Efficiency Increase of Multi Half-Wave Radiators

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Abstract **– The article presents the results of the studies aimed at the efficiency increase of the piezoelectric vibrating systems with multi half-wave radiators made in the form of the bar with variable diameter. It is determined, that the change of the form of junction between the parts of different diameters of the radiator essentially influences on the efficiency of ultrasonic radiation in liquid media.**

Index Terms **– Ultrasound, ultrasonic technological equipment, ultrasonic vibrating system, multi half-wave radiator.**

I. INTRODUCTION

ULTRASONIC TECHNOLOGIES are widely used in different branches of industry helping to generate new and efficiently intensify known technological processes [1].

It became possible due to development and industrial application of various high-power (up to 8000 VA) specialized ultrasonic equipment (see Fig.1) [2].

Fig. 1. Ultrasonic technological apparatuses of different embodiment

Constitutive components of the universal and specialized ultrasonic technological apparatuses are an ultrasonic vibrating system and an electronic generator of ultrasonic frequency for its power supply.

The ultrasonic vibrating system provides transformation of electric oscillations produced by the generator into mechanical vibrations of specified frequency, amplification of their amplitude the values, which are enough for the realization of the technological process. The ultrasonic radiator (working tool of the vibrating system) provides the introduction of vibrations into technological media through the radiating surface, which vary in forms and sizes (see Fig.2) [3].

Fig. 2. Ultrasonic vibrating system with the multi half-wave radiator

To increase the power of radiation at the industrial application the ultrasonic vibrating systems containing multi half-wave radiators (working tools) in the form of variable cross-section bar characterized by enlarged radiating surface are widely used (see Fig.3) [4].

Fig. 3. Ultrasonic radiator

The enlargement of the radiating surface in such tools is provided due to coaxial and sequential installation of half-wave in length waveguides of cylindrical form with the variable diameter. In this case the surfaces of the junctions between the parts of various diameters are the surface of active radiation of ultrasonic vibrations [5].

At the same time the radiators can have different in form junctions between the parts of various diameter and the efficiency of radiation can substantially differ.

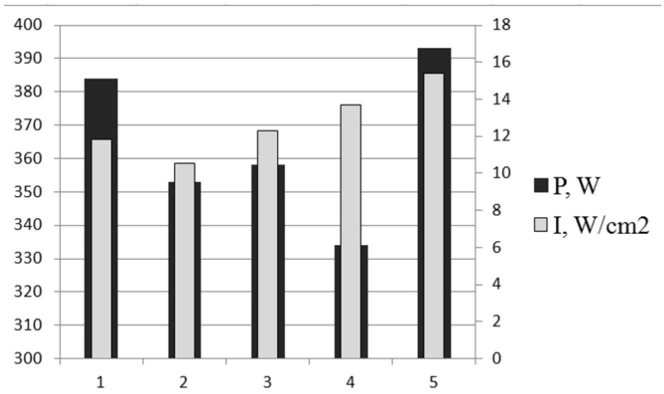
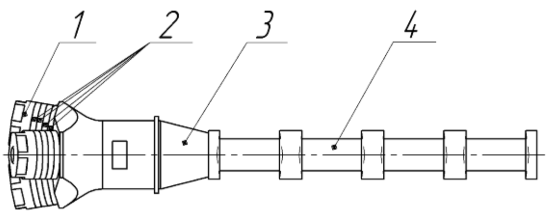


Fig. 4. Dependence of the characteristics of ultrasonic influence on the type of the junction

As it is shown in the paper [6] the ultrasonic radiator, in which the junctions are made in the form of conical surface incurved into cylindrical element of larger diameter (see Fig.5), has the best parameters.



1 – reflecting frequency lowering cover-plate; 2 – piezoelectric elements; 3 - booster; 4 – four half-wave ultrasonic radiator

Fig.5. Ultrasonic vibrating system with the junction in the form of conical surface

Unfortunately produced for the different purposes and by different manufacturers the ultrasonic apparatuses vary in form and size of radiating surface. That is why, there is a need to determine slope angle of the radiating surface to the axial line of the working tool (the angle at base of the cone) schematically shown in Fig.6.

