of cavitation bubbles in water on the clustering of gas molecules. According to the results [22], molecules of gas dissolved in water form clusters, reducing surface tension.

Nevertheless, despite a large number of studies in the field of creating cavitation in deonized and degassed liquids, technological processes based on the effects of cavitation, except for laboratory studies, are practically not related to the treatment of degassed and purified liquids. The most promising areas of application of cavitation effects, according to the research literature, are associated either with the purification and disinfection of wastewater, or with the treatment of oil and petroleum products. Both types of liquids are complex multi-dispersed liquids. It is almost impossible to predict the exact composition of the constituent components in such liquids. Multi-dispersed liquids can simultaneously contain not only dissolved gas, but also solid particles, which also affect the threshold of development and the intensity of cavitation. At the same time, natural systems contain a large range of solid particle sizes from nanometer (solid mechanical impurities in oil products) to centimeter scales (deposits in the form of silt and clay in rivers or wastewater). It is well known that the presence of solid particles in cavitating liquids can change hydrodynamic conditions.

Due to the complexity of controlling the size and properties of particles in a real natural system, in experimental studies, distilled water is often used to assess the degree of influence of the presence of solid particles on cavitation, into which solid particles with known dimensions are artificially placed. As mentioned earlier, the cavitation threshold of pure water decreases as the concentration of gas in it increases. The presence of solid impurities in the liquid also affects the cavitation threshold. Thus, both gas inclusions and solid particles have an effect on the cavitation threshold and its intensity, and together represent cavitation nuclei. However, the effect of solid particles on the cavitation threshold and its intensity is somewhat more complicated than the effect of gas inclusions.

In [27], aluminum oxide particles with a size of 10 microns were added to an aqueous solution of KI. The intensity of cavitation in the framework of experimental studies, the authors evaluated by measuring the temperature of the processed raw materials. According to the results of this experimental study, the addition of aluminum oxide particles increased the intensity of acoustic cavitation.

In their study, Greenspan and Tschiegg [28] filtered dust grains from distilled water and found that the tensile strength of water, measured by acoustic cavitation at 43 kHz, increased as the grain size decreased, until at 0.2 microns the tensile strength a gap of more than 200 bar could not be maintained. Similarly, the tensile strength increased when the gas content of the water was reduced, but when filtered down to particle sizes less than 0.2 microns, the gas content did not affect the tensile strength. According to the conclusions made by the authors, the filtered particles could be both particles and bubbles of stabilized gas, but gas bubbles with a size of 0.2 microns would not cause such a high tensile strength. The authors of the study concluded that the solid particles were responsible for the tensile strength, and that the cavitation cores were interfacial gas bubbles much smaller than the particles themselves. The numerical relationship between particle size and tensile strength was not reported by Greenspan and Tschiegg.

Thus, the addition of solid particles has a direct effect on the cavitation threshold. Nevertheless, the intensity and threshold of cavitation creation is influenced not only by the fact of the presence of certain solid impurities, but also by their size and hydrophilicity.

According to the results of the works [29], hydrophobic particles work more efficiently as cavitation nuclei compared to hydrophilic particles. Cavitation bubbles can easily form on the surface and crevices of such solid particles. The cavitation threshold of coarse hydrophobic silica was lower than that of smooth hydrophobic glass beads. This indicates that the wettability of a smooth particle is higher than that of a rough particle. In other words, coarse particles will trap more gas nuclei on their surface in water than smooth particles. Cavitation threshold tests were carried out with suspensions of particles of various hydrophobicity, surface roughness, concentration and gas content. The authors found that the degassing of the liquid enhances the wetting of solid particles. The cavitation threshold of hydrophobic silica suspensions before and after degassing was 0.2 and 1.0 MPa, respectively. The degassing process removed the bubbles trapped on the surfaces of the particles, thereby contributing to the wetting of minerals with water.

Based on the information presented, it can be assumed that certain cavitation numbers may be valid for a uniform homogeneous nucleation of cavitation bubbles. Nevertheless, it is practically impossible to achieve homogeneous cavitation initiation under real conditions, since cavities are formed either in the region of cavitation nuclei or near the surface of solid walls. Thus, the probability of cavitation depends on two factors: the probability of formation of nuclei and the concentration of nuclei. However, in addition to the presence of so-called cavitation nuclei, other properties of liquids, including vapor pressure, temperature, viscosity and surface tension, also affect the intensity of cavitation created.

