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ARTICLE

APPLICATION OF LOW-FREQUENCY ACOUSTIC VIBRATIONS FOR TECHNICAL WATER TREATMENT

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ABSTRACT

This paper describes the general structure of the LabVIEW program package. The program was developed using the National Instruments LabVIEW software package. The algorithm of operation of the automated system of the experimental setup is described. For experimental studies, an automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations was specially developed and manufactured. A schematic diagram of an automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations is presented. A block diagram of an automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations is presented. The results of experimental studies are presented and presented graphically. To compare the results of changes in the concentration of suspensions as a function of time, we plotted the effects of sedimentation for each sensor at different impact frequencies. The purpose of the experimental studies was to confirm the calculations of the optimum frequency of resonance formation in the pipe and the intensity of precipitation at frequencies other than of resonance formation, but adjacent thereto in the interval of ±15 Hz and ±30 Hz.

KEY WORDS
LabVIEW, technical water, acoustic oscillations, sedimentation, resonance, ultrasonic vibrations (US), acoustic transducer (AT), acoustic speed, technical water, scale.

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INTRODUCTION

Increasing energy efficiency and introducing energy-saving technologies are priority areas for the development of heat and power engineering.

The concept of using ultrasonic technology to prevent the formation of scale on heat exchange equipment is based on the excitation of ultrasonic vibrations (ultrasonic waves) on the surface of a heat exchanger or in a heat carrier (water) [1, 2].

For shell-and-tube heat exchangers (water heaters), the welded connection of radiators with the tube board of the water heater is the most optimal method of transferring ultrasonic waves from the ultrasound emitter to the excited medium [Fig. 1.1]. Distributed along the tube board, ultrasonic vibrations are transmitted through welded or rolling joints into the tube bundle, preventing deposition of scale or deposits of other origin, for example, organic matter on the heat exchanger surface. In the case of a steam or hot water boiler, the radiators are welded to the drums and collectors of the side and rear screens [Fig. 1.2], which provides protection against the scale in high-temperature boiler sections. For plate heat exchangers, the formation of ultrasonic oscillations in the water column is preferable [Fig. 1.3], which is achieved due to a certain change in the design of the radiators. The frequency of forced ultrasonic vibrations is 15-25 kHz and is selected from the results of numerous studies, as optimal to prevent the formation of deposits and friendly to welded and rolled joints [3, 4].

Ultrasound technology (UST) is designed to prevent the formation of scale, which ensures high-quality indicative results of operation in a relatively short time. Its maximum efficiency is achieved by the parallel equipping of heat exchange equipment with instrumentation and automation, subject to consideration of energy-saving technologies and recording of heat consumption and supply as a single direction in a series of technical measures for the development of heat power engineering. [5, 6, 7]

MATERIALS AND METHODS

The algorithm of operation of the automated system of the experimental setup.

For experimental studies, an automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations has been developed and constructed.

Fig. 2.1 shows a schematic diagram of an automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations. The principle of the plant is described in the utility model patent No. 104319 dated 03.12.2010 "A device for laboratory studies of the intensity of industrial water treatment from suspended solids" by Kondratiev A.Ie., Iliasov N.Kh., Gaponenko S.O. [8,9,10, 11].

Fig. 1.1: Installation of Acoustics-T on a shell-and-tube water heater.

Fig. 1.2: Installation of an Acoustics-T device on a DKVr-10 boiler.

Fig. 1.3: Installation of an Acoustics-T device on a plate heat exchanger.

