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Optimization of construction of the acoustic radiator with a concave surface for improvement of directivity patterns

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Introduction

The bending mode radiators are widely used in acoustic measurements in gaseous (in air) environment because the acoustic impedance of these radiators is the nearest to the acoustic impedance of gas. Unidirectional acoustic radiators with bending mode-vibrating transducers are usually made exploiting various complicated constructive solutions. It is necessary to adjust surface vibrations at different parts with opposite phases [1]. We investigated rectangular acoustic antennas applicable in echolocation measurements [2, 3, 4].

In our opinion the symmetric bending mode radiators with a concave surface are most promising for practical applications. Manufacturing of such radiators is convenient and cheap.

We investigate the influence of angle and length of the cone part of the radiator on formation of unidirectional radiated field. We shall determine the optimal construction of such an antenna.

We used the Huygens - Fresnel principle in calculations. According to this principle we chose distribution of amplitudes and phases on the vibrating surface. These amplitudes at various points are sampled into the matrix of distribution of vibrations $\left\|V_{j,k}\right\|$. The scalar amplitude potential ϕ of the acoustic field at a some point in a far field was calculated as a surface sum

$$\phi_{lm} = \sum_j \sum_k \left\|V_{j,k}\right\| \frac{e^{ikr_{jklm}}}{r_{jklm}}; \qquad (1)$$

where $k=2\pi/\lambda$ is the acoustic wave number; r_{jklm} are the distances between points on the transducer's surface and the points in space in which the values of ϕ_{lm} were calculated.

The position out of points in which values $\left\|V_{j,k}\right\|$ were measured depends on the shape of the radiating surface. We used the cylindrical coordinates' system for the concave acoustic radiator.

Models for calculations

We investigated the concave form of acoustic radiator, which is shown in Fig. 1.

The distribution of vibrations on the bottom surface of this radiator. It was modeled taken as the Bessel function along the radius r_r (Fig. 2) and uniform along arc.

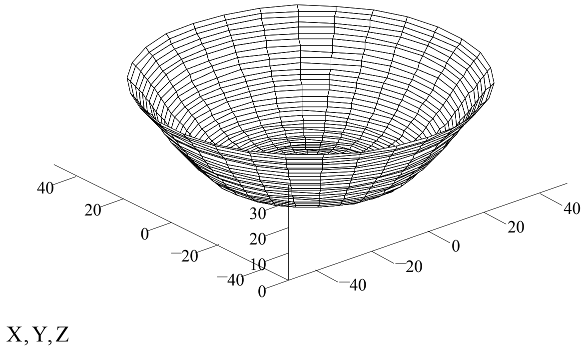

Fig.1. **Concave form of the acoustic radiator under investigation**

For more simplified and fast evaluation the calculations of ϕ_{lm} were performed along one radius. We obtained an approximate directivity pattern in this case.

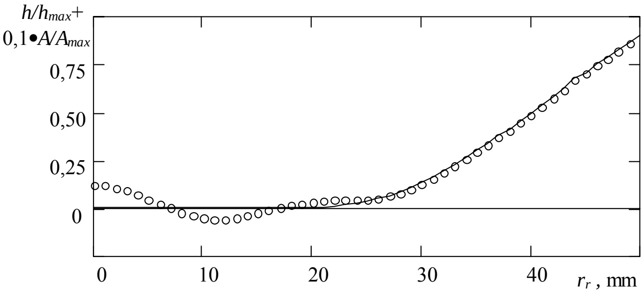

Fig. 2. **Distribution of normalized amplitude of vibrations in the direction of spherical formation r_r: form of concave surface - solid line; h/h_{max} + $0{,}1A/A_{max}$ - points; h - height of a chosen point over the bottom level**

Calculation of amplitude on the symmetry axis of a directivity pattern

Using simplified calculation of directivity pattern we evaluated dependence of the amplitude on the symmetry axis of the directivity pattern on the angle and length of the lateral reflectors. We changed angle α between lateral reflectors and the bottom part and length of lateral reflectors l_r in chosen limits. The result of evaluations is shown in Fig. 3.