In the existing expressions describing the dimensionless number of cavitation, only the density and pressure of steam describes the characteristics of the processed liquid raw materials. At the same time, the viscosity and surface tension of the liquid also affects the creation threshold and the intensity of cavitation, but are not directly related to the vapor pressure or density used in calculating the cavitation number.

In order to fully evaluate and simulate the influence of the physical properties of a liquid on the threshold of creation and the intensity of cavitation, scientists use methods of controlled changes in physical properties. Salt solutions (NaCl) based on distilled water are often used in scientific works. The addition of NaCl can linearly affect a number of properties of liquids [7,30], including vapor pressure and surface tension, and the physical properties of salt solutions at various concentrations are reliably known.

One of the effects of dissolved salts in a liquid is to slow down the fusion of cavitation bubbles due to the drying of the liquid film between the two bubbles upon contact, which accordingly leads to a decrease in cavitation bubbles [31]. Additional reduction of cavitation bubbles is achieved with an increase in salt concentration due to an increase in surface tension. Based on the results of the work [32], it can be concluded that the surface tension has a significant effect on the dynamic behavior of the cavitation bubble. A lower surface tension leads to more intense bubble dynamics, including a reduction in bubble lifetime, an increase in microjet velocity and instability.

The effect of surface tension on the dynamics of the cavitation bubble was also evaluated in the work [33]. The results of the study showed that a lower surface tension increases the deformation of the gas–liquid interface, which leads to a more concentrated microjet.

An increase in the concentration of dissolved salt in the liquid also leads to a decrease in the concentration of saturated gas, which leads not only to a decrease in cavitation bubbles, but also to a decrease in their size [30].

In the work [34], comparative experimental studies were conducted to study the mechanism of formation and dynamics of cavitation bubbles in distilled water and in water saturated with NaCl and KCl salts. In distilled water, both inertial and non-inertial cavitation bubbles are observed, and in saturated salt solutions only inertialess cavitation bubbles, the zones of occurrence of which are strictly fixed, and their location does not depend on the power of the ultrasonic source.

Another parameter that also influences the development of cavitation is the temperature of the processed raw materials. The degree of influence of the temperature of the processed liquid raw materials on cavitation has been evaluated in many different works [35-38]. According to the results presented in these papers, the low temperature of the treated liquid (water) prevents the formation of cavitation bubbles, but leads to their more intense collapse, while the increased temperature of the medium, on the contrary, leads to accelerated formation of cavitation bubbles, reducing the energy released when they collapse. A decrease in the collapse energy of cavitation bubbles at high temperatures occurs due to the inability of the bubbles to retain steam inside themselves [39]. The authors [38] have shown that the ideal balance between the number of cavitation bubbles and the force of bubble collapse is achieved at an average temperature between the freezing point and the boiling point. For water, the optimal temperature for creating cavitation, which allows achieving the necessary balance between the collapse energy and the number of bubbles, is 40-50℃.

When studying the effect of temperature on cavitation, it is necessary to take into account the effect of temperature on other liquid parameters, including viscosity. The viscosity decreases at higher temperatures, and the Reynolds number increases [8]. At the same time, the temperature change has practically no effect on the change in the dimensionless number of cavitation in the existing expressions. The decrease in viscosity, in turn, leads to an increase in the intensity of cavitation due to the weakening of molecular bonds.

Taking into account the versatility of parameters that directly affect the cavitation onset threshold and its subsequent intensity, the use of a dimensionless cavitation number in its current form does not make it possible to reliably predict the cavitation onset threshold. The complexity of cavitation also lies in the variability of fluid parameters in the course of work.

One of the most promising technologies for the application of cavitation is the treatment of liquid hydrocarbons. Cavitation treatment of such a multi-dispersed liquid as oil or oil residues can affect not only the rheological properties, but also change the fractional composition. At the moment of collapse of cavitation bubbles, the pressure and temperature of the gas reach significant values, and according to some data reach 100 MPa and 1000 ℃, respectively [40], heating the initial product and creating optimal conditions for chemical reactions, including for the destruction of chemical compounds.

