R&E-SOURCE *https://journal.ph-noe.ac.at*
Online Journal for Research and Education
Special Issue 17, Dec. 2019, ISSN 2313-1640

IMPROVING TEACHER EDUCATION IN THE SUBJECT OF LABOR PROTECTION. SONOLUMINESCENT SPECTROSCOPY IN THE SAFETY CONTROL OF TECHNICAL SYSTEMS

Baklanova Larisa[1], Baklanov Oleksandr[2]

Abstract

Improving engineering teacher education in the subject of labor protection is important for the success of the industry. The most important area of labor protection is automated control of the safety of technical systems. The use of sonoluminesce spectroscopy in the safety control of vacuum evaporators was studied. The safety of which depends on the thermo physical properties of brines. Thermo physical properties of brines depend on the concentration of the main substance - sodium chloride and impurities of calcium and magnesium salts. Sonoluminescent spectroscopy is used for automated control of the content of the basic substance and impurities of calcium and magnesium salts. It is shown that the simultaneous action of ultrasound initiation of high and low frequencies sonoluminescence allows a 5-10-fold increase in the value of the analytical signal for calcium and magnesium in brines and its content in accordance with the metrological characteristics required in the salt industry. An automated safety control system for vacuum evaporators was developed and tested in laboratory conditions.

Keywords:
Professional education (Labor protection)
sonoluminescence
safety of technical systems

1 Introduction

Vacuum evaporation apparatus is a complex system, the safe operation of which requires continuous information about the content of the main substance and macroimpurities - calcium and magnesium - in natural brines. The use of gravimetry, titrimetry, flame atomic absorption spectrometry, and even a stationary version of sonoluminescent spectroscopy for this does not satisfy the requirements of modern production for expressness and accuracy. This is mainly due to the aperiodic cyclical nature of the change in the composition of the brine in each particular well. In addition, after sampling the brine from a depth of 300-400 m, due to a change in pressure, a change in its primary composition occurs. At the same time, brine gets into vacuum evaporators practically under the same pressure under which it was in natural conditions. As a result of this, there is a mismatch in the composition of the brine in the sample for analysis and in its technological version. In this connection, the efficiency and safety of operation of vacuum-evaporators is reduced.

[1] Ukrainian Engineering Pedagogics Academy, Department of Labor Protection and Environmental Safety, 84500, Bakhmut, Sibirtseva street, 19-73. *E-mail:* baklanovalarisa@ukr.net
[2] Ukrainian Engineering Pedagogics Academy, Department of Labor Protection and Environmental Safety, 84500, Bakhmut, Sibirtseva street, 19-73. *E-mail:* baklanovalarisa@ukr.net

2 Chapter

2.1 Section

A sonoluminescent spectrometer based on the AAS-3 atomic absorption spectrometer (Germany) was used. The study of samples and the measurement of the main substances detected in the sonoluminescent chamber -1 is located in the well (Fig. 1). The brine through the inlet valve-2 under the action of pressure in the system (1.2-1.4 atm.) Is Suppressed in the chamber with a capacity of 1000 ml. Using an automatic temperature measurement system consisting of thermocouples -3, placed in a protective shell, a special jacket for coolant-4 and a block of coolant-coolant -5, which is set in accordance with the set brine temperature and measurement. Then the brine was pumped out using a micropump-6 in accumulator-7 and from there it was again discharged into the well. Then the cycle was repeated again. Within 25 minutes, which corresponds to the technological cyclic effect of brine in vacuum evaporators. Analysis results prior to technological cyclic analysis.
The camera is made of quartz glass with a skinny 20-22 mm and installed in an internal protective steel casing. The source of ultrasonic vibrations are standard -8 piezoelectric emitters with operating frequencies of ultrasound 500 kHz, 1 MHz, 2 MHz and 2.5 MHz of the type TsTS-19, made of titanium-zirconate-lead. The piezoelectric emitter was powered from a tube generator of the type 24 - UZGI - K - 1.2 - 9, which made it possible to change the ultrasonic frequency from 50 kHz to 2.5 MHz. Sonoluminescent radiation was recorded by an FEU-109 - 10 photomultiplier through a -11 transparent quartz window. The story about the degree of saturation with argon is the highest through the bubbler - 13. Safety valves-14 were designed for a pressure of 20 atm, while there are bypass microchannels with keys for relieving pressure into the chamber. Used reagents not lower than analytical grade. Solutions were prepared in distilled water.

3 Chapter

Section 3.1

EXPERIMENTAL TECHNIQUE. 1000 cm3 of brine solution under pressure in the system (1.2-1.4 atm.) Was supplied into a chamber with a capacity of 1000 ml, saturated with argon for 5 min, cooled to a certain temperature, brought cesium chloride to a concentration of about 30 g / l and was affected by ultrasound at a frequency of 1 MHz, 2 MHz, 2.5 MHz, an intensity of 1 to 12 W / cm2. A sonoluminescence spectrometer was tuned to the corresponding analytical lines of sodium and calcium, and the content of the main component and macroimpurity were determined. During the experiments, the gas supply was not stopped in order to avoid degassing of the solution. The experiments on the influence of ultrasonic frequency on sonoluminescence intensity were carried out using the maximum possible ultrasonic intensity - 12 W / cm2, limited by the capabilities of the equipment used, in particular - the mechanical strength of the piezoceramic emitter. The whole process proceeded automatically.