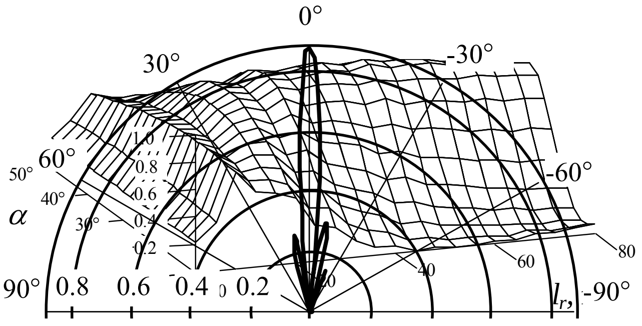

Fig. 3. **Dependence of amplitude in the central part of directional characteristic on the angle α and the length of side reflectors l_r**

We can decide according to the fig. 3 that the biggest amplitude will be achieved in the case of angles in 28°...32° limits and lengths in 40...45mm limits.

Directional pattern of spherical radiator

We evaluated directional characteristic in the optimum case of angles and lengths of side reflectors for concave acoustic radiator as full construction. The obtained result is shown in fig. 4. The irregularities of amplitudes along arc were received because of discrete division of angle.

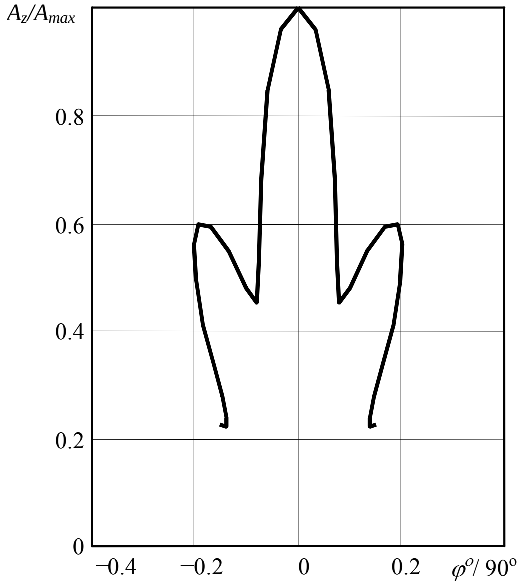

Fig. 4. **Calculated directivity pattern of the concave radiator**

Experimental results

The radiator used for experiments was made constructive elements evaluated by calculations. The directivity pattern of this radiator was obtained from measurements carried out in an acoustic chamber (Fig.5).

Fig. 5. **Experimentally measured directivity pattern of the concave radiator**

Conclusions

We have proposed approach for modeling of directivity patterns of acoustic radiators with a concave surface. Changing the length and the angle of the radiating cone and searching for the extremum of radiation enables us to simplify and make cheaper the designing works of vibrating antennas. We used this approach for design of bending mode acoustic antennas having concave symmetric surface. In this way we can develop various antennas with minimized side radiation. The results obtained may be used in design of ultrasonic distance meters operating in a complicated technological environment.

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Įgaubto paviršiaus akustinio spinduolio konstrukcijos optimizavimas kryptingumo charakteristikai pagerinti

Reziumė

Siūloma apskaičiavimo metodika ir gauti rezultatai naudingi projektuojant lankstymosi virpesių fokusuojančias akustines antenas su įgaubtu simetriniu paviršiumi. Naudojant kūginės antenos sudaromąsias parametrų reikšmes,- kampą ir ilgį, gautus iš antenos maksimalaus spinduliavimo simetrijos ašies kryptimi, sąlygos, - galima suprojektuoti keletą antenų su minimizuotu šoniniu spinduliavimu. Gauti rezultatai naudojami kuriant aidolokacinius nuotolio matuoklius.

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