Control Device of Ultrasonic Vibration Amplitude

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Abstract **–the article presents the results of the study, which allows design the control device of the amplitude of the radiating surface of complex form generating vibrations with the amplitude of more than 10 micron.**

Index Terms **– Ultrasound, ultrasonic vibrating system.**

I. Introduction

VIBRATION AMPLITUDE of the radiating surface of the vibrating system is the main parameter, which determines the quality of the operation of the radiator and the efficiency of the technological processes. It is fundamentally important to provide the control of vibration amplitude at the realization of the technological processes, as practically all technological processes have extreme character, i.e. their efficiency has maximum value at certain amplitude.

Last years at the realization of ultrasonic technologies in industrial conditions multi half-wave radiators [1] are widely used, they are connected in series half-wave modules with the radiating surface of complicated form, it aggravate the problem essentially. It is caused by the fact, that there are several radiating surfaces (from 3 to 15) in the form of transition sectors between half-wave links of the radiator. The shape of the transitions between them is determined by the technological task. Vibration amplitudes can essentially vary, that causes different efficiency of ultrasonic treatment along the radiator and decreases quality of produced articles.

Different control devices of the amplitude of mechanical vibrations of the radiating surfaces in the field of acoustic and ultrasonic frequencies are known at present.

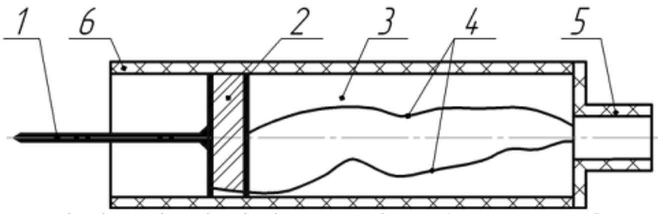
The main disadvantage of the most part of modern devices is complexity or impossibility to obtain absolute magnitudes of measured value (especially in opaque media) with preliminary calibration according to particular measuring situation.

II. Problem Definition

The control device for the measurements of vibration amplitude [2,3] being a part of special-purpose measuring equipment [4] containing installed in series in the case and acoustically connected with each other the metal waveguide pointed from one side and the piezoelectric element (see Fig. 1) is widely used in practice.

The device is applied for the control of amplitude and its distribution on radiating transition surfaces and end surface by transmitting of vibrations through point contact of the metal rod on the piezoelectric transducer.

At the control realization in laboratory conditions test voltage, which does not exceed 0.1 of working voltage at the operation of the vibrating system at the realization of technological processes, is supplied to the controlled electromechanical (magnetostrictive or piezoelectric) transducer of the vibrating system.



1 – metal rod; 2 – piezoelectric element; 3 – damper (epoxy compound); 4 – connecting wires; 5 – electrical connector; 6 – case.

Fig. 1. Construction of piezoelectric receiving transducer.

The metal rod 1 in the form of the needle connected to the piezoelectric element 2 is placed perpendicularly to the vibrating surface of the ultrasonic vibrating system and touches it with predetermined force. Perceived mechanical vibrations are transmitted to the piezoelectric element 2 and excite its vibrations. On the electrodes of the piezoelectric element electric voltage appears which is proportional to amplitude of mechanical vibrations of the radiating surface of the ultrasonic vibrating system. The piezoelectric element is the element made of piezoelectric ceramics of LZT-19 mark. The electrical connector 5 is intended for the connection of the control device to the measuring device in order to measure the parameters of generated voltage – amplitude and frequency. Designed device is housed in the case 6.

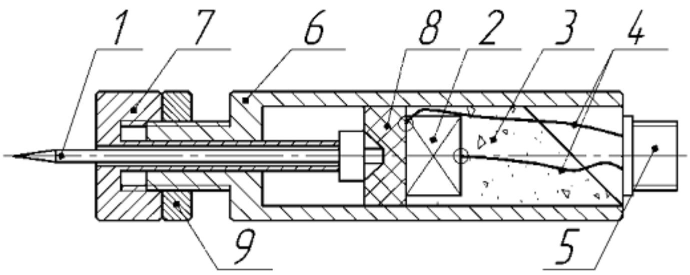
The operation of developed device allows determine the possibility to control the amplitude of the radiating surfaces vibrating at the amplitudes of more than 5…10 micron, namely such amplitudes are realized in the conditions of real operation of the vibrating systems. It is caused by the fact, that at vibration amplitude of more than 5…10 micron the piezoelectric receiver loses contact with the surface of the radiator, the contact of the metal rod with the piezoelectric element and the piezoelectric element itself are damaged.