Section 3.2

RESULTS AND ITS DISCUSSION. The maxima of all recorded sonoluminescence spectra with an increase in the ultrasound frequency were shifted to the infrared region (Table 1) and approximately corresponded to the spectra used in emission spectrometry, which also confirms our earlier conclusion about the emission nature of sonoluminescence spectra. The intensity of sonoluminescence of the same elements during the transition of the ultrasound frequency from 500 kHz to 2.5 MHz decreased, and a significant decrease in the intensity of sonoluminescence was observed during the transition from 1.0 to 2.5 MHz (Table 1). This is because in order to achieve a certain level of cavitation activity, at which the maximum possible intensity of sonoluminescence occurs, a corresponding value of the ultrasound intensity is also necessary, which increases with increasing frequency. It should be noted that the dependence of the intensity of sonoluminescence on the concentration of element chlorides was directly proportional in nature when using ultrasonic frequencies from 500 kHz to 2.5 MHz. The sonoluminescence intensity of elements with increasing ultrasound intensity increased up to the maximum possible ultrasound intensity - 12 W / cm2 (Table 2). It is obvious that, as in the case of using low-frequency ultrasound (18–47 kHz), the optimum value of the ultrasound intensity should be observed, corresponding to the maximum possible intensity of sonoluminescence for this system. It follows from the results of the experiments given in Tables 3 and 4 that the gravimetric and sonoluminescent methods have the best metrological characteristics when determining high concentrations of salt solutions, but the gravimetric method is time-consuming and laborious. Other methods have worse metrological characteristics than sonoluminescent spectrometry.

3 Conclusion

Thus, the possibility of using sonoluminescent spectroscopy in an automated system for the safe operation of vacuum evaporators has been shown. Moreover, the relative standard deviation of the results of determining the content of sodium chloride did not exceed 0.02, and potassium 0.08, which is worse than the gravimetric method - 0.01, but better than the atomic absorption method 0.11 and 0, 12 respectively. We use our scientific developments in lecture and laboratory work. We also attract our students to scientific work. This allows you to increase the activity of students of the specialty "Professional education (labor protection)."

4 Tables, Figures

Table 1. The intensity of sonoluminescence of elements in aqueous solutions of element chlorides, depending on the frequency of ultrasound and the concentration of solutions

Detectable component. The concentration of the solution, g / l		Sonoluminescence intensity, rel.			
		500 kHz	1 MHz	2 MHz	2,5 MHz
NaCl	50	3,5	1,5	0,7	0,5
	100	7,1	3,1	1,4	1,0
	200	14,0	6,3	3,1	2,1
	300	18,5	9,2	4,1	3,2
	λ, нм	589,8	590,0	590,1	590,1
KCl	50	6,5	2,1	1,2	1,0
	100	12,8	4,0	2,0	1,9
	200	24,0	8,1	4,0	3,9
	λ, нм	766,6	766,8	766,8	766,9

Table 2. The intensity of sonoluminescence of elements in aqueous solutions of element chlorides, depending on the intensity of ultrasound and the concentration of solutions

Defined component. Solution concentration, g / l		Sonoluminescence intensity, rel.			
		9 W/cm ^{2}	10 W/cm ^{2}	11 W/cm ^{2}	12 W/cm ^{2}
NaCl	200	3,5	5,0	5,8	6,3
	300	5,1	7,3	8,5	9,2
KCl	100	1,8	2,5	3,2	4,0
	200	3,6	5,0	6,4	8,1

Note. The table presents the averaged results of six experiments. The ultrasonic frequency is 1 MHz for NaCl, KCl solutions.

Table 3. The results of the determination of the basic substance in brines

Sample	introduced, g/l	Found, g/l (n=6)							
		Sonoluminesce method				Potentiometric or gravimetric method		Atomic absorption method	
		УЗ 2,0 кГц		УЗ 2,5 МГц					
		x	S_r	x	S_r	x	S_r	x	S_r
brines NaCl	0	185	0,03	179	0,05	159	0,10	162	0,12
	20	203	0,02	195	0,05	175	0,12	170	0,11
brines LiCl	0	–	–	55	0,02	50	0,11	48	0,05
	100	132	0,08	151	0,02	147	0,12	150	0,08
brines KCl	0	125	0,04	119	0,05	120	0,06	119	0,12
	50	170	0,02	172	0,02	177	0,07	165	0,11

Table 4. The results of the determination of the main substance in the galurgic brines

Sample	Found, g/l (n=6)			
	gravimetric method		titrimetric method	
	x	S_r	x	S_r
brines NaCl	187	0,01	180	0,04
brines KCl	123	0,01	119	0,05

