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ABOUT CALIBRATION OF INTENSITY METER UNDER CAVITATION BY AVERAGE VALUE

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A calibration method of an intensity meter is written by average values of an intensity field values in a section of a cavitation torch. Results of this calibration of a wide-range intensity meter with a combined receiver of floating type and experimental data of cavitation field description are presented. Information about possible sensitivity receiver variation inside of cavitation torch information's and also about cavitation medium as one with equivalent acoustic properties were obtained on the base of mention data.

Acoustic fields using in cavitation regime for technological purposes was got about widely. Therefore it is interesting directly measurement of intensity waves, that give rise to liquid cavitation. Information about this physical value is also used under theoretical modules working out of cavitation occurrences for scientific purposes. Intensity metering is of importance for mention conditions as a certain perspective. A known expression mean by time intensity of acoustic wave is taken as a principle of intensity metering:

$$I = \frac{1}{T}\int_0^T pv dt, \qquad (1)$$

where p, v - instant sound pressure and vibration velocity of medium particles values; T, t – period of vibrations and time accordingly. Meanwhile it is important to provide with working frequency band of a device, independence of medium properties for a receiver's part sensitivity and a device calibration.

This work was devoted to experimental researches of an intensity meter. Its wide-range spectrum in an interval of 5-6 most power intensity harmonic and sub harmonic frequency spectrum components of radiating is provided by means of combined receiver miniaturization and concrete working out of device's electronic block. Reception of sound pressure by piezoceramics sphere with 3,2 mm diameter and thickness of a wall 0,4 mm one may supposes not independent of mean medium density decrease at the expense of steam-to-gas cavitation bubbles, arise into it. One may draw a conclusion about it on the basis of got at work [1] theoretical and experimental results for a spherical piezoceramics transducer sensitivity properties definition in water and air.

Reception of medium particles vibration velocity v_0 by oscillations velocity v_s measure for rigid sphere by means of accelerometers and theirs signals integration into drop liquid in particular depends on ratio of mean sphere density $\bar{\rho}_s$ to liquid density ρ_0 [2, 3]. For low frequency region it is written by

$$\frac{v_s}{v_0} = 3\left(\frac{2\bar{\rho}_s}{\rho_0} + 1\right)^{-1}. \qquad (2)$$

However, as known there are a lot of theoretically insoluble questions for liquid with cavitation bubbles. Therefore for first approximating it is expedient to apply a suggesting model of cavitation medium in the form of one with equivalent acoustic properties differing from drop liquid properties. Then without taking into consideration of steam-to-gas mixture density into cavitation bubbles a mean density ρ_c in interval for cavitation medium one may write in the form of

$$\rho_c = \rho_0\left(1 - \bar{k}\right), \qquad (3)$$

where $\bar{k}$ - a mean in interval cavitation index.

For cavitation medium an expression (2) with taking into consideration (3) is written

$$\frac{v_{sc}}{v_c} = 3\left(\frac{2\bar{\rho}_s}{\rho_0\left(1-\bar{k}\right)} + 1\right)^{-1}, \qquad (4)$$

where v_{sc}, v_c - a sphere velocity and vibration one for particles in cavitation medium accordingly.

Equation for vibration velocity of drop liquid particles v_0 and cavitation medium particles v_c is permitted to get an expression for ratio of a sphere velocity in cavitation medium v_{sc} to a sphere velocity in drop liquid v_{s0} in the form of

$$\frac{v_{sc}}{v_{s0}} = \left(\frac{2\bar{\rho}_s}{\rho_0} + 1\right)\left(1-\bar{k}\right)\left(\frac{2\bar{\rho}_s}{\rho_0} + 1 - \bar{k}\right)^{-1}. \qquad (5)$$

It is clear (5), that increase of a cavitation index $\bar{k}$ may result to reduce of a velocity for an oscillating sphere and, accordingly to reduce of an intensity meter sensitivity over compare with mention values of drop liquids. If $\bar{\rho}_s/\rho_0$ = 3,5 and values $\bar{k}$ = 0,1; 0,2; 0,3; 0,4; 0,5 then values v_{sc}/v_{s0} accordingly equal 0,911; 0,82; 0,727; 0,632; 0,533.

