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CLEARING OF THE SECONDARY FIELD BY THE ACTIVE SYSTEM LOCATED ON THE SURFACE OF THE BODY

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The decision of a problem of clearing of the secondary field disseminated by a cylindrical environment is offered, the algorithm of definition of a falling field on measurements of full moving and full sound pressure upon surfaces of a body is received. It is offered three variants of clearing of a secondary field: with use of vibrators, with use of radiators and with sharing vibrators and radiators.

Until recently the unique theoretically proved method of clearing of the secondary (absent-minded) field was Maljuzhinets's method [1]. An indispensable condition of this method is the arrangement of active (measure-radiating) system in the environment surrounding a body. Lack of a method consists that accommodation of active system outside a body is interfaced to the certain technical difficulties interfering practical realization of this method.

In work [2] the alternative method of clearing of the sound field disseminated by an elastic body, placed in a liquid, by the appendix to it of compelling forces is offered and proved. As an elastic body the cylindrical environment is considered. Dependence of parameters on time t is accepted in the form of $\exp(i\omega t)$ and below it is lowered. The problem is solved with use of the equation of movement of a cylindrical environment and a boundary condition as follows. Let on an environment placed in a boundless liquid with density ρ , from an external source under a corner α the flat sound wave with wave number k and sound pressure p_0 , [3] falls

$$p_0 = A_0 e^{ikz \sin \alpha} \sum_{n=0}^{\infty} \varepsilon^n i^n J_n(kr \cos \alpha) \cos n\varphi . \quad (1)$$

Under action of a falling field there are compelled fluctuations of an environment and there is an absent-minded field with sound pressure p_s

$$p_s = A_0 e^{ikz \sin \alpha} \sum_{n=0}^{\infty} B_n H_n^{(2)}(kr \cos \alpha) \cos n\varphi . \quad (2)$$

The full sound field is defined by the sum falling and disseminated water

$$p = p_0 + p_s . \quad (3)$$

Including, that interaction of an environment with a liquid occurs only on radial coordinate, we shall present the equation of the compelled fluctuations of the cylindrical environment having radius $R=a$ and a longitudinal axis, conterminous with an axis z coordinate system (r, φ, z) , in the form of [4]

$$\left(L(\gamma) + \omega_*^2 \bar{E} \right) \begin{pmatrix} u \\ v \\ w \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ (a/q)(p_0 + p_s) \end{pmatrix}, \quad (4)$$

where u, v, w -longitudinal, tangents and radial movings at fluctuations of a surface of an environment, elements of matrix $L(\gamma)$ are functions of a phase γ falling field [2].

$$q = Eh(1 - \mu^2)^{-1} \cdot a^{-1}, \quad \omega_* = \omega^2 a^2 \rho_* (1 - \mu^2) E^{-1}, \quad \delta^2 = h/a, \quad \gamma = ka \sin \alpha,$$

h – thickness of a wall of an environment, E - the module of elasticity, μ - factor Пуассона, ρ - density of a material, \bar{E} – individual matrix, $\omega = 2\pi f$, f -frequency.

After reduction of system of the equations (4) to the third equation (rather w) the last can be presented in the form of

$$(\Delta_0(\gamma)/\Delta_1(\gamma))w = (a/q)(p_0 + p_s),$$

where $\Delta_1(\gamma)$ - a minor and $\Delta_0(\gamma)$ A-determinant of a matrix of the left part of the equation (4)

$$\Delta_1 = (L_{11} + \omega_*^2)(L_{22} + \omega_*^2) + L_{12}^2, \quad \Delta_0 = |L(\gamma) + \omega_*^2 \bar{E}|.$$

The mechanical impedance of a dry cover can be presented in a kind

$$Z = (q/a) [\Delta_0(\gamma) / \Delta_1(\gamma)].$$

1. Clearing of an absent-minded field by the compelling forces enclosed to a cover

In addition we will put to a cover surface s the distributed compelling forces $f_a = Fa/s$, dimensional pressure. The equation of movement of a cover in a liquid at joint action of a falling field, an absent-minded field and compelling forces. (5)

$$Zw = p_0 + p_s + f_a. \quad (5)$$

Using the equation of movement (5) and a boundary condition on border of a cover with a liquid, we will define an absent-minded field and its communication with compelling forces. For simplification of record of formulas in expressions (1) and (2) we will lower summation on district harmonics n and we will be limited to consideration of functions of any harmonic n

$$p_0 = A \varepsilon_n i^n J_n(kr \cos \alpha), \quad \text{где} \quad A = A_0 \exp(ikz \sin \alpha); \quad p_s = AB_n H_n(kr \cos \alpha) \quad (6)$$

