# VARIATION OF THE SOUND VELOCITY IN CAVITATING LIQUID

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A method based on the properties of the sonocapillary (SC) effect and developed to determine the sound velocity in a cavitating liquid is described. The features of the method have been analyzed in the cases where it is applied to liquids with various molecular properties, in particular, distilled water, an aqueous solution of glycerol, and a solution of castor oil in dibutyl phthalate. The results obtained are compared with the data known for vapor-liquid media in a stationary state and under the phase transformation. A conclusion concerning the character of oscillations of cavitation voids under the capillary channel has been drawn.

## 1. Introduction

Cavitation is a powerful enough and effective instrument for affecting the properties of liquids and the course of physical and chemical processes in them [1]. But the absence of reliable methods for the localization of the cavitation process makes the study of the physical phenomena, which accompany the cavitation excitation, complicated and substantially confines the potentialities of researches of the general physical parameters of cavitating media. The application of the SC effect to the localization of a cavitation cloud just under the capillary channel expands the capabilities in studying the cavitating liquid. In particular, the SC method was used to study the variation of the electric properties of a cavitating liquid, as well as the corresponding phenomena of the electrokinetic nature occurring under new physical conditions [2]. Moreover, the SC method turned out an effective tool in researching the modification of the molecular properties (in particular, the viscosity) of a liquid that was subjected to a cavitation influence, as well as the features of the flow of such a liquid through capillary channels [3, 4]. In this work, the capabilities of the SC method in determining the sound velocity in a cavitating liquid — the $c_c$ parameter which characterizes the thermodynamic properties of the medium – are described.

It is known [5] that the sound velocity $c_0$ is determined in the general case in terms of the substance density $\rho_0$ and its adiabatic compressibility $\beta_a$ as

$$c_0 = \frac{1}{\sqrt{\beta_a \rho_0}}. \tag{1}$$

Consider biphasic media, in particular, liquids with gaseous bubbles, for which the high density and the high compressibility are predetermined, respectively, by the high density of a liquid and by the high compressibility of the gaseous component. In this case, a significant reduction of the sound velocity in comparison with the corresponding value $c_0$ for a dense liquid is observed. According to the data reported by various authors [6–10], the experimentally determined sound velocities in various vapor-liquid mixtures are equal to 20—100 m/s.

A cavitation cloud formed in the ultrasonic field is the association of periodically arising vapor-gaseous inclusions in the liquid, i.e. it is a kind of the biphasic medium. Therefore, from the viewpoint of the authors of work [1], the relevant expected values of the parameter $c_c$ should fall within the indicated interval. Nevertheless, as was shown in work [10], it is reasonable to consider the cavitation in liquefied gases as the process of liquid boiling at low temperatures owing to the periodic reduction of the pressure in it. Supposing that such an interpretation is valid for the cavitation in distilled water as well, we note that the modification of medium properties owing to the sound propagation is also

responsible for a change of the parameter $c$. In particular, for a liquid, where an ultrasonic wave stimulates the phase transition (vapor formation), the sound velocity is determined by the expression [7, page 10]

$$c = \frac{P_m L}{\rho_1 \sqrt{CT}} \frac{\mu}{RT}, \tag{2}$$

where $L$ is the specific latent heat of the phase transition, $\mu$ the molar mass of a substance, $R$ the universal gas constant, $C$ the specific heat of the liquid, $T$ the temperature, at which the process runs, and $P_m$ the pressure amplitude in the sound wave. Using expression (2) with the parameters corresponding to those for distilled water, we obtain the value $c_c \approx 1$ m/s, i.e. two orders of magnitude lower than that for a stationary gas-liquid medium. We emphasize that the interpretation of the cavitation as a phase transition in distilled water, especially at high contents of a gas, remains debatable [10, 11]. Therefore, the experimental evaluation of the parameter $c_c$ will allow one, in particular, to draw a conclusion about which model (oscillating bubbles filled with gas or voids into which the evaporation from the as-formed interface takes place) is more adequate to the real situation.

