The Development of The Equipment For Ultrasonic Defoaming For Industrial Application

Vladimir N. Khmelev, *Senior member*, IEEE, Andrey V. Shalunov, Roman V. Barsukov, Maxim V. Khmelev, Andrey A. Romashkin, Anton N. Galakhov
Center of Ultrasonic Technologies, Biysk, Russia
Biysk Technological Institute (branch) Altai State Technical University named after I.I. Polzunov, Biysk, Russia

Abstract **– This paper is devoted to the development of equipment of industrial applications. The model setup that can provide various types of extinguishing foams in industrial scale. The results measure the distribution of vibration amplitude, sound pressure level of the emitting surface of the disk radiator step-variable form.**

Index Terms **– Ultrasonic, oscillating system, industrial foam breaking.**

I. INTRODUCTION

EXTREME FOAMING in industry adversely affects the volume of mined and processed raw materials namely at the production of oil coke at the plants of slowed-down coking, where most part of low-ash oil coke is produced, which is used at the manufacture of aluminium and for melting of high-quality steel. However the process of slowed-down coking of naphtha residue in such plant is accompanied by considerable foaming, as a result yield of volatile substances increases, mechanical hardness of coke decreases. Moreover foaming of coking material leads to the necessity of early stopping of raw material supply, and as a result 35 – 40% of the volume of coking chamber is not used and the productivity of coke-oven battery falls. The efficiency of operation of sugar production is connected with the problems of foaming. Foaming negatively influences on the process of sugar production:

- it makes difficult the process of sugar extraction from cuttings;
- water evaporation at the evaporator system;
- boiling;
- centrifugal separation.

High foaming of diffusion juice is one of the obstacles for normal operation of the diffusers. Moreover foam covering cuttings reduces its surface and it makes difficult the process of saccharose diffusion. Also there is a problem of measurements of liquid level in reactors, reservoirs, vessels, where the measurements are carried out with the help of different level gauges. The most used are level gauges of contact action, which disadvantage is, that if liquid is inclined to foaming, the sensor checking liquid level switches on at the contact with foam, which is rested above liquid.

Thus for many productions foam influences negatively, that is the reason of degradation of products, that finally leads to spoilage in production.

For solving problems of foaming in industry many methods are used, they are chemical, mechanical, thermal, acoustic, etc. Chemical method of defoaming in spite of its wide use has a number of disadvantages. [1]The main disadvantage of chemical defoamers is the possibility of pollution of half-finished products, finished products and processing line. Besides that introduction of antifoaming agents leads to the increase of costs for manufacture of made production, as consumption of these substances can achieve several tones in a day. For introduction of chemical defoamers there is a need in the devices for their supply to the apparatus, that in turn requires additional expenses for the production [1]. Mechanical defoaming also has disadvantages. At the destruction of foams of heavy foaming liquids and viscous foams with firm walls of the bubbles mechanical method of defoaming is ineffective. Besides mechanical defoaming is very power-consuming.

The most interesting and perspective is acoustic method of foam destruction based on energetic influence on foam by high-intensity sonic or ultrasonic vibrations.

Defoaming by ultrasound has a number of advantages in comparison with other known methods: it excludes failure of sterility of finished products, it can be used for defoaming of extremely flammable liquids and it does not require special materials (in comparison with chemical methods). Acoustic method of defoaming lies in the generation of high-intensity ultrasonic vibrations (more than 130 dB) directed to the zone of foam formation. Alternating sound field influences most effectively on upper (open) layers of foam, as it penetrates weakly inside because of high level of damping.

At high intensities of sound wave alternating forces achieve the values, at which breakage of foam layers occurs. For different types of foams there is a threshold intensity of vibrations, at which it disappears. Stability of foam to acoustic influence depends on the structure of foam. Foams consisting of large bubbles, as a rule, can be easily and quickly destroyed at low intensities. Foams consisting of small bubbles are more stable to the influence of acoustic fields and require higher intensity.