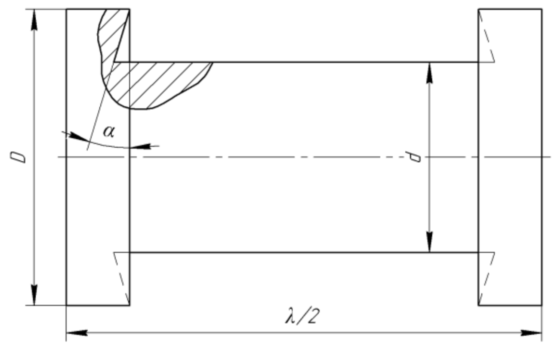


Fig. 6. Half-wave module

At that optimum angle will be the slope angle of radiating surface to the axial line of the radiator, at which vibrations going out in the direction perpendicular to the radiating surface will optimally influences on processed media.

II. MODELING

To determine conditions of optimum propagation of vibrations in the zone of the action we simulate different variants of half-wave modules having various slope angles of the radiating surface to the axial line of the radiator.

The example of the model of the half-wave module with optimum slope angle of the radiating surface is schematically shown in Figure (see Fig.7).

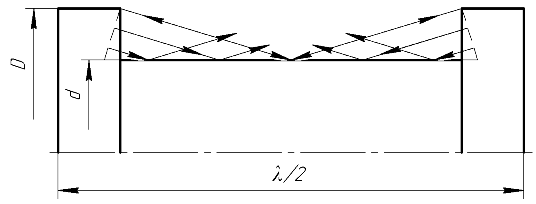


Fig. 7. Determination of optimum slope angle of the radiating surface

As a result of the analysis of different variants of embodiments it was ascertained, that in the ultrasonic vibrating system with the ultrasonic radiator made in the form of the bar, which has parts of different diameter, the junctions between the parts of various diameter of the radiator should be performed as holes inside the cylindrical part of larger diameter, the form of the holes should have the form of truncated cone in the cross-section with the angle at the base of the cone chosen from the condition:

$$\alpha = 90^0 - arctg\,\frac{11\lambda}{30(D-d)},$$

where λ is the length of wave in the material of the radiator at operating frequency of vibrating system, m; D is the diameter of the larger cylindrical part of the radiator, m; d is the diameter of the smaller cylindrical part, m.

III. CONCLUSION

Thus, in the result of carried out researches we developed the ultrasonic vibrating system characterized by maximum transformation coefficient of electric energy into energy of ultrasonic vibrations, maximum amplification coefficient of the ultrasonic radiator, maximum uniformity of radiation along all half-wave resonance modules with the intensity of radiation, which is enough to provide cavitation mode of the action making possible to realize processing liquid media with different viscosity and powder at the solving of tasks of dispersion, emulsion, extraction, cleaning in chemical, pharmaceutical and food industries.

REFERENCES

[1] Khmelev V.N. Application of high-intensity ultrasound in industry/ V.N.Khmelev, A.N. Slivin, R.V. Barsukov, S.N. Tsyganok, AV. Shalunov; Altay State Technical University, BTI. – Biysk, 2010. – 196 P.

[2] Ultrasonic technological apparatus «Bulava» [Electronic source]. – Access mode: http://www.u-sonic.com/catalog/apparaty_dlya_protochnoy_obrabotki_zhidkikh_sred/apparat_ultrazvukovoy_protochnyy_serii_bulava_p_01/

[3] Patent 2473400 of Russian Federation, MPK b06b1/06. Ultrasonic vibrating system [Text] / V.N. Khmelev, S.N. Tsyganok, S.V. Levin, S.S. Khmelev; applicant and patentholder Limited liability company «Center of Ultrasonic technologies ». – № 2011133763/28, claimed in 10.08.2011; published in 27.01.2012.

[4] Levin S.V., Khmelev V.N., Tsyganok S.N., Khmelev S.S. Design of ultrasonic vibrating systems with enlarged surface of radiation. Measurements, automation and modeling n industry and scientific researches: Materials of 7th Russian science and technical conference.– Biysk: AltGTU, 2010. – p.147-151.

[5] Khmelev V.N., Levin S.V., Tsyganok S.N., Khmelev S.S. Efficiency increase of the processes by the optimization of the ultrasonic vibrating system consisting of half-wave modules of variable cross-section. XII international conference and seminar of young specialists on Micro / Nanotechnologies And Electron Devices EDM 2011, Novosibirsk, NSTU. 2011. – p.275-280.

[6] Khmelev V.N., Levin S.V., Tsyganok S.N., Khmelev S.S. Determination of optimum form of radiating surface of multi half-wave working tools / South Siberian scientific bulletin. – 2013. – №2(4). – P. 20–22. – Access mode: http://s-sibsb.ru/images/articles/2013/2/4_20-22.pdf.

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