Intensity meter calibration under cavitation by mean intensity to a field section in an outlet of a pivot transducer with a guide through a field topographic survey is carried out by a calorimetric method [5, 6]. At the same time systematic various errors of this method were taken into consideration. In consequence it was ascertained that mean sensitivity to a field section for an intensity meter are reduced under transducer's square voltage increases (a fig. 1, diagram 1). Also there is a calibration dot, corresponding to a mean sensitivity of an intensity meter M_0 = 22,3 mV·sm^2/W. This quantity was got under an intensity meter calibration by a boundary-cavitation method over various working regimes for a transducer. Pointed out value must approximately equal to an intensity meter sensitivity in a before-cavitation regime. Most probable hypothesis: mean sensitivity to a field section for an intensity meter reduces under increase of a transducer excitation because of reduce of a receiver sensitivity to a velocity in consequence of increase of mean cavitation index $\bar{k}$ to a field section accordingly to an expression (5). For a cavitation torch intervals it is a result of concentration increase of cavitation bubbles but for a whole section it takes place at the expense of area a cavitation torch section expand.

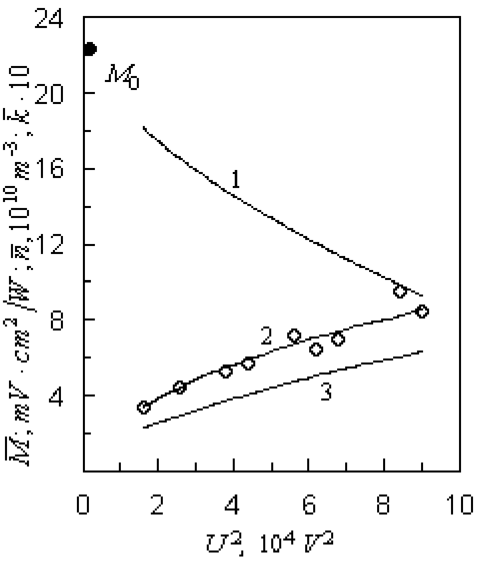

Fig. 1. Diagrams of dependences: mean to an acoustic field section of intensity meter sensitivity (1), concentration of cavitation bubbles (2) and index of cavitation (3) on voltage square of a transducer.

An ascertained fact of reduce about mean intensity meter's sensitivity to a field section brings to conclusion of its variation along section radius because of variation of cavitation index. Hence follows that diagrams dependence of intensity meter signals on a field section radius [7] require correction for more precise description of disposition intensity field value towards acoustic axis.

It is known, that mean to volume cavitation index of working liquid is measured by dilatometer method [8], and for local liquid volume is made that by moving-image camera [4]. Also it is known about metering of a cavitation medium density along a field section diameter by weightless in medium of a steel sphere with diameter 3 mm, covered by a rubber layer [7]. Measurements results show about reduce of medium density in some field dots for 20÷25 %. This method has deficiency – power hydrodynamics flows in cavitation medium in a transducer outlet influence over a sphere and not be removed completely.

For measures along a field section radius it was offered to use a widely applied demonstration method of cavitation influence by aluminum foil. Last one by thickness of 10÷20 μm was placed through diametric plane on an acoustic axis by a support and then, it was moved to outlet of a transducer surface. An ultrasonic generator and a transducer were switch on for one second. Time was measured by a stop-watch. Experiments were conduced under preliminary determined and measured by electronic voltmeter various voltage at transducer. In experiment joined to an outlet transducer surface near border of foil its area was examined by a mask with a square window having dimension of 5×5 mm. Made by cavitation bubbles quantity of deformation tracks was calculated along perpendicular axes in a central part of area by microscope MBS-2 with oculars $8^{\times}$. For example a foil's deformation disposition by cavitation bubbles was shown in a fig. 2. Least scale division corresponds to 0,05 mm an outlet transducer surface disposes to left and perpendicularly to foil plane. In the time of volumetric concentration determination of deformation *n* it was assumed that theirs a mount equally along parallel to outlet surface of transducer axes. A mask was moved by 5 mm along a foil border. In result disposition of volumetric concentration of deformation with mean to volume of cube V_k = $1{,}25\cdot10^{-7}$ m^3 was defined. Then mean volumetric concentration $\bar{n}$ into a medium layer by thickness of 5 mm under various voltages *U* at a transducer was determined. Dependence on $\bar{n} = f\left(U^2\right)$ was shown by diagram 2 in a fig. 1. Deviations of measuring results of diagram were presented by continuous dots. There is also in a diagram 3 an alteration of mean cavitation index to full field section (fig. 1). It was calculated by most chance values of mean sensitivity alteration for intensity meter (diagram 1) through got expression