## 2. Physical Foundations of the SC Method for the Determination of the Sound Velocity in Cavitating Liquids

The concept of the parameter $c_c$, the sound speed in a cavitating medium, was first formulated while considering the wave resistance of a liquid $\rho_c c_c$ in the volume of an ultrasonic concentrator on the cavitation excitation [1]. The same work reported the results of a study concerning a variation of the acoustic loading on an acoustic radiator on the cavitation excitation. These results were used to determine the ratio between the wave resistances $\rho_c c_c / \rho_0 c_0$ and, correspondingly, the parameter $c_c$. The values, deduced from experimental data, fell within the range $c_c = 30 \div 1000$ m/s and depended substantially on the ratio between the volumes of a cavitation cloud and a concentrator, i.e. on the conditions, under which the method was realized.

The results of researches of the sonocapillary flow of a liquid make it possible to tackle the problem of experimental determination of the sound velocity in a cavitating medium from another side, without making use of the wave resistance concept. In this case, the ratio between the volumes of the cavitation cloud and the ultrasonic bath turns out insignificant.

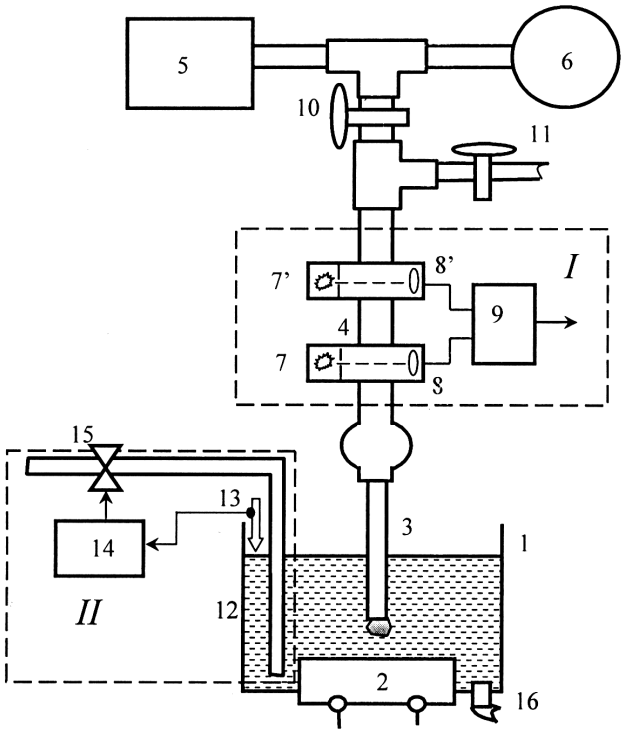



Fig. 1. Scheme of the experimental installation: *I* — the block for measuring the velocity of a liquid flow, *II* — the block of stabilization of the acoustic loading on a radiator

It is known that the ultrasonic field of a running wave can be characterized by two energy parameters: the energy transferred through a unit area per unit time, i.e. the intensity $J_0 = P_m^2/(2\rho c)$, and the energy accumulated in a unit volume of the ultrasonic field, i.e. the energy density $\omega_0 = P_m^2/(2\rho c^2)$. The ratio between these parameters characterizes the velocity of sound propagation in an unexcited liquid [5]

$$c_0 = \frac{J_0}{\omega_0}. \tag{3}$$

Therefore, provided that the experimental data for $\omega_c$ (the energy density in a cavitating liquid) and $J_c$ (the energy transferred through a unit area per unit time in a cavitating medium) are known and using a relation similar to expression (3), we can obtain the value of the parameter $c_c$, the sense of which is the velocity of sound in the cavitating medium.

**2.1.** The key element of the experimental installation (see Fig. 1) is ultrasonic bath *1* filled with a working liquid. In the bottom part of the bath is mounted ultrasonic transducer *2*. It generates 18.5-kHz ultrasonic oscillations with the regulated amplitude of pressure $P_m$

in the bath volume. Measuring tube *4* connects capillary *3* with compressor *5* and manometer *6*. The increase of static pressure $P$ in the capillary system owing to the local dissolution of a gas under the capillary channel stimulates the excitation of a cavitation cloud just here. The scheme shows the block for measuring the velocity of liquid flow ($I$) and block ($II$) that stabilizes the conditions for exciting the cavitation.

