Control Of Vibration Amplitude And Its Distribution At The Design And Operation Of Multi Half-Wave Vibrating Systems

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Abstract **– In the paper proposed by the authors new approaches and practical realization of the control of vibration amplitude of the ultrasonic multi half-wave radiators being a part of ultrasonic devices of different purposes are considered. Developed bench for the control of multi half-wave radiators realizing in practice the advantages of several known methods provides the possibility of control of vibration amplitude at the development and operation of ultrasonic technological devices.**

Index terms: **Ultrasonic equipment, measuring bench, vibration amplitude.**

I. INTRODUCTION

ULTRASONIC methods of intensification of the technological processes have wide application in different branches of industry.

It is possible due to the design and practical use of powerful ultrasonic devices, which are able to introduce vibrations with power of more than 3000 W into processed media with the help of radiators (see Fig. 1) with developed radiating surface (upto 300 cm).

Fig. 1. Multi half-wave radiator of variable cross-section

In such devices piezoelectric system is made according to special construction diagram [1] and consists of multi half-wave (upto 7...15 sizes of lengths of vibration half-wave) radiator representing titanium rod of variable cross-section and multi-pack (upto 7 pairs of ring piezolelctric elements with the diameter of 50 mm) piezoelectric transducer (see Fig. 2).

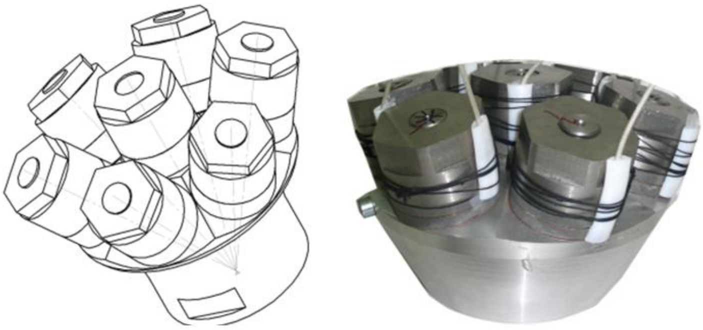

Fig. 2. The construction diagram of the multi-pack transducer

Increased area of radiating surface generated between parts of different diameter and high power of multi-pack piezoelectric transducer provide the possibility of essential rise of productivity (the volume of processed technological media) at the realization of various technological processes. At that providing with the most productivity of the processes is accompanied by maximum speed of realization of these processes due to the most effective ultrasonic influence in the mode of developed cavitation (at the intensity of no less than 10 W/cm^2).

On the base of known construction diagram the authors developed vibrating system, which appearance is shown in Fig. 3.

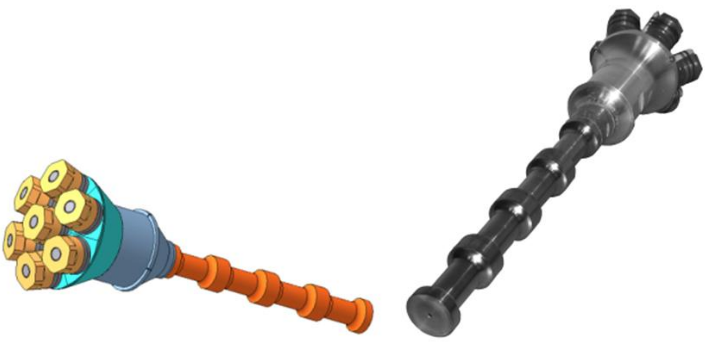

Fig. 3. Multi half-wave ultrasonic vibrating system

Developed ultrasonic vibrating system consists of piezoelectric transducer providing summation of power of vibrations generated by each of the packets of piezoelectric elements of small size. It allows to provide the generation of vibrations with the intensity, which is enough for cavitation mode of ultrasonic influence without excess of maximum permissible power parameters of the piezoelements and ultrasonic radiator with developed surface of variable cross-section.

At the operation of vibrating systems being a part of powerful ultrasonic equipment during the adjustment and operation there is a need to control the main parameters (resonance frequency and vibration amplitude) determining the quality of the operation of the devices and efficiency of realization of technological processes.

To control the main parameters of vibrating systems during their adjustment and operation several well-known methods are used.

The most commonly used method of parameter measurement of the ultrasonic vibrating systems is realized during the assembly, the adjustment and the test of newly produced systems on the special measuring bench consisting of the generator of model frequency, the oscillograph for monitoring of amplitude value, digital indicator of resonance frequency and receiving piezoelectric transducer with the point contact. The control is carried out in a following way. The signal of variable frequency from the generator is supplied in the form of voltage in several tens of volts to the electrodes of piezoelectric elements of vibrating system. The control of the amplitude of mechanical vibrations of ultrasonic frequency is carried out by receiving transducer with the point contact (sounding rod with the pin) pressed to vibrating surface. Mechanical vibrations come through the point contact to the piezoelectric transducer, they are converted into electric oscillations and registrable signal, which is proportional to vibration amplitude of studied surface and it is fixed by the oscillograph [2].

