Transducers of High Intensity for Gas Media

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Abstract—the paper is devoted to practical problems of development and projection of piezoelectric transducers for gas media. Authors confirm effectiveness of application of the created piezoelectric phased focalizing emitter using an example of process of drying of linen in drum-type washing machines.

I. INTRODUCTION

Recently twenty years ultrasonic technologies find in the industry the increasing application. Ultrasonic oscillations can be used for acceleration of technological processes in fluids, rigid bodies and gases. For action on fluids and rigid bodies enough for a long time are developed and radiants of ultrasonic oscillations with high engineering and operational performances are used. It has served one of reasons of rapid growth of number of ultrasonic inventory made in the world. The basic part of this inventory is intended for welding thermoplastic materials, the dimensional handling of rigid bodies or for cavitation handling fluid media.

Major prospect use of high-intensity ultrasonic oscillations in air media possesses. Their use allows accelerating such processes as coagulation, extinguishing of foam, drying.

At present, the devices, allowing ensuring high-intensity action on gas media, in the world practically it is not made. It speaks lack of the inventory allowing maximum effectively to transduce mechanical or an electrical energy in energy of ultrasonic oscillations of high intensity. Constructions of aerodynamic emitters existing at present are complicated in operation and have low efficiency; the best exemplars have efficiency of 39 %, and on the average the order of 20% [1].

Alternative to an aerodynamic method of making of ultrasonic oscillations in air is use of piezoelectric vibrating systems. Piezoelectric transducers existing at present are oriented, first of all, for needs of a defectoscopy or possess greater overall dimensions [2-4].

Gallego-Juarez [5] the emitter of ultrasonic oscillations of the high intensity, consisting of an ultrasonic vibrating system and an emitter in the form of a disk has offered. The ultrasonic potency introduced by the given transformer in a medium, up to 1 kW for an transducer in diameter of 0.7 m. the Resonance frequency of an transducer 20 kHz, intensity of sound pressure 160 decibel, efficiency - 80 %. To shortages of an transducer it is necessary to refer the following: greater overall dimensions, low intensity of sound pressure.

II. DEVELOPMENT OF ULTRASONIC PIEZOELECTRIC TRANSDUCER

Essential distinction of ultrasonic resistances of metals and air do not allow creating by means of solid-state emitters in an air medium flat or spherical wave with a noise level from above 130-140 decibel. Therefore, at use of piezoelectric transducers for making in an air medium of ultrasonic waves with a noise level 160-175 decibel use focusing (concentration) less intensive oscillations on the localized site. For focusing ultrasonic oscillations in an air medium the mirror, lens or phased systems are used. The last represent the greatest interest as have the most simple construction and small dimensions. The principle of operation of the phased focalizing emitter is shown in figure 1.

The surface of a rigid body (plate) makes bending oscillations, and allocation of their amplitudes of particle displacements along radius of a plate looks like standing waves. Each point oscillations surfaces radiate an ultrasonic wave in an air medium. If due to the shape of a plate to arrange the “plus” maximas of particle displacements on distances from centre of a plate according to the formula:

$$Y_+ = \sqrt{naL + \frac{n^2a^2}{4}}$$
where \( n = 0, 2, 4 \ldots \), \( a \) - length of a sound wave in air, \( L \) - distance from centre of a plate up to a focal point, and the “subzero” maxima on distances calculated under the formula:

\[
Y = \sqrt{naL + \frac{n^2a^2}{4}}
\]

where \( n = 1, 3, 5 \ldots \); the waves radiated of each exact plate will come to a focal point in one phase. The Noise level in a focal point in that case reaches values 200 decibel and above, and around of focal point surfaces of equal phases where the noise level reaches values 130-150 decibel is formed.

In connection with lack of design procedures of disk transducers, mathematical model operation by a finite element method (figure 2) has been used. Observed data’s (figure 3) have confirmed correspondence of the basic characteristics gained by mathematical model operation to experimental data, that, having proved the offered concept of projection of a piezoelectric transducer.

Measuring was carried out by means of specially developed piezoelectric receiving transformer (clearance gauge) with dry point wise contact. The engineering singularity consists in linearity of an amplitude-frequency characteristic of a clearance gauge in the given gamut of measured frequencies.

The lead measuring of energy parameters have allowed erecting, that the transducer allows ensuring input of ultrasonic oscillations in a gas medium (air) with intensity in a focal point more than 165 decibel, in nearby focal space 140-160 decibel. The vibration amplitude of a radiating surface reached 200 micron.

**III. RESULTS OF PRACTICAL EXAMINATION**

By results of the lead calculations it has been designed and made (figure 4) an ultrasonic vibrating system with the disk emitter, (table 1) possessing following characteristics.

As transformer Lanzheven the piezoelectric ultrasonic vibrating system with the by degrees-radial concentrator was applied. The electromechanical transformer of last appeared piezoelectric ceramic the rings of mark APC-841 intended for use in inventory for force ultrasound. A material of the phased focalizing disk emitter - titanium alloy.

For acknowledgement of effectiveness of the developed construction, comparative trials of use gasjet and piezoelectric transducers for an intensification of process of drying of linen in a washing machine of drum-type type have been lead.

Carried out examinations have allowed to erect, that electric energy demand gasjet an emitter in 5 times more, than piezoelectric. The efficiency gasjet an emitter is less in 2,5 times, noise level gasjet than an emitter – 100 decibel, and piezoelectric - 70 decibel. The further examinations have allowed choosing optimum conditions of drying. Use of ultrasonic oscillations has allowed to lower consumption of an electrical energy by a washing machine in a condition of drying about 2 kW up to 1, 2 kW.
Fig. 3 Comparison theoretical and experimental data about allocation of a vibration amplitude to a transducer.

Fig. 4 Developed construction of a ultrasonic piezoelectric transducer for action on gas media (appearance).

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<th>TABLE I. TECHNICAL CHARACTERISTICS</th>
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<tr>
<td>Resonance frequency, kHz</td>
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<td>Diameter, m</td>
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<td>Efficiency, %, not less</td>
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<tr>
<td>Intensity of ultrasonic oscillations in a focal point, decibel</td>
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<td>Mass, kg</td>
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REFERENCES

[4] European Patent №0327486, G10K13/00, B06B3/04 Focal sonic or ultrasonic radiator to apply to high-intensity fluids / Juarez, Gallego J.A.; Corral Rodriguez G.; Prieto, San Emterio J.L.


Sergey N Tsyganok was born in Biysk, Russia, 1975. Now he is Ph.D (Machinery), he received degree on information measuring engineering and technologies from Altay State Technical University, key specialist of electronics. Laureate of Russian Government premium for achievements in science and engineering. His main research interest are development of high-effective multifunctional oscillators for ultrasonic technological devices.

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