VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

Ina TETSMAN

INVESTIGATION OF EFFICIENCY OF AEROSOL POLLUTION EXHAUSTER UNDER AEROACOUSTIC FLOW

SUMMARY OF DOCTORAL DISSERTATION

TECHNOLOGICAL SCIENCES,
MECHANICAL ENGINEERING (09T)

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Scientific Supervisor

Prof Dr Habil Vladas VEKTERIS (Vilnius Gediminas Technical University, Technological Sciences, Mechanical Engineering – 09T).

The dissertation is being defended at the Council of Scientific Field of Mechanical Engineering at Vilnius Gediminas Technical University:

Chairman

Prof Dr Habil Rimantas KAČIANAUSKAS (Vilnius Gediminas Technical University, Technological Sciences, Mechanical Engineering – 09T).

Members:

Prof Dr Habil Pranas BALTRĖNAS (Vilnius Gediminas Technical University, Technological Sciences, Environmental Engineering – 04T),
Dr Darius MARKAUSKAS (Vilnius Gediminas Technical University, Technological Sciences, Mechanical Engineering – 09T),
Assoc Prof Dr Reimondas ŠLITERIS (Kaunas University of Technology, Technological Sciences, Measurement Engineering – 10T),
Prof Dr Habil Vitalijus VOLKOVAS (Kaunas University of Technology, Technological Sciences, Mechanical Engineering – 09T).

Opponents:

Prof Dr Mindaugas JUREVIČIUS (Vilnius Gediminas Technical University, Technological Sciences, Mechanical Engineering – 09T),
Prof Dr Juozas PADGURSKAS (Aleksandras Stulginskis University, Technological Sciences, Mechanical Engineering – 09T).

The dissertation will be defended at the public meeting of the Council of Scientific Field of Mechanical Engineering in the Senate Hall of Vilnius Gediminas Technical University at 10 a. m. on 23 January 2014.
Address: Saulėtekio al. 11, LT-10223 Vilnius, Lithuania.
Tel.: +370 5 274 4952, +370 5 274 4956; fax +370 5 270 0112;
e-mail: doktor@vgtu.lt
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Mokslinis vadovas

prof. habil. dr. Vladas VEKTERIS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, mechanikos inžinerija – 09T).

Disertacija ginama Vilniaus Gedimino technikos universiteto Mechanikos inžinerijos mokslo krypties taryboje:

Pirmininkas

prof. habil. dr. Rimantas KAČIANAUSKAS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, mechanikos inžinerija – 09T).

Nariai:

prof. habil. dr. Pranas BALTRĖNAS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, aplinkos inžinerija – 04T),
dr. Darius MARKAUSKAS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, mechanikos inžinerija – 09T),
doc. dr. Reimondas ŠLITERIS (Kauno technologijos universitetas, technologijos mokslai, matavimų inžinerija – 10T),
prof. habil. dr. Vitalijus VOLKOVAS (Kauno technologijos universitetas, technologijos mokslai, mechanikos inžinerija – 09T).

Oponentai:

prof. dr. Mindaugas JUREVIČIUS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, mechanikos inžinerija – 09T),
prof. dr. Juozas PADGURSKAS (Aleksandro Stulginskio universitetas, technologijos mokslai, mechanikos inžinerija – 09T).

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Adresas: Saulėtekio al. 11, LT-10223 Vilnius, Lietuva.
Tel.: (8 5) 274 4952, (8 5) 274 4956; faksas (8 5) 270 0112;
el. paštas doktor@vgtu.lt
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Introduction

Topicality of the problem – the conventional side exhausters designed for aerosols collection from evaporating surfaces can be used in the rooms where the employees' exposure is short-term, however, to achieve decrease of pollution in the workers' area, new generation side exhausters with the operation efficiency higher than that currently used in the industrial sector, are necessary. Therefore, the new methods and measures of simple design aerosols collection systems must be developed and implemented, based on the acoustic field impact on fine, up to 10 µm diameter aerosols particles.