The structure of foam is determined not only effective intensity of acoustic wave, but its optimum frequency. For the destruction of foam consisting of small bubbles high-frequency vibrations are used. In any case vibration frequency is chosen out of the range of audibility of human ears (more than 18 – 20 kHz), as at high intensities of acoustic wave the application of acoustic defoamers requires special acoustic insulation.

For providing of effective ultrasonic influence developed apparatus should generate radiation of vibrations with the intensity of no less than 130 dB at the frequency of no less than

20 kHz. The main element of the technological apparatus is a piezoelectric vibrating system with the radiator, shown in Fig. 1.

a)

b)

Fig. 1. 3-D model of the ultrasonic vibrating system with the radiator of the diameter of 250 mm (a) and the ultrasonic device with disk radiator of the diameter of 250 mm and the generator (b)

Performance features of developed apparatus are presented in Table I.

TABLE I
PERFORMANCE FEATURES OF THE ULTRASONIC TECHNOLOGICAL APPARATUS

Consumed power, no more than, VA	220
Power supply from the line of alternating current, W	220±22
Intensity of vibrations (1 m), dB, no less than	135
Overall dimensions of the electronic unit, mm	270×270×110
Overall dimensions of vibrating system, mm	Ø250x150
Diameter of the radiator, mm	250
Frequency of vibrations, kHz	22

II. CARRYING OUT INVESTIGATIONS ON DETERMINING OF PERFORMANCE FEATURES OF DESIGNED READY-ASSEMBLED ELECTROACOUSTIC TRANSDUCERS WITH ELECTRONIC GENERATORS

Carrying out studies are intended for definition of performance features of both electroacoustic transducers with disks of stepped-variable form and ready-assembled ones with suitable electronic generators.

Measuring stand intended for the measurements of distribution of vibration amplitude of radiating surface of disk radiator of stepped-variable form is shown in Fig. 2.

Fig. 2. The stand for measurements of distribution of vibration amplitude

The results measurements for the disk radiator of stepped-variable form Ø250 mm are shown in Fig. 3 and in these figures obtained values are visualized in the form of 3-D bar graph.

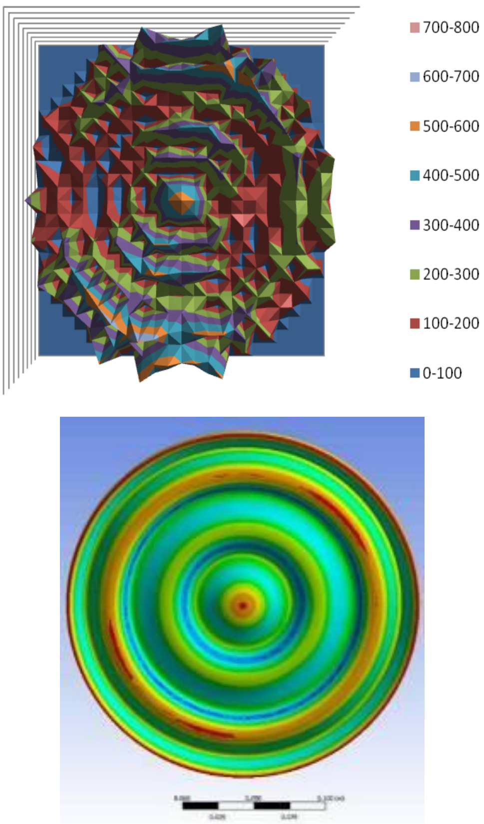


Fig. 3. The distribution of vibration amplitude on the surface of disk radiator Ø250 мм (on the left simulated, on the right measured)

The analysis of made bar graphs shows, that the distribution of amplitudes along the surface of the disk radiator of stepped-variable form has ring-shaped character. It is expressed in alternation of maximum and minimum of vibrations and proves correct calculation, production and matching of the disk radiator with the piezoelectric transducer. The comparison with the results of modeling obtained by the finite element method shows, that the form of distribution varies no more than in 10 – 15%. It indicates the accuracy of design procedure, correspondence of obtained characteristics of the disks to calculated ones and high precision of the production.