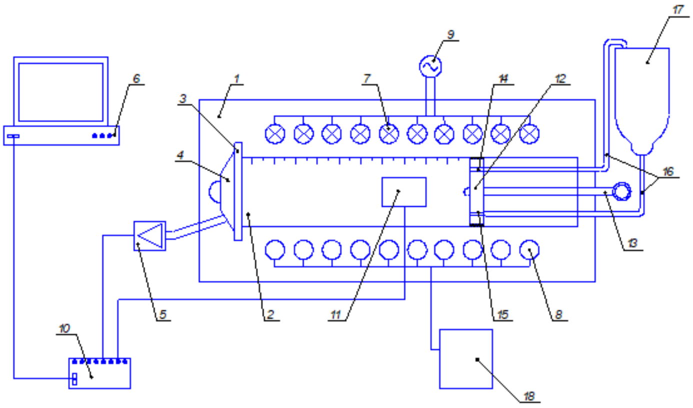

Fig. 2.1: An automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations: 1 - base; 2 - pipe, length 620 mm and diameter □45×2; 3 - membrane; 4 - acoustic radiator; 5 - signal amplifier; 10 - ADC-DAC; 6 - the computer with LabVIEW installed; 7 - light-emitting diodes; 8 - photocells; 9 - power adapter; 18 – milli voltmeter; 12 - movable piston; 13 - stem; 14 - output valve; 15 - input valve; 16 - flexible hoses; 17 - expansion tank.

[Fig. 2.2] presents a photo of an experimental plant for technical water treatment by acoustic vibrations.

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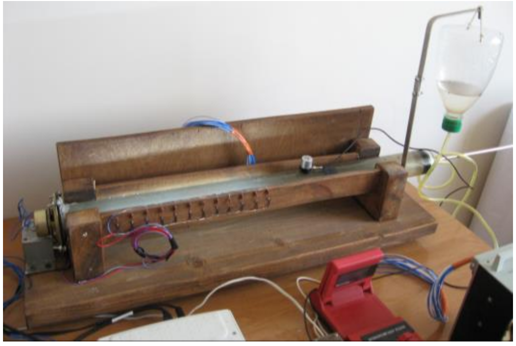

Fig. 2.2: A photo of an experimental plant for technical water treatment by acoustic vibrations.

RESULTS AND DISCUSSION

Experimental studies were carried out in several stages: with natural precipitation, with an acoustic effect on the water under investigation at 605 Hz, which, as the calculations show, is the optimum frequency of resonance in the tube.

The purpose of the experimental studies was to confirm the calculations of the optimum frequency of resonance formation in the pipe and the intensity of precipitation at frequencies other than of resonance formation, but adjacent thereto in the interval of ±15 Hz and ±30 Hz.

Experiment no.1.

The purpose of the first experiment is to determine the dependence of the change in the concentration of suspensions on time under natural precipitation. For this, the turbid water filled in a transparent pipe is illuminated by light-emitting diodes and by means of photocells we take readings of the change in concentration every 15 seconds from the measuring device for the concentration of inorganic contaminants. The data is entered in [Table 3.1]. After processing the results, the data looks as follows [Table 3.2].

Table 3.1: Time-based change in the concentration of suspensions with natural precipitation

Sec No.	1	2	3	4	5	6	7	8	9	10
15	0.226	0.235	0.234	0.193	0.194	0.205	0.206	0.215	0.211	0.226
30	0.208	0.217	0.215	0.169	0.171	0.183	0.186	0.191	0.189	0.211
45	0.189	0.191	0.198	0.155	0.156	0.17	0.176	0.18	0.178	0.197
60	0.179	0.181	0.19	0.148	0.149	0.162	0.171	0.174	0.17	0.186
75	0.173	0.174	0.186	0.142	0.141	0.159	0.167	0.17	0.165	0.178
90	0.168	0.169	0.182	0.138	0.135	0.154	0.164	0.166	0.162	0.174
105	0.167	0.167	0.179	0.135	0.133	0.152	0.162	0.164	0.16	0.172
120	0.165	0.164	0.178	0.132	0.13	0.15	0.161	0.162	0.157	0.168
135	0.164	0.162	0.175	0.129	0.126	0.148	0.159	0.161	0.155	0.164
150	0.16	0.159	0.172	0.125	0.121	0.145	0.157	0.16	0.153	0.16