In order to provide a required accuracy for the measurements of the flow velocity $v$, two point-like light sources *7* and *7′* are rigidly fixed on measuring tube *8*. The diaphragmed light beams emitted by those sources are directed to optical receivers *8* and *8′* (photodiodes). The signals from the receivers are sent to electronic converter *9* which forms two consecutive П-shaped pulses. The generated pulses are supplied to the input of a frequency meter operating in the mode of time interval measurements. Such a method allows the time which is needed for the tube volume between beam levels to be filled and, correspondingly, the volumetric water discharge to be determined with an error less than 0.01%. Using the ratio between the diameters of the capillary and the measuring tube, one can evaluate the average velocity of a liquid flow through the capillary.

Note that the velocity of the liquid flow in the capillary can achieve values of 1–2 m/s under the SC effect. This means that the meniscus moves along a 2–3-cm capillary during a few milliseconds. The formation time of a cavitation cloud is about several milliseconds as well, thus being comparable with the time of the liquid flow through the capillary. In order to register the parameters of the stationary flow, measuring tube *4* possesses an expanded section towards its bottom end. The time, which is needed for the liquid to fill the extra volume, considerably exceeds the cavitation development time and the time needed for the stationary liquid flow to form in the capillary. In this manner, the error, which can be induced by the instability of the cavitation process at its initial stage, becomes excluded.

Cocks *10* and *11* in Fig. 1 are mounted for technological purposes: after the conditions for the excitation of local cavitation having been created and the stationary flow having been formed, cock *10* is turned off to prevent the ingress of the liquid into a compressor and a manometer, while cock *11* is turned on to provide a continuous outflow of the liquid into a vessel.

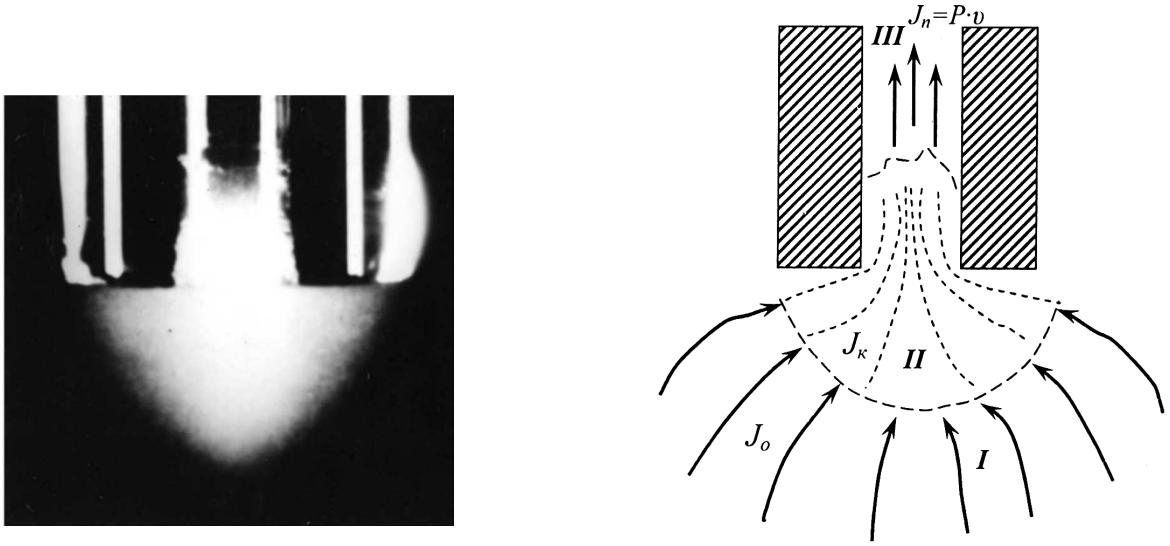
Stabilization block $II$ makes it possible to ensure, first, a constant acoustic loading on the radiator and, second, a constant low gas content in the liquid in the course of measurements. Distilled water, admitted into the bath through inlet tube *12*, was preliminary boiled and cooled in a coil serpentine away from the air intake. After the bath having been filled, the constant level of the liquid in it is maintained using pin *13*: if the liquid level decreases and the contact between the pin and the water surface becomes broken, electronic block *14* generates a signal that controls valve *15*, and the latter turns inlet nipple *12* on. In the course of the experiment, the gas-saturated liquid steadily flows out through outlet nipple *16*. Such a configuration allows one to provide an optimal constant gas content in the liquid.

