

V.V. Borodin, A.A. Danilov*, V.N. Kornienko**
**NUMERICAL SIMULATION OF SHORT ACOUSTIC PULSE DIFFRACTION ON
COMPLICATED CONFIGURATION MEDIA**

LPA Scientific Centre for Wave Research, IOPh, Russian Academy of Sciences
bld. 38, Vavilov st., Moscow, 117942, Russia
Tel.: (095) 940-0212; Fax: (095)
E-mail: borodinvv @ nsvi.ru

* Andreyev Acoustic Institute
bld. 4, Shvertik st., Moscow, 117036, Russia
Tel.: (095) 126-9837; Fax: (095) 126-8411
E-mail: bvp @ akin.ru

**Institute of radio facilities and electronics, Russian Academy of Sciences
bld. 11, Mokhovaya st., Moscow, 125009, Russia
Tel.: (095) 203-2396; Fax: (095) 2038414
E-mail: korn@cplire.ru

One of the most important problems of hydroacoustics is verification of big acoustic antennas. Their construction is rather complicated: it consists of its dome, an antenna's frame, its screens and etc. All this leads to appearance of a complicated acoustic picture, that is necessary to calculate before carrying out of calibration.

The authors have used the numerical algorithm solving non-stationary equations hydroacoustics, based on the method of finite differences. It allows to determine the dynamics of the sound field, developed by fixed spatial-distributed sources with free temporary dependence within areas, containing local heterogeneous things of a complicated geometric configuration. This algorithm has been used for research of flat sound pulses diffraction on media, which bounds properties are considered fixed.

Sonic transparent domes are installed in the bow compartment of a surface ship and they are a protective body for reception and radiation antennas. They must ensure a high transmission coefficient of sound in a wide frequency band and low phase distortion, under which an error to be set on an object caused by the dome's shell is not more than several minutes. In this case minimum distortions of the antenna direction characteristics, decreasing of acoustic noise and enough mechanical strength of a construction must be reached.

Domes made from polymer materials, for instance, glass plastics meet above mentioned requirements. Glass plastic domes with bigger thickness have the same and even higher sonic transparency than metal ones, moreover they can be made without stiffening ribs. Sonic transparent shells usually have complicate configuration and they must be made from material with density is very close to water density with simultaneous reach of high mechanic strength of the structure. When a sonic wave is radiated through a dome's shell amplitude-phase distortions are formed on its front. The antenna takes the main signal as well as reflected from shell's interior surface one. Signal reflected from the shell forms a side field which is caused by the shell's form in significant degree. That's why the slope of a shell can be considered as a determining factor. Obviously that coefficient of reflection from shell's interior surface is as small as high sonic transparency.

In connection with above mentioned issues it is necessary to investigate distribution of sonic field on an antenna's surface as a result of wave diffraction from a source of fixed type. Before recent time in order to solve such task they used mainly geometric acoustics approximation. This approach in spite of its limitations allows to explain qualitatively main observed in an experiment peculiarities of acoustic field forming in a medium with complex constructions.

The main aim of the work is calculation of non-stationary acoustic field creating in a liquid homogenous medium as a result of field diffraction developed by a fixed source on boundaries of hydro-acoustic system, consisting of dome's sonic transparent shell, antenna and special non-transparent screen (cofferdome).

It is proposed that geometric sizes, position of objects and their acoustic properties do not change during time. The task is given in the following way. Let us examine in plane of construction's (dome + antenna + cofferdome) horizontal section D area of rectangular form in rectangular coordinate system. In two-dimensional D area containing heterogeneities formed by contours of construction's section (pic.1), sonic field, caused by either a local point impulse source or a sonic impulse with plane front sets up.

Obtained as a result of diffraction on bounds of heterogeneities sonic field responds to the system of linear equations (Ailer equation and continuousness equation) [1], written in scholar form

$$\left\{ \begin{aligned} \frac{\partial v_x(\vec{r},t)}{\partial t} &= -\frac{1}{\rho_0(\vec{r})} \frac{\partial p(\vec{r},t)}{\partial x} \\ \frac{\partial v_y(\vec{r},t)}{\partial t} &= -\frac{1}{\rho_0(\vec{r})} \frac{\partial p(\vec{r},t)}{\partial y} \\ \frac{\partial p(\vec{r},t)}{\partial t} &= -\rho_0(\vec{r}) c^2(\vec{r}) \left\{ \frac{\partial v_x(\vec{r},t)}{\partial x} + \frac{\partial v_y(\vec{r},t)}{\partial y} \right\} \end{aligned} \right. \quad (1)$$

Here $p(\vec{r},t)$ is sonic pressure, $v_x(\vec{r},t), v_y(\vec{r},t)$ - are components of vector of speed of wave movement of medium's fragments in sonic wave, $\rho_0(\vec{r}), c(\vec{r})$ are density and sonic speed correspondingly. We notice that in the general case dependence of medium density and sonic speed on spatial coordinate can be free, however changing these quantities in scale of characteristic wave length must be small. On D bounds it is possible to write conditions of type conditions of Zommerfeld radiation.

