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ABOUT A SOUND FIELD OF A PARAMETRICAL SOURCE WITH REFLECT ANTENNA OF PUMP

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The results of experimental and theoretical researches of near and far sound fields of the parametric source's reflect cylindrical pump antenna are presented in this work. The efficiency of based on a solution of the parabolic equation method application in antenna's field characteristics calculations is shown. The presented experimental difference frequency's directivity pattern of a parametric emitter on the base of cylindrical reflect antenna of pump, shows a low level of emitter's side field and gives the reasons to suppose about perspectives of its use in hydrophysical fields thin structure study.

The acoustic parametrical gears which operation is based on nonlinear interaction of sound waves are numbered with a perspective tools for researches of hydrophysical fields characteristics. At use of these gears it is possible to carry out measurements of hydrophysical ocean heterogeneities acoustic characteristics operatively, in a broad band of frequencies with a consequent solution of inverses oceanology problems.

It is considered, that the parametrical antennas have not side lobes in its directivity pattern. However it is not absolutely so, because in parametrical antennas the side petals can take place if the antenna of pump (primary transducer) has a high level of side lobes. At classical directivity patterns of pump antennas, such as a rectangular or circle piston emitters has, the parametrical antennas practically have not side lobs, but level of a side field (let even smooth-nonoscillatory) appears rather high. It led to deterioration of space resolution, especially at bad contrast volume scattering objects sounding and at the analysis of its thin structure (texture).

The decreasing of a parametric antennas side field level can be realized by artificial creation of amplitude distribution on a radiating surface of pump antenna. The characteristics of a parametric emitter with a low level of a side field are considered in the this work. The pump antenna of this emitter is a cylindrical reflector with the interior conic reflector and has natural amplitude distribution of an aspect $1/r$, where r – current radius of antenna's aperture. Is shown (theoretically and experimentally), that the first side lob on primary sound bundles of such pump antenna has a level approximately 3.8 % from basic. And, the amplitude distribution on the antenna's aperture is falling down to its periphery not because of decreasing of exciting amplitude on electroacoustic transducers, but increasing of sound energy density at reaching the top of the conic reflector. Herewith the intensity of sound waves on a surface of electroacoustic transducers staying a constant. It has allowed to get a highly effective antenna of pump with a small side field level. For a considering parametric emitter the solution of the KZK equation is obtained, the experimental outcomes are represented.

The antenna of pump, consisting of cylindrical radiator 1 and conic reflector 2 is represented in fig.1. Here the graph of pump waves sound pressure distribution on the antenna's aperture (in a radial approximation) is represented at a rectangular distribution of pump waves sound intensity on a radiator's surface. The directivity pattern of such antenna for pump waves is defined in work [1]:

$$D(q) \approx 0.507 \sum_{m=0}^{\infty} \frac{(2m+1)\Gamma(\frac{1}{4}+m)}{\Gamma(\frac{3}{4}+1+m)} \frac{J_{2m+1}(kR\sin q)}{kR\sin q}, \quad (1)$$

where k – wave number for pump frequency, R – the antenna's aperture radius, q – angle of observation, $\Gamma(\circ)$ – gamma function.

The directional diagram (DD), calculated on the formula (1) is represented in fig.2. – curve 1, and for a comparison is shown DD of the round piston – curve 2. Distinctive singularity of considered antenna’s directivity pattern is that the magnitude of additional maximum falls down not monotonically, as, for example, in piston emitters, but periodically. The first additional maximum makes approximately 3,8%, second – 8%, third – 1%, fourth – 4% and etc.

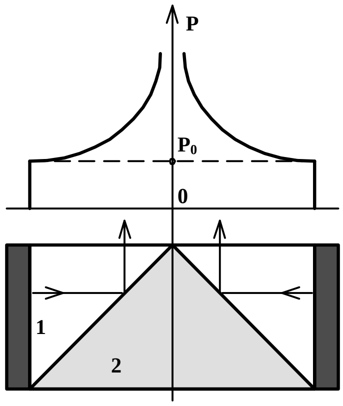

Fig.1. Antenna of pump and sound pressure distribution on it aperture.

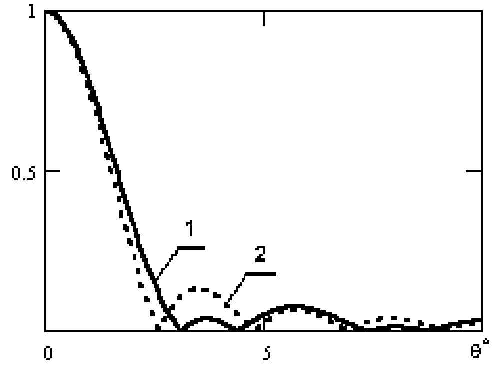

Fig.2. The directivity diagrams of: 1- the antenna, presented in Fig.1.; 2- the circular piston.