The index designating function by Gankelja H_n of the second sort, and angular dependence of parameters from $\cos n\varphi$ it is also lowered. Strokes over functions of Besselja J_n and Gankelja designate their derivatives. Unknown factors B_n we will find from a boundary condition

$$\partial(p_0 + p_s) / \partial r|_{r=a} = \rho \omega^2 W, \quad (7)$$

$$B_n = \varepsilon_n i^n J'_n(ka \cos \alpha) / H'_n(ka \cos \alpha) + \rho \omega^2 W / A(k \cos \alpha) H'_n(ka \cos \alpha).$$

After substitution B_n in the formula (6) we will define an absent-minded field

$$p_s = -\varepsilon_n i^n A \frac{J'_n(ka \cos \alpha) H_n(kr \cos \alpha)}{H'_n(ka \cos \alpha)} + \frac{\rho \omega^2 W H_n(kr \cos \alpha)}{(k \cos \alpha) H'_n(ka \cos \alpha)}, \quad (8)$$

where the first composed corresponds to a field reflected by absolutely firm cylinder, and the second composed - to a field radiated by a cover owing to its fluctuations.

We will substitute expression (8) at $r=a$ in the equation of movement (5)

$$Zw = p_0 - \varepsilon_n i^n A \frac{J'_n(ka \cos \alpha) H_n(ka \cos \alpha)}{H'_n(ka \cos \alpha)} + \frac{\rho \omega^2 W \cdot H_n(ka \cos \alpha)}{(k \cos \alpha) H'_n(ka \cos \alpha)} + f_a$$

and taking into account expressions of impedances on a cover surface

$$Z_s = \frac{\rho \omega^2 \cdot H_n(ka \cos \alpha)}{(k \cos \alpha) H'_n(ka \cos \alpha)} \quad Z_1 = \frac{\rho \omega^2 \cdot J_n(ka \cos \alpha)}{(k \cos \alpha) J'_n(ka \cos \alpha)}$$

we will find full moving of a surface of a cover

$$w = p_0 / Z_1 + (p_0 / Z_1) \cdot ((Z_1 - Z) / (Z - Z_s)) + f_a / (Z - Z_s), \quad (9)$$

where p_0 pressure of a falling field upon cover surfaces.

Having substituted full moving w (9) in expression (8), after elementary transformations we will receive an absent-minded field in a kind

$$p_s = (Z_{sr} / (Z - Z_s)) [(p_0 / Z_1) \cdot (Z_1 - Z) + f_a],$$

where

$$Z_{sr} = \rho \omega^2 H_n(kr \cos \alpha) / (k \cos \alpha) H'_n(ka \cos \alpha) \quad (10)$$

impedance of radiation of a cylindrical cover in external area.

From a condition of clearing of an absent-minded field, i.e. $p_s = 0$ in (10), we will receive compelling forces necessary for it

$$f_a = (p_0 / Z_1) (Z - Z_1). \quad (11)$$

Presence of impedance Z_{sr} in the formula (10) testifies that clearing occurs in all space $r > a$. As a result of action of the compelling forces applied to a cover f_a (11) the full field will be to equally falling field $p = p_0$, and full moving of a surface of a cover w in (9) will be equal to the moving created by the falling field $w = w_0 = p_0 / Z_1$. From the formula (11) follows that for definition of compelling forces f_a impedances Z , Z_1 and a falling field p_0 should be known.

We will find a parity between a falling field and parameters by which it is possible to measure on a cover surface. Full field on a surface of a cover (3) taking into account (10) we will transform to a kind

$$(p - p_0) / Z_s = (1 / (Z - Z_s)) [(p_0 / Z_1) \cdot (Z_1 - Z) + f_a]. \quad (12)$$