A number of research papers have confirmed that the treatment of crude oil by cavitation is able to reduce the viscosity of the product. At the same time, viscosity reduction is achieved both by heating the initial product [41] and by exposure to individual components of the liquid hydrocarbon product [42], including asphaltenes [43] and paraffins [44]. Considering the fact that during the cavitation treatment of liquid raw materials, the rheological properties of the initial product may change, it is worth noting that even with optimally selected parameters of the technological process before processing, during the implementation of the technological process itself, the conditions inside the working chamber of the cavitation generator will change, thereby possibly reducing the intensity of cavitation and, accordingly, the processing efficiency. At the same time, it is more difficult to predict changes in conditions during the implementation of the technological process than to find the initial optimal cavitation number. The change in the rheological properties of raw materials largely depends on the fractional composition of the initial product (oil), while there is still no common understanding of how cavitation affects various components of the oil product. On the example of petroleum products, it can only be noted, for example, that the effect of cavitation on various petroleum products is different. The article [45] states that paraffin oil was better exposed to cavitation, respectively, in paraffin oil, the change in rheological properties will be more noticeable.

4. Discussion

Until now, there are no precise methods in the scientific field for estimating the intensity of the cavitation created in a liquid. In each study, the authors use their own evaluation method, which is often difficult to compare with the evaluation results of other studies. The inconsistency of the results of using a dimensionless cavitation number and a large number of expressions for its calculation only confirm the lack of an accurate understanding among scientists of the mechanisms of influence of the initial parameters of the liquid product and the geometry of the cavitation generator on the threshold of the onset and intensity of the cavitation created.

In most studies, scientists artificially create controlled conditions by adding certain substances to assess their effect on the threshold of creation and intensity of cavitation. Nevertheless, under real conditions, when processing a lot of dispersed liquids, the complexity of the fractional composition has additional unpredictable mutual effects both on each other and on the intensity of cavitation. The lack of information about the mutual influence of various parameters on each other and on the intensity of cavitation does not allow predicting the treatment of natural systems by cavitation. Given the versatility of the fluid parameters, further research should be based not on an assessment of the effect of individual fluid parameters on cavitation, but on the gradual complication of experimental research conditions by sequentially adding new variables within the experiment that affect the threshold for creating cavitation. Such a nonlinear regression analysis for a specific geometry of the generator and the cavitation fluid should be based on all the basic parameters of the liquid raw materials obtained from the results of a theoretical study, including the concentration of dissolved salts, the presence of solid impurities (hydrophilic and hydrophobic), gas inclusions, surface tension, temperature and viscosity. Regression analysis will allow us to assess the degree of influence of individual raw material parameters and include them in the calculation of the dimensionless cavitation number. The results of such experimental studies will allow us to obtain new empirical data to clarify the dimensionless cavitation number.

However, the complexity of cavitation also lies in the variability of the parameters of the processed raw materials during the implementation of the proposed technological process. The collapse of cavitation bubbles, as mentioned above, leads to the release of energy and a local increase in temperature and pressure. During the collapse of cavitation bubbles, not only the temperature of the raw material increases and the viscosity of the liquid changes accordingly, but also the fractional composition of the liquid medium changes. For certain types of liquid materials, for example, liquid hydrocarbons, a change in the fractional composition leads to a change in the viscosity and density of the medium. Even with the initially correctly calculated dimensionless cavitation number, and the selected parameters of the technological system for the corresponding liquid substance, conditions will change during processing, which will entail changes that worsen the predicted cavitation intensity. These conditions will require researchers to calculate not only the number of cavitation of the start of work, but also the number of cavitation of the implementation of the technological process, which will compensate for changes in the number of cavitation during the design of the processing system.

5. Conclusion

In general, based on the theoretical research conducted, it can be concluded that it is impossible to use the cavitation number in its existing form to predict the threshold for the onset of cavitation and its intensity. The disadvantages of the existing expressions of the dimensionless cavitation number include not only the apparent lack of connection with the geometry of the cavitation generator, but also the lack of connection with the basic parameters and properties of a liquid substance, including surface tension, the presence of solid impurities and dissolved gas, the concentration of dissolved substances.

Nevertheless, further research in the field of regression analysis of the influence of liquid properties on the threshold of the onset of cavitation and its intensity will reduce the existing range of the spread of the number of cavitation for different types of liquids.

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