However such method allows to control only relative changes (steadiness of vibration distribution).

For the control of absolute values of vibration amplitude of radiating surface stroboscopic method of visual observation of vibrating surfaces is used [3].

This method does not let control vibration amplitude of radiating surfaces of complex forms (transition points of variable cross-section) and in liquid technological media (i.e. under load).

In this connection there is a need to create new method of control of vibration amplitude of the radiators with developed radiating surface during their operation in liquid media, which can unite all advantages of described above well-known methods of measurement.

II. Problem Definition

Developed measuring bench uniting the advantages of described above methods of measurement and allowing to control the value and distribution of vibration amplitude in all radiating surface has the volume, which is filled with technological liquid to provide real conditions of the operation of the device (see Fig. 4). However the height of the technological volume is chosen in a following way, that the end surface of the radiator is situated above the surface of liquid.

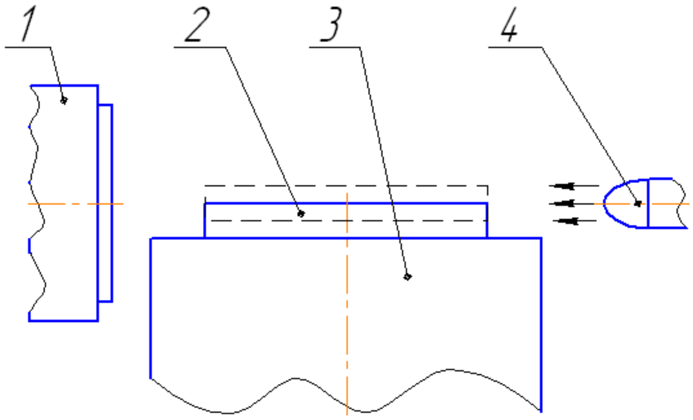

Fig. 4. The scheme of the bench for measuring of vibration amplitude, where 1 – the microscopic eyepiece, 2 – the end surface of the ultrasonic vibrating system, 3 – the technological volume with liquid, 4 – the stroboscopic lighting system

The bench for parameter control of the piezoelectric vibrating systems with multi half-wave radiators of variable cross-section at the operation in liquid medium consists of the ultrasonic generator 4 and vibrating system 1 in the technological volume 3 (see Fig. 5). The end surface of the radiator does not submerge in liquid and it is located between the stroboscopic lighting system 5 and microscopic eyepiece 2.

The developed bench was used for the parameter control of the ultrasonic technological device of the model UZTA-8/22-O with consumed electric power of upto 8000 VA [4].

As a result of measurements it was determined, that at the operation in liquid medium in cavitation mode excursion of vibration amplitude of the end surface of the ultrasonic radiator was 14 – 16 micromicron.

Fig. 5. The measuring bench, where 1 – the ultrasonic vibrating system, 2 – the microscope, 3 – the technological volume, 4 – the ultrasonic generator, 5 – the stroboscopic lighting system, 6 – the electronic impulse generator, 7 – the generator of model frequency, 8 – the oscillograph, 9 – sounding rod

Comparing the data obtained by two used methods of control the vibration amplitude of all radiating surfaces was defined (see Fig. 6).

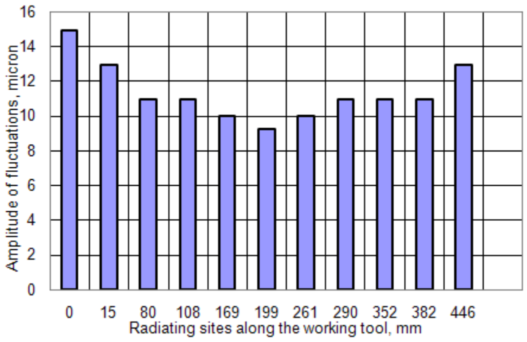

Fig. 6. The distribution of vibration amplitude of radiating surfaces of the tool along the axis

The results of control of vibration amplitude allow to define radiation intensity in liquid:

$I=2\pi^2\rho c f^2 A^2$,

where ρ is a wave resistance of the medium [kg/m^3], c is a velocity of sound in the material of the radiator (titanium) [m/sec], f is a resonance frequency [Hz], A is a vibration amplitude [m]. Measured values of the amplitude and its distribution along the radiator let define mean intensity of radiation, which is 12 W/cm^2 for the radiation into liquid.

Comparing obtained results with the results of the calorimetric method of control [5] it was determined correspondence of the results with the accuracy of no less 10 %.

III. CONCLUSION

As a result of carried out investigations and design the measuring bench was proposed and designed allowing to control the parameters of the piezoelectric vibrating systems with the multi half-wave radiators of variable cross-section not only at the stage of the creation but also during the operation.

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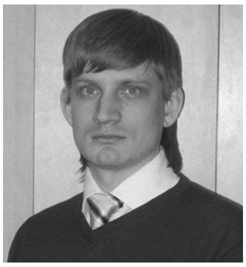

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