**2.2.** As follows from the description of the experimental installation, a stationary wave arises in the liquid volume under our experimental conditions. In the absence of cavitation, the stationary wave does not transfer energy. But as soon as the cavitation has been excited under the capillary channel, a directed liquid flow emerges, i.e. a channel, which serves for the removal of the acoustic field energy transformed into the energy of the hydrodynamic flow, becomes open.

Figure 2 demonstrates a stationary cavitation cloud created under the capillary channel (panel $a$) and a scheme which allows one to analyze the energy transformation and the energy transfer in this region (panel $b$). It is significant that the volume of the cavitating liquid (panel $b$, region $II$) has a well-pronounced boundary with the rest of the liquid that fills the bath (region $I$), as well as with the liquid in the capillary (region $III$). The liquid in region $I$ oscillates, but, on the average, it does not move. The liquid in the capillary (region $III$) does not oscillate, but it creates a stationary unidirectional flow with a velocity $v$ directed from the ultrasonic field volume. The SC flow can be characterized by the power density $\omega_p$ and the power $J_p$ transferred through a unit area of the capillary cross-section; the latter parameter, by its dimension and physical sense, is analogous to the intensity $J_0$ of the acoustic field created in the cavitation excitation region.

It is evident that the ultrasonic field energy is converted into the energy of directional liquid flow just in the cavitation volume (region $II$ in Fig. 2,$b$), and just the cavitation region serves as a channel for removing the acoustic energy. Hence, the existence of the flux of the primary exciting field power $J_0$, as well as the power flux $J_p$ in the capillary channel, implies the energy transfer through the cavitating medium which is characterized by the density of energy flux $J_c$.

Similar speculations were presented in work [12] while discussing the mechanism of formation of the SC flow in a capillary. In particular, it was shown there that the amplitude of $J_p$ does not exceed the density of the




**a** **b**

Fig. 2. (*a*) Cavitation cloud excited under the capillary channel; (*b*) the scheme of energy conversion and energy flow in the cavitation excitation region

acoustic energy flux in a cavitating medium $J_c$, and the energy flux density $\omega_p$ does not exceed the energy density in the cavitating medium $\omega_c$. Moreover, provided that the static pressure $P$ in the capillary is low, the approximate equalities $J_c \approx J_p$ and $\omega_c \approx \omega_p$ are satisfied. Therefore, applying formally relation (3) in order to determine the sound velocity in the cavitating medium, we obtain

$$c_c = \frac{J_c}{\omega_c} \approx \frac{J_p}{\omega_p}. \tag{4}$$

As follows from the last expression, the determination of power characteristics of the SC liquid flow forms the basis of the method concerned. The energy density $\omega_p$ of the liquid that flows with the average velocity $v$ is evaluated by the well-known expression $\omega_p = \rho v^2/2$, while the power of the liquid flow through the capillary under the conditions of our experiment by the expression $J_p = Pv$ (the quantity $P$ characterizes the counteracting static pressure in the capillary).

## 3. Results and Their Discussion

Following the technique described above, the dependences $v(P)$ of the liquid flow velocity on the counter pressure in capillaries with various diameters $d_{\rm cap}$ and lengths $l_{\rm cap}$ and for various amplitudes of the sound pressure $P_m$ were measured. Distilled water, the aqueous solutions of glycerol with various concentrations, and the solution of castor oil in dibutyl phthalate were chosen for researches. The obtained body of data on $v(P_m, P)$ was used to determine the energy parameters of the flow, $J_p$ and $\omega_p$, as well as their ratio $J_p/\omega_p$.

**3.1.** It is well known that, for the liquid flow through the capillary to be stationary, the static counter pressure $P_{\rm st}$ should be applied, and it is the minimal experimentally achievable value for the quantity $P$. Therefore, if relation (4) is used, the ratio $J_p/\omega_p$ evaluated at the pressure $P = P_{\rm st}$ is closest to $c_c$. Some of the results obtained for distilled water and using various capillaries are presented in Table 1.

The analysis of all experimental data brings about the results, which do not contradict the data quoted in Table 1, and allows the following generalization to be made: for distilled water, the values of the ratio $J_p/\omega_p$ at $P = P_{\rm st}$ fall within the interval $(4.50 \pm 0.50)$ m/s for capillaries with the internal diameter $(0.30 \div 0.70)$ mm and do not depend on their length.