With powerful computer equipment it is possible to use the method of final differences. In [2] difference schemes to solve system (1) are given and conditions of selection of net steps $\Delta x; \Delta y$ by coordinates x and y correspondingly are identified. With this step for time Δt is given. In [2] condition for selection Δt for which difference scheme is stable is identified. Final difference conditions on bounds of D area are written for normal to bounds components of wave speed. If it is proposed that on the right bound of the area structure of sonic field coincides with the structure of plane going wave the meanings v_x of speed component in net's bound nodes will meet the following correspondence:

$$v_{x_{i,j}}^{k+3/2} = \frac{\left(1 - c_{i,j} \frac{\Delta t}{\Delta x}\right) v_{x_{i,j}}^{k+1/2} + \frac{2\Delta t}{\rho_{i,j} \Delta x} p_{i-1,j}^{k+1}}{1 + c_{i,j} \frac{\Delta t}{\Delta x}} \quad (2)$$

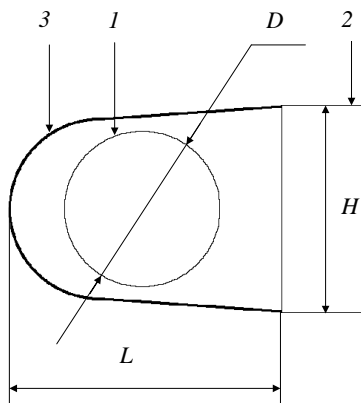


Fig.1. Scheme of construction.

In the task two types of sources: point and impulse with flat front were used.

Water medium where is the construction (dome + antenna + cofferdome) is considered homogenous with permanent density and sonic speed. Density of material used for a sonic transparent dome's shell and correspondingly sonic speed in the shell is higher than in the medium. Cofferdome, established in the stern part of the dome is ideally reflecting. On fig.1 figures 1, 2, 3 give antenna's contour, ideally reflecting screen and dome's shell taken in plane of construction section on the level of the fastening platform.

Results of simulation of diffraction of a short impulse developed by a point source on the distance from the antenna equal its 12 radiuses in the direction corresponding heading angle of 60 degrees are given in fig.2.

Multiple re-refractions of a falling impulse from an antenna's surface, a dome's interior bounds and a cofferdome's cruel wall lead to development of a rather complicated interference image which view is changing by the time.

The image of the acoustic field as a result of diffraction of a short impulse with the flat front under 30 degrees heading angle is shown on fig.3

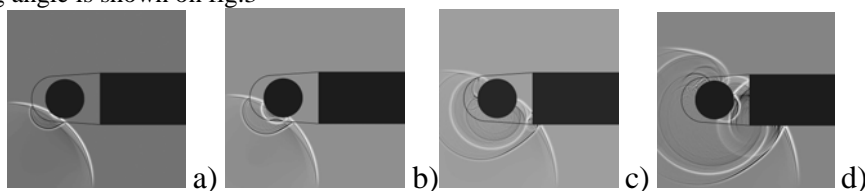


Fig.2. Spatial distribution of acoustic pressure in moments of time a) 3.25 ms; b) 3.5 ms; c) 4.5ms; d) 5.5 ms after beginning of a point source radiation.

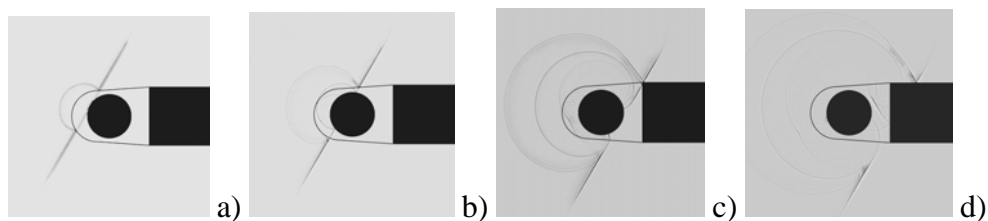


Fig.3. Spatial distribution of acoustic pressure in different moments of time a) 1.5 ms; b) 2 ms; c) 3 ms; d) 3.75 ms after beginning of source's radiation forming impulse with flat front.

From above mentioned numerical results it is possible to make the conclusion that a dome's shell influences on forming diffraction field in a medium. Appearance of multiple re-reflections of a sonic field in an acoustic camera among a dome's shell, cofferdome and an antenna's body. This effect is significant. In some cases it leads to being strong of an antenna's side field up to 60-70%.

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