The results of measurements of acoustic pressure – intensity of pressure amplitude generated by the transducer in arbitrary point of space in front of the transducer – (construction of directivity pattern) generated by the electroacoustic transducer with the radiator of stepped-variable form Ø250 mm are given in Fig. 4.

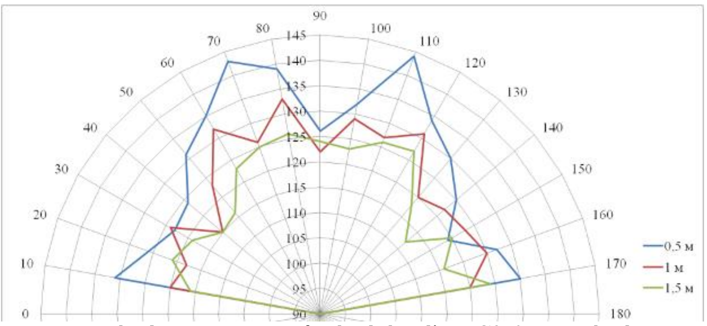


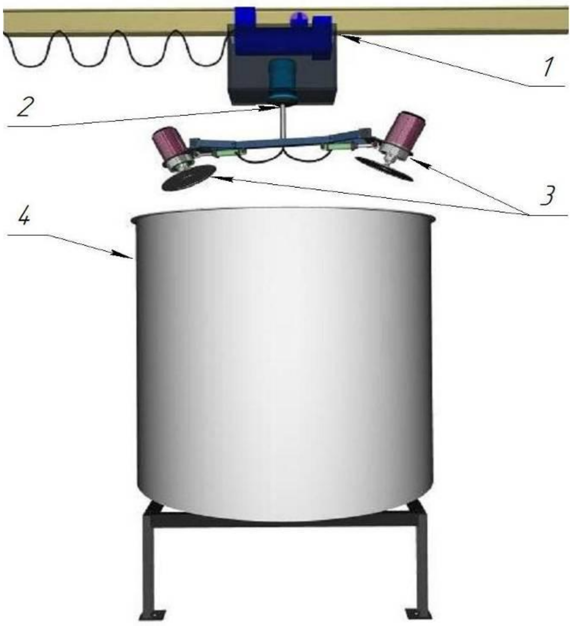
Figure 4 – The directivity pattern for the disk radiator Ø250 mm at the distance of 0.5 m; 1 m; 1.5 m without reflecting device

Obtained results are the evidence of the achievement of acoustic pressure, which is necessary and enough for the intensification of defoaming process.

III. Theorythe Apparatus For The Destruction Of Different Types Of Foam In Industry

In the conditions of large industrial productions, where used volumes can achieve Ø3 m and the height of 10 – 40 m, for the realization of defoaming process it is necessary to apply several radiators. The appearance of the installation for the destruction of different types of foams in industry is shown in Fig. 5.

Proposed installation for the destruction of different types of foams is an automated system, which evenly influences on the total volume of foam.



1 – transfer mechanism of the installation; 2 – electric motor; 3 – high-intensity radiators of ultrasonic vibrations; 4 – vessel

Fig. 5. The industrial installation for the destruction of different types of foams

The installation of the destruction of different types of foams consists of transfer mechanism along the monorail, which length corresponds to necessary conditions of the industrial process, vessel with foam, electric motor with axial shaft, which is necessary to provide rotation of developed ultrasonic vibrating systems, electronic generator (it was not shown in Fig. 2) intended for power supply of the ultrasonic vibrating system. The radiators with the piezoelectric transducer are fastened to the main bar on the rotation gears with hydraulic cylinders and they have possibility of changes of the slope angle in the range of 30-90º from strengthening bar. Change of the slope angle is controlled by the operator.