Table 3.2: Time-based change in the concentration of suspensions with natural precipitation after processing the results

Sec %	1	2	3	4	5	6	7	8	9	10
15	1	1	1	1	1	1	1	1	1	1
30	0.92	0.923	0.918	0.875	0.881	0.892	0.902	0.888	0.895	0.933
45	0.836	0.812	0.846	0.803	0.804	0.829	0.854	0.837	0.843	0.871
60	0.792	0.77	0.812	0.766	0.768	0.79	0.83	0.809	0.805	0.823
75	0.765	0.74	0.794	0.735	0.726	0.775	0.81	0.79	0.782	0.787
90	0.743	0.719	0.777	0.715	0.695	0.751	0.796	0.772	0.767	0.769
105	0.738	0.71	0.765	0.699	0.685	0.741	0.786	0.762	0.758	0.761
120	0.73	0.697	0.76	0.683	0.67	0.731	0.781	0.753	0.744	0.743
135	0.725	0.689	0.747	0.668	0.649	0.722	0.771	0.748	0.734	0.725
150	0.708	0.676	0.735	0.647	0.623	0.707	0.762	0.744	0.725	0.708

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Experiment no.2

The purpose of the second experiment is to determine the dependence of the change in the concentration of suspensions on time under acoustic impact at 605 Hz. For this, the turbid water filled in a transparent pipe is illuminated by light-emitting diodes and by means of photocells we take readings of the change in concentration every 15 seconds from the measuring device for the concentration of inorganic contaminants. Acoustic impact occurs through the combined operation of an acoustic generator, an acoustic radiator and a membrane. The turbidity level should correspond to the initial value of the turbidity index in experiment 1. The applied frequency is set at a value of 605 Hz, which, according to the calculations, is the optimum frequency for resonance in the pipe. The data is entered in [Table 3.3]. After processing the results, the data looks as follows [Table 3.4].

Table 3.3: Time-based change in the concentration of suspensions under acoustic impact at 605 Hz

Sec No.	1	2	3	4	5	6	7	8	9	10
15	0.239	0.237	0.253	0.193	0.192	0.196	0.2	0.204	0.203	0.217
30	0.186	0.186	0.204	0.151	0.155	0.157	0.169	0.173	0.171	0.181
45	0.166	0.167	0.189	0.138	0.135	0.147	0.159	0.165	0.162	0.171
60	0.16	0.16	0.185	0.133	0.13	0.144	0.156	0.161	0.155	0.167
75	0.158	0.157	0.181	0.129	0.125	0.141	0.154	0.158	0.152	0.163
90	0.156	0.155	0.179	0.126	0.122	0.139	0.152	0.154	0.15	0.161
105	0.155	0.153	0.178	0.124	0.119	0.137	0.151	0.152	0.148	0.157
120	0.152	0.151	0.176	0.122	0.117	0.136	0.15	0.151	0.147	0.156
135	0.151	0.15	0.175	0.121	0.116	0.135	0.149	0.15	0.146	0.153
150	0.15	0.15	0.175	0.12	0.114	0.134	0.148	0.149	0.145	0.151

Table 3.4: Time-based change in the concentration of suspensions under acoustic impact at 605 Hz after processing the results

Sec No.	1	2	3	4	5	6	7	8	9	10
15	1	1	1	1	1	1	1	1	1	1
30	0.778	0.784	0.806	0.782	0.807	0.801	0.845	0.848	0.842	0.834
45	0.694	0.704	0.747	0.715	0.703	0.75	0.795	0.808	0.798	0.788
60	0.669	0.675	0.731	0.689	0.677	0.734	0.78	0.789	0.763	0.769
75	0.661	0.662	0.715	0.668	0.651	0.719	0.77	0.774	0.748	0.751
90	0.652	0.654	0.707	0.652	0.635	0.709	0.76	0.754	0.738	0.741
105	0.648	0.645	0.703	0.642	0.619	0.699	0.755	0.745	0.729	0.723
120	0.636	0.637	0.695	0.632	0.609	0.693	0.75	0.74	0.724	0.718
135	0.631	0.632	0.691	0.626	0.604	0.688	0.745	0.735	0.719	0.705
150	0.627	0.632	0.691	0.621	0.593	0.683	0.74	0.73	0.714	0.695

To compare the results of changes in the concentration of suspensions as a function of time, we plotted the effects of sedimentation for each sensor at different impact frequencies.