**3.2.** The data quoted in Table 1 testify that the static pressure $P_{\rm st}$ in the capillary is high enough and substantially affects both the liquid flow through the capillary and the ratio $J_p/\omega_p$. Nevertheless, in the framework of the technique applied to excite the cavitation, a further reduction of the pressure in a real

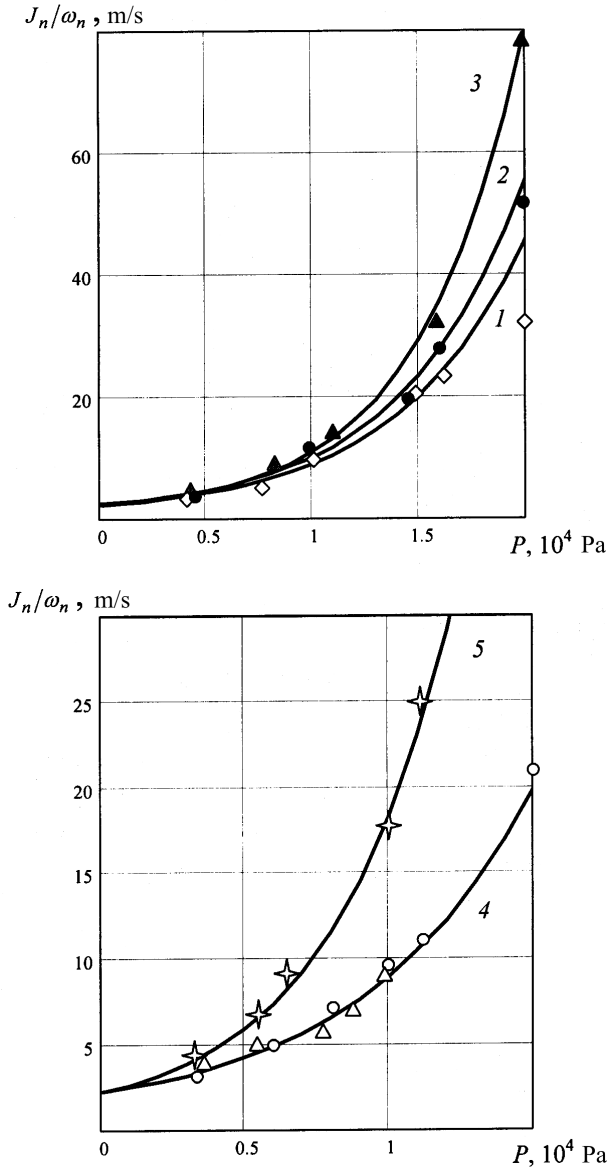



Fig. 3. Influence of the static pressure on the ratio $J_p/\omega_p$ in the case of distilled water for ($a$) capillaries 2.5 cm in length and with various internal diameters $d_{\rm cap}$ = 0.30 (diamonds), 0.50 (solid circles), and 0.70 mm (solid deltas) and ($b$) capillaries with the internal diameter $d_{\rm cap}$ = 0.30 mm and the lengths $l_{\rm cap}$ = 1.5 (hollow deltas), 2.5 (hollow circles), and 5.4 cm (stars). Curves *1–5* are approximation ones. The sound pressure amplitude $P_m = 4.0 \times 10^4$ Pa

experiment is impossible. Therefore, the value of $c_c$ was determined using the extrapolation method, i.e. we found the limit $c_c = \lim(J_p/\omega_p)$ at $P \to 0$ graphically.

The obtained body of experimental data on $v(P)$ was used to plot the dependences $J_p/\omega_p$ versus $P$. The latter were grouped according to the parameters $P_m$, $d_{\rm cap}$, and $l_{\rm cap}$; and the obtained graphic dependences were extrapolated to $P = 0$. Figure 3 exhibits the groups of curves $J_p/\omega_p$ versus $P$ for various capillary diameters (panel $a$) and lengths (panel $b$). Despite the considerable divergence of the curves when $P$ grows, all of them, being extrapolated to $P = 0$, converge to a value of $c_c$ of the order of 2 m/s. Similar results were obtained by extrapolating the groups of $J_p/\omega_p$-versus-$P$ curves for various amplitudes of the sound field (they are not presented graphically).