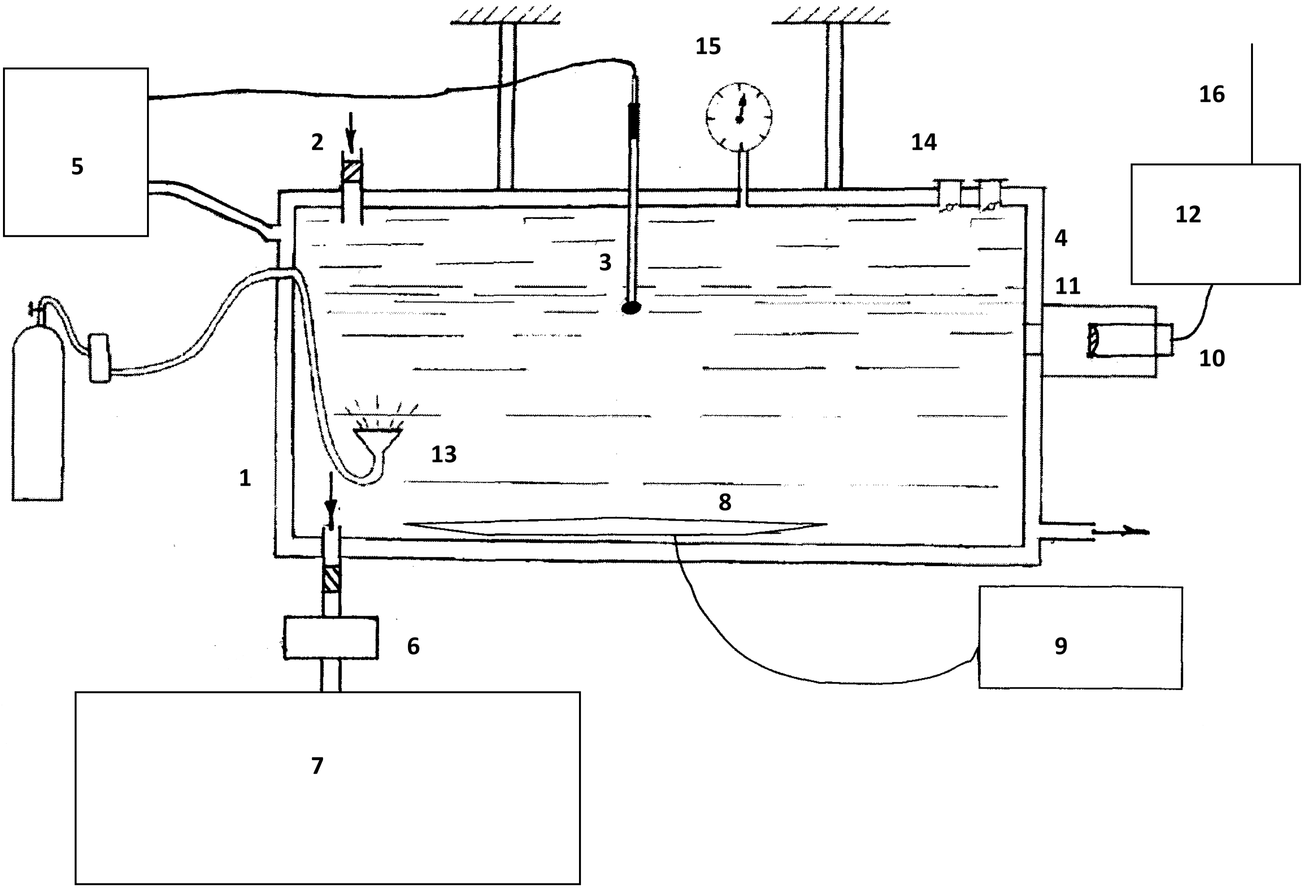

Fig. 1. Sonoluminescent camera. 1 sonoluminescent camera; 2 - inlet valve; 3- thermocouple; 4 - shirt for pumping coolant; 5- pumping unit; 6 - micropump; 7 - drive; 8 - piezoelectric ultrasonic emitter; 9 - ultrasound generator; 10 - photomultiplier; 11 - quartz window; 12 - amplifier; 13 - barbator; 14 - safety valves; 15 - control pressure gauge; 16 - antenna.

References

1.Furman A.A., Bel'dy M. P., Sokolov I.D. (1989) Povarennaya sol'. Proizvodstvo i primeneniye v khimicheskoy promyshlennosti. Khimiya
2.Furman A.A., Shraybman S.S. (1966) Prigotovleniye i ochistka rassola. Khimiya .
3.Baklanov A., Chmilenko F., Sonolyuminestsentnaya spektroskopiya – novyy perspektivnyy metod analiza. Izvestiya vuzov. Khimiya i khimicheskaya tekhnologiya. 2005. T.48, № 1.
4.Fridman V.M. Ul'trazvukovaya khimicheskaya apparatura (1967) Mashinostroyeniye.

5.Chmilenko F.., Baklanov A. Ul'trazvuk v analiticheskoy khimii.Teoriya i praktika (2001). Dnepropetrovsk: izd-vo Dnepropetrovskogo gosuniversiteta.
6.Ul'trazvuk. Malen'kaya entsiklopediya (1979).
7. Chmilenko F., Bezkrovnyy G., Baklanov A. Analiz povarennoy soli i rassolov.(1994). DGU.