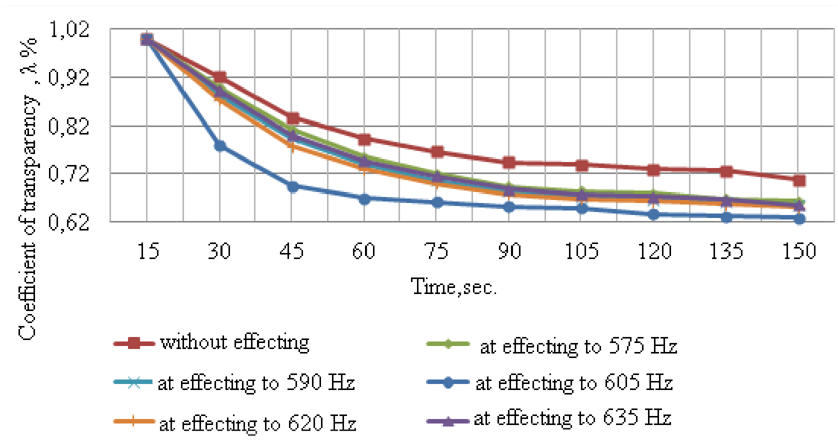

Fig. 3.1: Diagram of the change in the transparency index as a function of time for the 1st sensor.

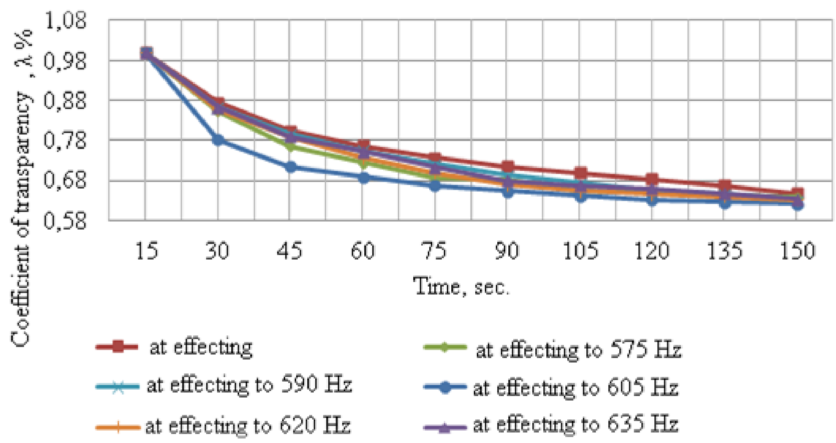

Fig. 3.2: Diagram of the change in the transparency index as a function of time for the 2nd sensor.

CONCLUSION

As we can see, the percent change in the concentration of suspensions flows much faster at a frequency of 605 Hz, which, according to calculations, was the optimal frequency of resonance formation than with natural precipitation.

For experimental studies, an automated system for technical water treatment by acoustic oscillations was developed and constructed. The program was developed in the LabVIEW software environment to determine and maintain natural oscillations. The automated system for determining and maintaining the natural oscillations of an experimental plant for technical water treatment by acoustic oscillations was developed and constructed. Analysis of the obtained experimental data shows that the percent change in the concentration of suspensions is much faster when water is exposed to the frequency at which a standing wave forms than in the case of natural precipitation.

CONFLICT OF INTEREST

There is no conflict of interest.

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None

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