To find the limit value of $c_c$ more accurately, the experimental dependences were formally approximated by the function $y(x) = b + k\exp(\alpha x)$, and the parameters $b$, $k$, and $\alpha$ were determined numerically with the help of the MathCad software package [11]. The resulting expressions for the approximation function $y(x)$ and the corresponding extrapolation values $c_c = y(0)$ are listed in Table 2.

The obtained functional dependences are plotted by solid curves in Fig. 3. The deviation of the experimental points is at most 7% within the whole exposed range of counter pressure; the maximal deviation of 25% was obtained only for a point which corresponded to the parameters $d_{\rm cap} = 0.3$ mm and $P = 2 \times 10^4$ Pa. So, such an approximation is satisfactory, and the extrapolation to $P = 0$ gives the average value $c_c = 2.23$ m/s. The measurement error was caused by the stochasticity of the cavitation process and the scatter of velocity values, but, no doubt, did not exceed 25%, so that the final result for cavitating distilled water is $c_c = (2.2 \pm 0.5)$ m/s.

**T a b l e 1. SC flow parameters of distilled water at $P_m = 4.0 \times 10^4$ Pa for capillaries with various lengths and internal diameters**

| $d_{\rm cap}$, mm | $l_{\rm cap}$, cm | $P_{\rm cap}$, $10^4$ Pa | $\nu$, m/s | $J_p$, W/m$^2$ | $\omega_p$, J/m$^3$ | $J_p/\omega_p$ m/s |
|---|---|---|---|---|---|---|
| 0.34 | 2.5 | 0.4 | 1.25 | $0.5{\cdot}10^4$ | $0.78{\cdot}10^3$ | 6.67 |
| 0.50 | | 0.5 | 2.5 | $1.25{\cdot}10^4$ | $3.15{\cdot}10^3$ | 3.97 |
| 0.70 | | 0.4 | 2.0 | $0.8{\cdot}10^4$ | $2{\cdot}10^3$ | 4.0 |
| 0.30 | 1.5 | 0.45 | 1.93 | $8.7{\cdot}10^3$ | $1.86{\cdot}10^3$ | 4.67 |
| | 2.5 | 0.32 | 2.06 | $6.4{\cdot}10^3$ | $2.12{\cdot}10^3$ | 3.01 |
| | 5.4 | 0.32 | 1.3 | $4.16{\cdot}10^3$ | $0.85{\cdot}10^3$ | 4.89 |

**T a b l e 2. Approximation functions used to determine parameter $c_c$**

| Curve N in Fig. 3 | Approximation function | $c_c$, m/s |
|---|---|---|
| *1, 4* | $0.7 + 1.5\exp(1.7 \cdot 10^{-4}P)$ | 2.2 |
| *2* | $0.9 + 1.5\exp(1.8 \cdot 10^{-4}P)$ | 2.4 |
| *3* | $1.0 + 1.2\exp(2.1 \cdot 10^{-4}P)$ | 2.2 |
| *5* | $0.6 + 1.6\exp(2.4 \cdot 10^{-4}P)$ | 2.2 |

One should note that the variation of the capillary diameter by a factor more than two did not affect the behavior of the dependence $J_p/\omega_p$ versus $P$ substantially in a wide enough range of pressures (Fig. 3,*a*). Moreover, for capillaries with the length $l_{\rm cap} = (1.5 \div 2.5)$ cm, the experimental points can be fitted — with a sufficient accuracy — by a single curve (Fig. 3,*b*). Therefore, we may take, as a fact, that the properties of the capillary — as the stabilizer of the cavitation process and the key element of the experimental installation for the determination of the parameter $c_c$ — do not distorted the final result.

Making use of the SC method allows one to obtain a well reproducible value for the sound velocity in cavitating distilled water; this value can be regarded as having the physical basis: it corresponds to the representation of the cavitation process as a periodic boiling of the liquid under lowered pressure conditions.

**3.3.** Now, we will demonstrate the features of the SC method, when it is applied to study the liquids, whose viscosity is 1—2 orders of magnitude higher than that of water. In particular, we used the aqueous solutions of glycerol with concentrations of 60 and 65%, which had the initial viscosity of $16.8\times10^{-3}$ and $23.6\times10^{-3}$ Pa × s, respectively, and a solution of castor oil in dibutyl phthalate with a viscosity of $56.2 \times 10^{-3}$ Pa × s.