Full moving on a surface of a cover (9) also we will transform to a kind

$$w - p_0/Z_1 = 1/(Z - Z_s) \left[(p_0/Z_1)(Z_1 - Z) + f_a \right]. \quad (13)$$

From a condition of equality of the right parts of expressions (12) and (13)

$$w - p_0/Z_1 = (p - p_0)/Z_s \quad (14)$$

we will receive the parity, allowing to define a falling field p_0 , on the measured sizes of full moving w and a total pressure p on a cover surface

$$p_0 = \frac{Z_s(w - p/Z_s)}{Z_s/Z_1 - 1}. \quad (15)$$

having substituted this parity in the formula (11), we will define compelling forces

$$f_a = \frac{Z_s(Z - Z_1)}{(Z_s - Z_1)}(w - p/Z_s). \quad (16)$$

Practically to measure full moving w and full sound pressure p it is possible with use of sensor controls (accelerate-meter and gauges of sound pressure). To excite the compelled fluctuations of a cover by forces f_a , enclosed to its surface, it is possible with use actuator (vibrators). Researches and workings out of sensor controls and actuator, carried out in the form of an external active covering, are intensively conducted abroad already more than 10 years [5].

2. Clearing of an absent-minded field by the radiators located on a surface of a cover

Full field, for lack of clearing of an absent-minded field by radiators, is defined by the formula (3). Using expressions for pressure (1) both (2) taking into account (6) and a boundary condition (7), and also the equation of the compelled fluctuations (5) without compelling forces, i.e. at $f_a=0$

$$Z \cdot w = p_0 + p_s,$$

it is possible to receive expression for an absent-minded field at $r=a$ in a kind

$$p_s = -p_0 Z_s/Z_1 + w \cdot Z_s. \quad (17)$$

Here the falling field p_0 is defined by the formula (15), and full moving w is the measured parameter. The absent-minded field can be extinguished with use established on a cover «non-strong» the radiators creating a sound field with pressure p_a , extending in the same direction, as an absent-minded field, but with an opposite phase $p_a = -p_s$.

In this case full результирующее the field taking into account a compensating field p_a , will be to equally falling field $p = p_0 + p_s + p_a = p_0$, and full moving of a cover w according to (14) will be equal to moving in a falling sound wave $w = w_0 = p_0/Z_1$.

Here and more low under concept «non-strong» radiators mean radiators which can compensate an absent-minded field, without causing fluctuations of the free cover which are in a condition of zero buoyancy. Judging by available theoretical workings out, such radiators (Gjujgens' es sources) can be created [6]. Advantage of the given method of clearing consists that here it is not required to know impedance cover Z .

3. The combined clearing of an absent-minded field by the forces enclosed to a cover, and radiators

Idea of the combined clearing of a secondary field consists in the following. With use of the compelling forces applied to a cover the part of an absent-minded field caused by vibrations of a cover, caused by a falling field is extinguished, i.e. Cover fluctuations are eliminated. The Rest of an absent-minded field caused by reflection of the submitting field from a cover as from a firm body, is extinguished by radiators.

Using the equation of movement for a cover in a liquid at joint action of a falling field, an absent-minded field and compelling forces f_{at} , (5) and boundary conditions (7), it is possible to define an absent-minded field p_s in the form of (17), and cover moving to a kind

$$w = 1/(Z - Z_s) \left[p_0(1 - Z_s/Z_1) + f_{at} \right].$$

From a condition of elimination of movings, i.e. $w=0$, required forces

$$f_{at} = -p_0(1 - Z_s/Z_1),$$

where the size of a falling field still is defined by expression (15).

At a motionless surface of a cover $w=0$ in an absent-minded field p_s there is a part characterizing a field, reflected from absolutely firm cylindrical cover,

$$p_{st} = -p_0 \cdot Z_s / Z_1 .$$

For clearing of this part of an absent-minded field the radiators creating compensating field with sound pressure $p_{at} = -p_{st}$ are used. As a result of action of a compensating field the full field will be to equally falling field

$$p = p_0 + p_{st} + p_{at} = p_0 .$$

Advantages of the third method of clearing consist that here the same as and in the previous case, is not required to define an impedance of cover Z . To operate clearing of an absent-minded field on a condition $w=0$ with possibility of simultaneous clearing of a primary field easier. Presence of vibrators and radiators allows to duplicate elements of active system and by that to raise its reliability. Thus it is possible to realize any of three clearings of an absent-minded field specified above methods.

Thus, it is established that it is possible to apply three to clearing of an absent-minded (secondary) field specified above a method in which elements of active system settle down on a body surface. The question of a choice of this or that method for practical use should dare taking into account opinion проектантов and manufacturers of protected object and concrete active system.

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