Study of Efficiency of Ultrasonic Treatment In Running Volumes

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***Abstract* –The article presents the results of studies allowing us to reveal the operation condition of the ultrasonic apparatuses with multi half-wave radiators in confined space, at which efficiency of ultrasonic influence on the technological process decreases and essential deviation from nominal operation mode is observed.**

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

I. INTRODUCTION

ULTRASONIC ACTION is applied in different branches of industry providing intensification of various technological processes. At that ultrasonic equipment utilizing for intensification of technological processes in liquid and liquid-dispersed media (dispersion, emulsification, extraction, cleaning) are the most widely used in practice.

At modern productions to provide maximum energy action the ultrasonic equipment [1] used multi half-wave piezoelectric vibrating systems [2,3] guarantying ultrasonic action in closed technological volumes is applied.

Available or special tanks of various constructions, forms and sizes are used as a technological volume. The forms and sizes of such constructions are not optimized to provide maximum efficient action, that in practice leads to uneven action of treated medium and finally to loss of quality of the produced goods.

In this connection the methods of the processes realization, at which ultrasonic action is provided on the thin layer of treated material near the radiator, are applied. It can be made by the completing of the ultrasonic equipment with running volumes placed horizontally and vertically, the influence on processed media are carried out at maximum vibration intensity continuously and uniformly [1].

The simplest technological volumes are the hollow cylinders, in which the radiator of ultrasonic vibrations made in the form of cross-section rod with the length of several sizes of half-waves of ultrasonic vibrations propagated in the rod is placed.

Main radiation of ultrasonic vibrations occurs on the area, in which the diameter of the radiator changes; that is why intensity distribution of the field of ultrasonic vibrations inside the limited volume filled with liquid has complicated character. Its study is necessary for the understanding of the processes taking place inside the volume and for perfecting of the apparatuses due to the choice of the optimum sizes of the radiator and the technological volume, the form of internal surface of the volume, placement of additional reflectors correcting and intensifying the process.

In this connection there is a need to study the propagation of ultrasonic vibrations in running volumes.

II. PROBLEM DEFINITION

As the main parameter characterizing the efficiency of ultrasonic action [4] – [6] is the vibration amplitude (intensity), it is evident, that it is necessary to control it for determination of uniformity of vibration distribution and as, consequence, efficiency of influence.

Unfortunately, the study of amplitude value and its propagation inside the volume is impossible due to the complexity of carrying in and traveling of the probes, their cavitation damage. That is why, the task is to control vibration amplitude on the external surface of the technological volume allowing indirectly obtain the value and the vibration amplitude distribution generated by the ultrasonic radiator.

Thus, taking into account the design of multi half-wave radiators having maximums and minimums at the distribution of vibration amplitude along the axis of the radiator and its placement in the running technological volume there is a need to realize the control of intensity of ultrasonic action on treated liquids over the volume.

The control of the distribution of vibration amplitude of the radiator on the surface of the technological volume was carried out on the developed measuring test bench [7] (see Fig.1).

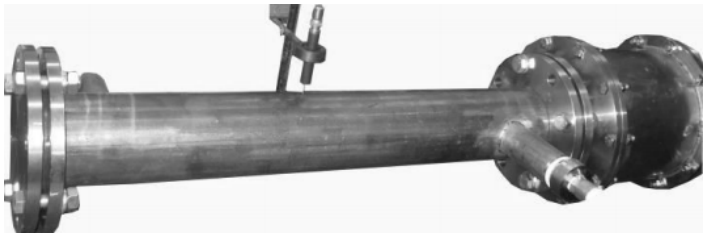

Fig. 1. Control of the distribution of vibration amplitude

As a result of carried out measurements it was determined the presence of the maximums and minimums of the vibration amplitude along the axis of the running volume (see Fig.2).