The liquid flow with a constant average velocity $v$ through a capillary is described by the equation [13, page 539]

$$P_{\rm sc}\pi R^2_{\rm cap} = P\pi R^2_{\rm cap} + 8\pi\eta l_{\rm cap}\upsilon, \qquad (5)$$

where the term on the right-hand side is the viscous force. The comparison of this quantity with the term $\pi P R^2_{\rm cap}$ testifies that, in the case of distilled water and for capillaries used, it has no considerable effect, while for viscous solutions with $\eta = (22 \div 56) \times 10^{-3}$ Pa × s it is almost two orders of magnitude higher than the value of the quantity $\pi P_{\rm st} R^2_{\rm cap}$. This means that the variations of the flow velocity and its power characteristics are governed by the variation of the parameter $l_{\rm cap}$ to a greater extent than it is done by the variation of the static pressure $P_{\rm st}$. Hence, while studying the liquids, whose viscosity is 1–2 orders of magnitude higher than that of water, it is reasonable to analyze the influence of the capillary length on the ratio $J_p/\omega_p$. In accordance with that, the dependences $J_p/\omega_p$ versus $l_{\rm cap}$ were plotted for values obtained at $P = P_{\rm st}$ and extrapolated to $l_{\rm cap} = 0$.

In Fig. 4, the experimental results obtained for the aqueous solutions of glycerol (panel *a*) and the solution of castor oil in dibutyl phthalate (panel *b*) are depicted,

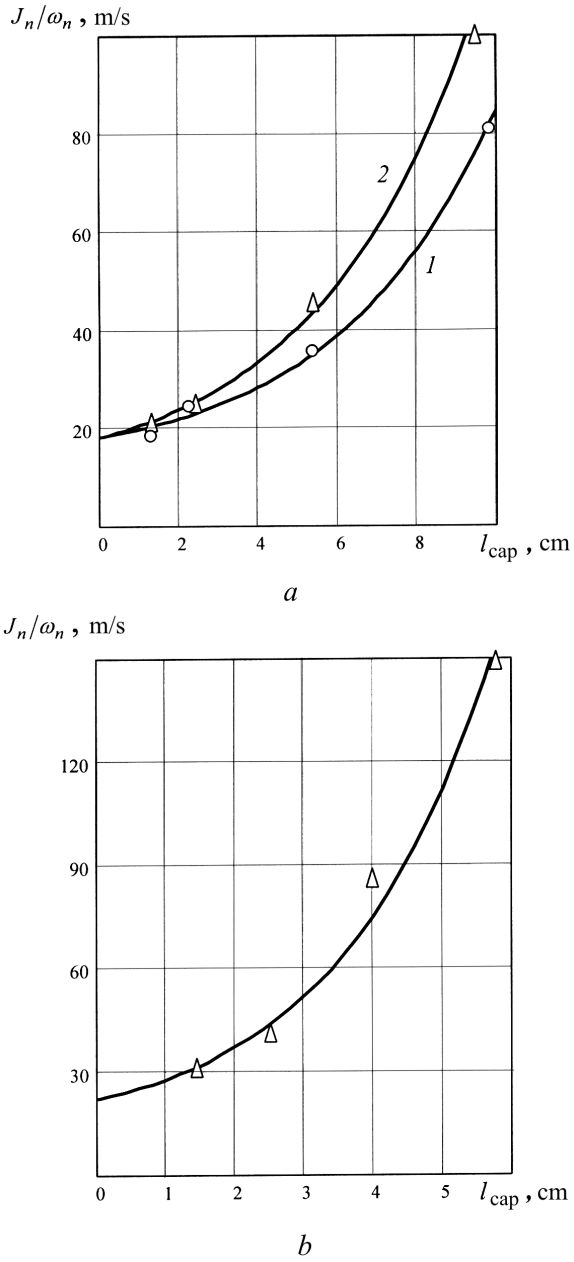



Fig. 4. Influence of the capillary length $l_{\rm cap}$ on the ratio $J_p/\omega_p$ for the lowest counter pressures (*a*) for the aqueous solutions of glycerol with the initial viscosity $16.8 \times 10^{-3}$ (*1*) and $23.6 \times 10^{-3}$ Pa × s (*2*) and (*b*) for the solution of castor oil in dibutyl phthalate

as well as their approximations by the function $y(x) = b + k\exp(\alpha x)$; $x$ stands for $l_{\rm cap}$. The specific approximations are $J_p/\omega_p = 12 + 6\exp(0.25 \times 10^2 l_{\rm cap})$

(curve *1*) and $J_p/\omega_p = 9+9\exp(0.25\times10^2 l_{\rm cap})$ (curve *2*) for the glycerol solutions and $J_p/\omega_p = 12+10\exp(0.46\times 10^2 l_{\rm cap})$ (curve *3*) for the castor oil one.