That is why, it is possible to realize the control only at lowered supply voltage of the vibrating systems and measured values essentially differ from the real ones.

Noted disadvantage makes impossible the application of the device at solution of research tasks, the measurement at production conditions of the operation of the devices in various technological media and it should be eliminated.

In this connection it is evident, that we should develop the device able to control amplitude of radiating surface vibrating at the amplitudes of more than 5…10 micron in the conditions of real operation of the vibrating system.

Proposed and developed control device is shown in Fig.2.



1 – metal waveguide; 2 – piezoelectric element; 3 – damper (epoxy compound); 4 – wires; 5 – electrical connector; 6 –case; 7 – cylindrical bushing with the screw nut; 8 – elastic layer made of sound-absorbing material; 9 – check-nut
Fig. 2. Control device of mechanical vibration amplitude.

Distinctive feature of proposed device is in following, metal waveguide with the side opposite to the pointed end has contact pad, which size does not exceed the size of the piezoelectric element, there is an elastic layer made of sound-absorbing material between the contact pad and the piezoelectric element.

The waveguide is located with the possibility to move perpendicularly to the surface of the piezoelectric element in the cylindrical bushing, one side of which touches the reverse side of the contact pad of the waveguide, fixed threaded connection with the case are made on the other side of the cylindrical bushing, the dimensions of the piezoelectric element are chosen from the conditions of providing its minimum resonance frequency exceeding in no less than 10 times minimum frequency of controlled signal (see Fig.2).

The metal waveguide 1 being a body of revolution has complex cross-section geometric shape and consists of the element with pointed end (the needle) at one side and the contact pad of larger diameter at the side opposite to the pointed end, which size does not exceed the size of the piezoelectric element. Between the contact pad and the piezoelectric element there is an elastic layer 8 made of sound-absorbing material, which allows avoid loss of contact of the piezoelectric receiver with the surface of the radiator, damage of contact of the metal rod with the electrodes of the piezoelectric element and damage of the piezoelectric element itself. The change of layer thickness lets adjust sensitivity of the control device.

The waveguide is placed with the possibility of the movement perpendicularly to the surface of the piezoelectric element in the cylindrical bushing 7 having complex form uniting in one construction hollow cylinder and thread screw nut for the fastening to the case 6, which provides its coaxiality and prevents displacement of the bushing and its touch of the waveguide. At that the side of the bushing, which is opposite to the thread screw nut, touches reverse side of the contact pad of the waveguide 1 without fixed mechanical joint. The sizes of the piezoelectric element 2 are chosen from the conditions of providing its minimum resonance frequency exceeding minimum frequency of controlled signal in no less than 10 times.

At the realization of the control of vibration amplitude of the ultrasonic radiator the control device is placed perpendicularly to the radiating surface of the radiator and for the control of vibration amplitude of the transition surfaces of cross-section multi half-wave radiators the control device is located in a such way, that the signal registered by the oscillograph has largest value. Thus the control device touches vibrating surface in the point generated by the tangent line to the circular arc of the transition surface of the radiator, at that the device is placed perpendicularly to tangent line.

The metal waveguide 1 touches by the pointed side in the position of the vibrating surface of the ultrasonic vibrating system. Received mechanical vibrations are sent to the elastic layer 8 made of sound-absorbing material, where their normalized weakening occurs in order to prevent damage of the piezoelectric element. Further sent vibrations excite the piezoelectric element 2, on which appears electric voltage proportional to mechanical vibration amplitude of the radiating surface of the ultrasonic vibrating system. At that during the measurement at the touch of studied vibrating surface in the point by the waveguide it is pressed with certain force to the surface, as a result of which the contact of one side of the cylindrical bushing and the reverse side of the contact pad of the waveguide 1stops due to the deformation of the elastic layer 8. The electrical connector 5 is intended for the connection of the control device to the measuring equipment to measure the parameters of generated voltage – amplitude and frequency.

Moreover to avoid the loss of dynamic stability of the waveguide the cylindrical bushing 7 has a length, which is less than the waveguide length, and it is fastened on the case 6 by thread part. The device is supplied with the check-nut 9 in order to prevent untwisting and change of pull of waveguide contact pad to the elastic layer made of sound-absorbing material.

The damper 3 made of epoxy resin with the filler helps to eliminate parasitic vibrations of the transducer elements.

III. CONCLUSION

As a result of the study we proposed and developed the device able to control mechanical vibrations of the radiating surface with the amplitudes of more than 5…10 micron.

Developed device was tested at the laboratory and it can be recommended for the application both at laboratory and industrial conditions.

ACKNOWLEDGEMENT

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