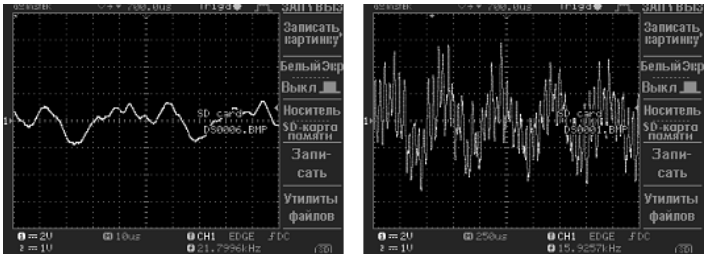

Fig. 2. Maximums and minimums of the vibration amplitude

This shows that the view of the distribution of vibration amplitude on the surface of the technological volume corresponds to the distribution of the amplitude of half-wave radiator itself. In order to exclude noise term caused by the cavitation processes the measurements are carried out at the excess pressure in the running volume (see Fig.3).

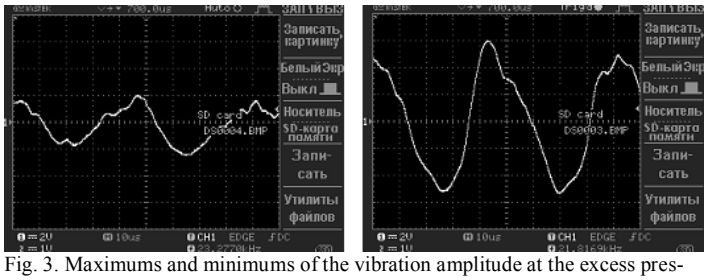

Fig. 3. Maximums and minimums of the vibration amplitude at the excess pressure.

Taking into consideration the presence of the maximums and minimums of vibration amplitude of the surface of the running volume from the presented oscillograms it is evident, that even at the presence of the zones with maximum and minimum intensities inside the volume subject to damping and diffractional deviation the mean vibration amplitude due to resonance phenomena inside the technological volume (at the internal surface of the walls) rises in no less than three times, that is sufficient for providing of intensive cavitation treatment even in high-viscous media.

Such situation can be realized in practice at the ultrasonic treatment of homogeneous liquids.

However at the treatment of various media, for example at the emulsification process (oil in water or water in oil) in horizontally placed technological volume media flowing along the axis of the volume can be treated by ultrasonic action in different way (see Fig.4).

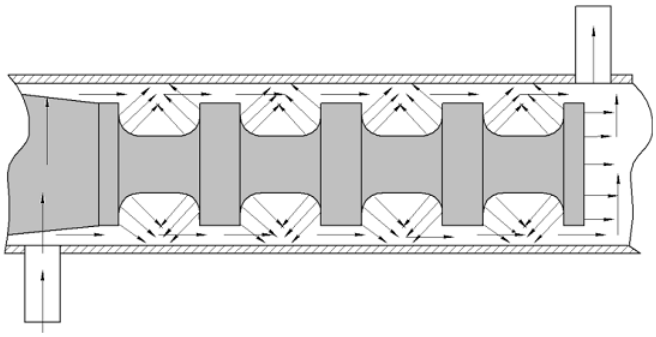
Fig. 4. Scheme of treatment process of liquid media.

The problem is increased at the solution of the tasks of ultrasonic treatment of dispersed media with liquid carrier phase (dispersion, extraction, spreading of reinforcing components in resins and polymers, realization of the processes on the catalysts). Abnormally high degree damping and possibility of formation of solid particle residual make it impossible to provide necessary intensity level in some zones of the technological volumes, in such situation uniformity of treatment cannot be achieved (see Fig.5).