The measured directivity pattern (Fig.3., curve 1) is well agreed with calculated on the formula (1) – Fig.3., curve 2. In experiment was used continuous ring piezoceramic radiator with 6,5 mm thickness and 100 mm minor diameter with a longitudinal resonance (on a thickness of the ring) on 400kHz frequency. By taking a method of parametrical antennas calculation, based on a solution of the KZK equation [2], for a cylindrical antenna of pump with the conic reflector we shall get expression for sound pressure in waves of pump:

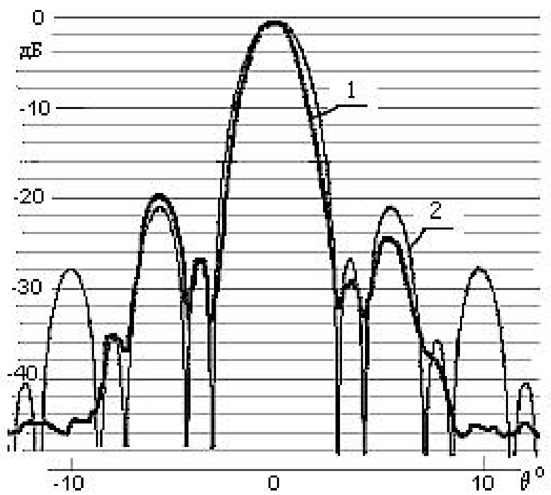

Fig.3. The pump antenna’s (see Fig.1) directivity diagrams : 1- experimental; 2- theoretical.

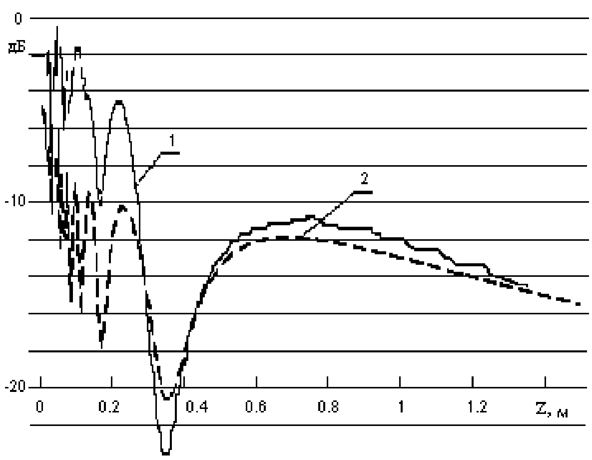

Fig.4. Axial distribution of sound pressure: 1- experimental; 2- theoretical.

$$P(r,z) = \frac{iP_0\sqrt{R}\cdot k}{z} e^{-a\cdot z} \int_0^R \sqrt{r_1}\cdot J_0\left(\frac{krr_1}{z}\right) e^{-jk\frac{r^2+r_1^2}{2z}} dr_1, \quad (2)$$

where r, z – transversal and longitudinal coordinate, accordingly; $Đ_0$ – sound pressure on a surface radiator; $J_0(\circ)$ – Bissell’s functions; a - attenuation coefficient on frequency of pump.

The expression (2) is rather precisely describes distribution of sound pressure along acoustic axes (*r=0*). For a comparison, in Fig.4 the curves of sound pressure axial distribution on carrier frequency 400 kHz are represented: curve 1 – experimental, curve 2 – calculated on the formula (2). The good coincidence of a curve behavior character is visible. For far zone of emitter and small angles of observation the expression (2) is reduces to (1). In this case it can be used for calculation of the directivity pattern of emitter.

Using the formula (2), we can find the expression for sound pressure in waves of difference frequency:

$$P_{-}(r,z) = j\frac{k_{-}e}{2r_0 c_0^2}\int_0^z dz_1 \int_0^\infty \tilde{P}_1 \tilde{P}_2^*(n,z_1)\exp[\frac{j(z-z_1)n^2}{2k_{-}}]\, n\cdot J_0(n\cdot r)dn\,, \quad (3)$$

where

$$\tilde{P}_1\tilde{P}_2^*(n,z) = D\int_0^R\int_0^R \sqrt{r_1 r_2}\exp(-j\frac{k_1 r_1^2 - k_2 r_2^2}{2z})\int_0^\infty r' J_0(\frac{k_1 r_1 r'}{z})J_0(\frac{k_2 r_2 r'}{z})J_0(nr')dr'dr_1 dr_2\,,$$

$D = P_{01}P_{02}k_1 k_2 R/z^2 \exp(-a_{-}\cdot z)$; a_{-} – attenuation coefficient on difference frequency.

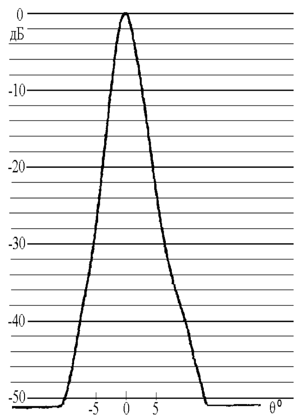

Fig.5. The parametric antenna directivity diagram, F_{-}=80 kHz.

There is no exact solution of expression (3), and the analysis of it is rather hard. Therefore, in summary is represented only the experimentally obtained directivity pattern (Fig.5.), which confirms a lack of side lobs in directivity pattern and low level of side field of parametric source with cylindrical reflect antenna of pump. Sound pressure level, reduced to 1m from 4m distance, has made 1.6 10^4 Pa on difference frequency 80 kHz.

R E F E R E N C E S

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