The extrapolation of the curves to the zero-length capillary region gives the value $c_c = 18$ m/s for the sound velocity in cavitating glycerol solutions, which does not depend on the initial viscosity of the liquid within the experimental error limits. For the solution of castor oil in dibutyl phthalate, the extrapolated value is $c_c = 22$ m/s.

Substituting the tabulated data for the thermodynamic parameters of pure glycerol ($C = 2.1 \times 10^3$ J/(kg $\times$ K), $\mu = 92 \times 10^{-3}$ kg/mol, $L = 0.83 \times 10^6$ J/kg, and $\rho = 1.2 \times 10^3$ kg/m$^3$) and dibutyl phthalate $C_{16}H_{22}O_4$ ($C = 1.5 \times 10^3$ J/(kg $\times$ K), $\mu = 279 \times 10^{-3}$ kg/mol, $L = 0.83 \times 10^6$ J/kg, and $\rho = 1.2 \times 10^3$ kg/m$^3$) into expression (2), we obtain the value $c_c = 1.29$ m/s for the sound velocity in glycerol and $c_c = 1.23$ m/s for the sound velocity in dibutyl phthalate. These values essentially differ from the experimental ones.

At the same time, the result obtained agrees well with those of the researches dealing with the influence of viscosity on the dynamics of pulsations of individual cavitation voids [14]. In particular, it is known that the time of the cavity collapse grows as the viscosity of the liquid increases. Therefore, a cavity, which has been formed during a half-cycle of lowered pressure in the liquid, has no time to collapse completely during the following half-cycle of the increased pressure. Therefore, if the formation of the cavities did happen once, the latter exist further without collapse, i.e. they become pulsating bubbles. For a liquid medium filled with pulsating bubbles, the amplitude of the sound velocity $c_c$ of about 20 m/s is reasonable. The result obtained testifies that, after cavitation having been excited in the viscous liquids concerned, the cavitation cloud contains pulsating cavities, which do not collapse during every oscillation cycle.

## 4. Conclusions

Using the SC effect, a method of determination of the sound velocity in the cavitating medium bulk has been developed. The method is based on such properties of the SC effect as the localization of the cavitation process just under the capillary channel and the formation of a stationary liquid flow through the capillary owing to the cavitation excitation. The method allows one to obtain results which are well reproducible for liquids with various molecular properties and are practically independent of the properties of a capillary used for localizing the cavitation process.

The experimentally obtained value for the sound velocity in each cavitating media under investigation turned out to be 2—3 orders of magnitude lower than the corresponding sound velocity in a dense surrounding liquid. Such a result is in agreement with general physical concepts and allows the processes that take place in a cavitating medium to be distinguished. In particular, it testifies that the formation and the collapse of cavities in distilled water occur within every cycle of the pressure oscillation, and the cavitation process can be regarded as a localized phase transition in a confined medium. In viscous liquids, the cavitation cloud can be considered as a separate volume predominantly filled with pulsating bubbles.

The method proposed allows one to study the specific properties of the cavitation processes in pure liquids and mixtures which are used in physical and chemical technologies.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ЗМІНА ШВИДКОСТІ ЗВУКУ У КАВІТАЦІЙНО ЗБУРЕНІЙ РІДИНІ

*О.Ю. Розіна*

Р е з ю м е

Описано метод визначення швидкості звуку у кавітуючій рідині, в основу якого покладено властивості звукокапілярного ефекту. Проаналізовано особливості застосування методу для рідин з різними молекулярними властивостями, зокрема для дистильованої води, водних розчинів гліцерину, розчину касторового масла у дибутилфталаті. Отримані результати порівнюються з відомими результатами для пароріднного середовища у стаціонарному випадку та в процесі фазового перетворення, що дозволяє зробити висновок про характер пульсацій кавітаційних порожнин під каналом капіляра.