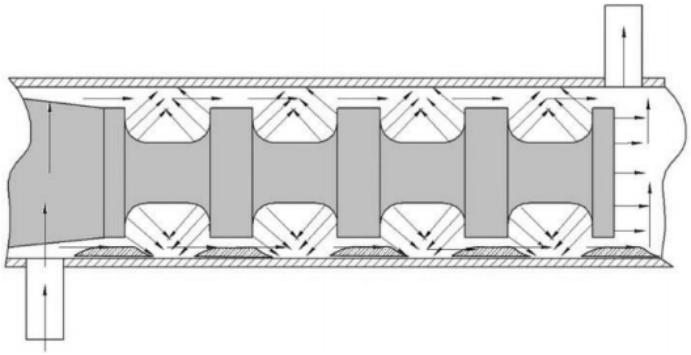
Fig. 5. Residual formation.

The simplest solution of the problem of providing of ultrasonic action uniformity on all treated medium is the placement of the mixing device in the running volume, which guarantees residual elevation and its distribution in the medium over the volume or additional mixing of liquids with different viscosity in order to provide efficiency increase of ultrasonic action (see Fig.6).

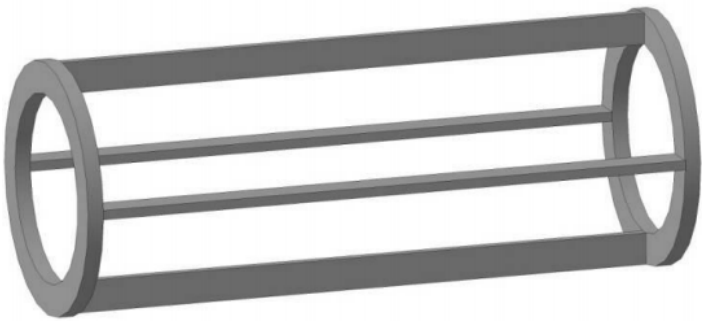
Fig. 6. Mixing device

The fragment of the running volume with the mixing device allows rise residual at horizontal positioning of the running volume distributing it in treated medium and it lets have additional ultrasonic action, which is presented in Fig.7.

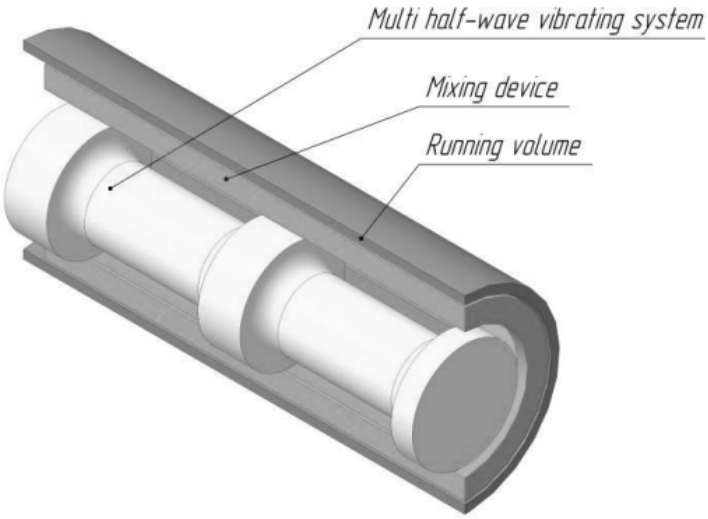

Fig. 7. Fragment of running volume with mixing device.

At that varying the combination of the speed of flowing of treated medium through the volume and rate of rotation of the mixing device it is possible to achieve maximum effect of ultrasonic action at the treatment of various media.

III. CONCLUSION

Thus as a result of carried out researches we developed the test bench for the control of vibration amplitude and its distribution along the surface of the technological volumes, which let determine:

1. The application of running volumes as a part of ultrasonic technological apparatuses allows provide uniformity of ultrasonic action on technological media by ultrasonic vibrations with the amplitude, which exceeds in no less than three times vibration amplitude on the surface of the radiator.

2. To provide uniformity of ultrasonic action on complicated in composition (heterogeneous, superfine) technological media it is necessary to apply additional mixing devices inside used technological volumes.

ACKNOWLEDGEMENT

The reported study was supported by RFBR, research project No. *14-08-31521* мол_а.

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