Defoaming process is realized in a following way. The transfer mechanism of the installation along the monorail is switched on (position 1), it places the installation directly over the vessel with foam. The electric motor and the ultrasonic generator are switched on (position 2) (it was not shown in Fig. 5). At that the radiators (position 3) begin revolving on their axis with angular velocity, which is necessary for the realization of even defoaming generated in the vessel (position 4). Acoustic vibrations radiated by the disk radiator are formed in focus, looking like the cone with the single focal point, in which vibration amplitude is maximum. Under the action of high-intensity ultrasonic vibrations directed to the zone of foam generation alternating forces achieve the values, at which destruction of foam occurs. Alternating acoustic field more actively influences on upper (open) layers of foam, as it penetrates weakly deep into because of high damping. Thus, the uniformity of acoustic (ultrasonic) influence in whole volume is provided in the mechanisms.

The technical device for defoaming of different types of foams has following performance features: for the formation and focusing of acoustic vibrations in the volume with the diameter of 1800 mm two radiators in the form of stepped-variable disks with the diameter of 250 mm each are used. Generating vibrations on 5th or 7th modes in the frequency range of from 20 to 30 kHz the radiators provides the formation of ultrasonic vibrations with intensity of 130...150 dB at near focal distance (up to 1 m), the formation of ultrasonic vibrations with intensity of more than 150 dB at the focal distance of 0.5 m. As the distance from the focus of the radiator increases, intensity of radiation reduces. The material of the radiator and the concentrator is titanium alloy.

III. CONCLUSION

Thus after carrying out investigations following results are obtained:

The distribution of vibration amplitude of radiating surface of disk radiator of stepped-variable form Ø250 mm was measured.

The results of measurements of acoustic pressure generated by electroacoustic transducer with disk radiator of stepped-variable form Ø250 mm were obtained.

The model of the installation, which is able to provide defoaming of different types of foam in industrial volume, was designed.

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Vladimir N. Khmelev (SM'04) is deputy director for scientific and research activity at Biysk technological institute, professor and lecturer, Full Doctor of Science (ultrasound), honored inventor of Russia, laureate of Russian Government premium for achievements in science and engineering, IEEE member since 2000, IEEE Senior Member since 2004. His scientific interests are in field of application of ultrasound for an intensification of various technological processes. His biography published in 7th issue of book "Who is who in scientific and engineering".

Andrey V. Shalunov has got engineer's degree at 2003 and Philosophy degree (Candidate of Engineering Sciences) at 2006. He is leading specialist in designing of interface systems of ultrasonic technological equipment and other devices, docent and lecturer in Biysk Technological Institute, laureate of Russian Government premium for achievements in science and engineering. His research interests are in designing of ultrasonic technological equipment and in applying of ultrasonic vibrations of high intensity for intensifying of technological processes and for changing of materials and substances properties, constructing of technological assemblies for ultrasonic technologies realization.

Roman V Barsukov has got engineer's degree at 1998 and Philosophy degree (Candidate of Engineering Sciences) at 2005. He is leading specialist in designing of modern electronic ultrasonic generation devices, laureate of Russian Government premium for achievements in science and engineering, docent and lecturer in Biysk Technological Institute. His research interests are in field of ultrasonic equipment and technologies and in applying of high intensive ultrasonic vibrations for intensifying of technological processes and for changing of materials and substances properties.

Maxim V. Khmelev has got engineer's degree on information science and measuring engineering at 2005. He is a Chief Executive Officier of innovative company specialized in designing and manufacturing of various ultrasonic equipment for applying in different technological processes.

Anton N. Galakhov (S'10) has got engineer's degree on information science and measuring engineering at 2009. He is post-graduate student of Biysk Technological Institute. His research interests are in field of finite-element modeling.

Andrey A. Romashkin (S'10) is post-graduate student of Biysk Technological Institute now and IEEE Student Member since 2010.