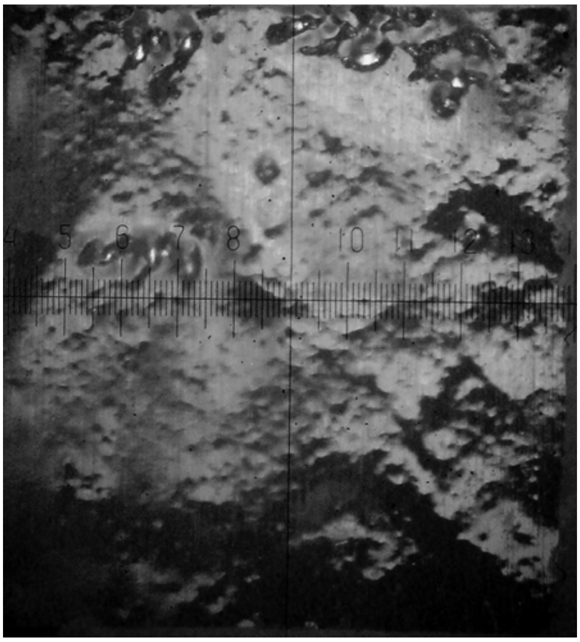

Fig. 2. An example for deformation situation of a foil by cavitation bubbles.

$$\bar{k} = \left(\frac{2\bar{\rho}_s}{\rho_0} + 1\right)(1-\delta)\left(\frac{2\bar{\rho}_s}{\rho_0} + 1 - \delta\right)^{-1}, \qquad (6)$$

where $\delta = \bar{M}/M_0$ - a ratio of an intensity meter sensitivity into cavitation medium to that one into drop liquid.

So far as diagrams 2 and 3 by slope approximately coincide one may suppose that mean to section index of cavitation $\bar{k}$ and volumetric concentration of deformations $\bar{n}$ is linear dependence for measure error limits. On the bases of it an empirical equation of connection for abovementioned values was got: $\bar{k} = C\bar{n}$, and C = $6{,}87\cdot10^{-12}$ m^3. It was allowed to calculate an index of cavitation and corresponding value of correction signal for intensity meter in dependence on field section radius at various regimes of excitement for transducer. A diagram of an intensity meter signal in dependence on a field section radius under transducer voltage of 300 V is shown in a fig. 3. In the same place got by taking into consideration index of cavitation corrections of intensity meter signal (diagram 2) were shown too in the form of polygon.

One may note the intensity field decrease in its central part may be explained for given transducer radius by interference occurrences because of sound velocity decrease into medium cavitation.

At the end it is note about like conformity calculated and got experimentally intensity meter sensitivity values with co-vibrating receiver under similar index of cavitation. Besides, mean to field section calculated results of maximum cavitation bubbles radiuses $\bar{R}_m = 0{,}112 \div 0{,}120$ mm at excitements transducer given correspond to known by order of magnitude. There is confirmation about justice of use a model for cavitation medium and possibility of intensity meter application as research instrument for ultrasonic cavitation study.

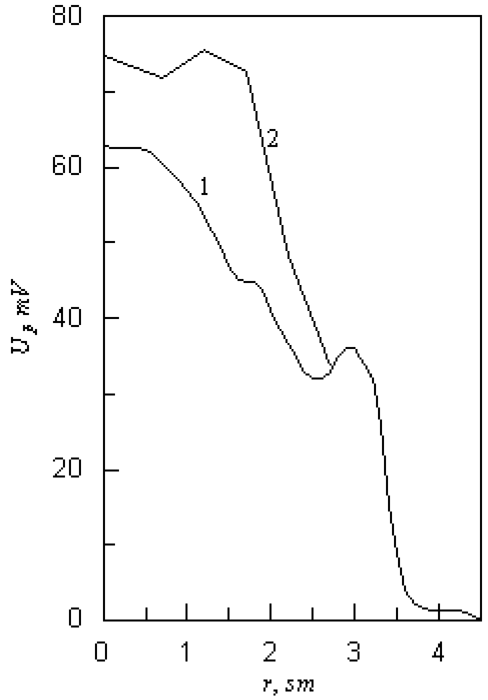

Fig. 3. Diagrams of dependences: an intensity meter signal on a section radius of acoustic field under transducer voltage 300 V (1) and a correction value of an intensity meter signal at the expense of taking into consideration of cavitation index (2).

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