To assess the influence of acoustic field on aerosols coagulation over evaporating surfaces, certain scientific and technical tasks must be resolved. When performing the analysis of aerosols interaction in acoustic field, the issues of developing a sophisticated probabilistic pattern of the researched system as well as of defining of the parameters necessary for calculations are faced. To achieve this task, a thorough analysis of such flows must be performed. To perform such experiments and define the regularities taking place in process flows, new-type instruments able to generate aeroacoustic flows over evaporating surfaces and create acoustic coagulation in aerosols and at the same time, reduce pollutant concentration in atmosphere, must be developed.

The object of research – side exhauster under aeroacoustic flow.

Aim of the work – to investigate the efficiency of aerosol pollution side exhausters under aeroacoustic flow and formulate the methodology of exhausters research.

Tasks of the work. To achieve the aim of the work, the following tasks must be completed:

1. The review of scientific literature on aerosol exhaust system types, as well as their research and analysis performed.
2. Theoretical research of the designs of aerosol pollution side exhausters under aeroacoustic flow were suggested.
3. The methodology of experimental research of aerosols pollution side exhauster under aeroacoustic flow systems suggested.
4. Experimental research on aerosols pollution side exhausters under aeroacoustic flow performed.
5. Experimental studies of efficiency of aerosol pollution side exhauster and the efficiency of such systems' operation analysed.

Methodology of research includes theoretic and experimental research performed while employing analytical methods, defining the parameters of aerodynamic flows with acoustic field, using new methodology of exhausters research.

Scientific novelty

1. Efficiency analysis of aerosols collection by side exhausters using the comparative methods of their efficiency evaluation was performed. The obtained aerodynamic characteristics of aerosols pollution side exhausters under aeroacoustic flow allow assessing aerosols coagulation effect. It was defined that the aerosols with the of 5–10 µm diameter particle size can be settled at low acoustic air flow frequency, and due to the use of acoustic field, the rate of exhaust air at 55–85 °C fluid temperature.
2. The comparison of the efficiency of proposed and traditional side exhausters has shown that the efficiency of aerosols pollution side exhausters under aeroacoustic flow is up to 58.5% higher than traditional. It has been found that without a change of removed air flow rate at various temperatures of a liquid, the concentration of harmful substances can not be exceeded in the worker's breathing zone, at the same time reducing the costs of disposal equipment.
3. The suggested methods and systems of aerosols localisation by activating with aeroacoustic flows enable making solutions on the technological processes used for working environment air pollution reduction.

Practical value. The developed, analysed and experimentally tested aerosols pollution side exhauster under aeroacoustic flow can be applied for collection of vapours and aerosols from evaporating surfaces. Its application with noise generator, blowing and suction equipment significantly simplifies pollutant reduction process, makes it a more high-performance and cost efficient in comparison with other currently employed pollutant management methods.

Defended propositions

1. The best characteristics of acoustic fied of newest construction of aerosols pollution side exhauster under aeroacoustic flow, when parameters of sound generator which ratio of nozzle and resonator diameters are 1.66, while cavity length 12.7 mm and staff-off distance 2 mm of the exhauster.
2. The proposed side exhauster under aeroacoustic flow has permissived the better reduction of aerosol pollution in work environment to 58.5%.

The scope of the scientific work. The scientific work consists of introduction, three chapters, general conclusions, list of literature, list of publications and addenda. The total scope of the scientific work – 72 pages, 29 pictures, 6 tables and 3 annexes.

1. The review of aerosol pollution exhausters and aeroacoustic flows research methods

Many scientists examined the speed influence of blown, intake and steam rise flows to the concentration of pollutants in the working environment (Fig. 1), however, they have not suggested any methods to reduce their concentration in the place of emission.

A new design of the side exhauster (patent no. LT5891) with generated aeroacoustic flow were proposed to reduce the concentration of aerosol (Fig. 2). Such a device is used to remove aerosols from the surface of various temperature liquid, which is stored at the limited size tanks, designed for performance of various technological operations and processes. The advantage of the construction of aerosols pollution side exhauster under aeroacoustic flow is that, compared to the constructions of other exhausters, it allows to reduce not only the amount of sucked air, but also to reduce the concentration of aerosols in it by levigating aerosols formed directly over their formation zone.

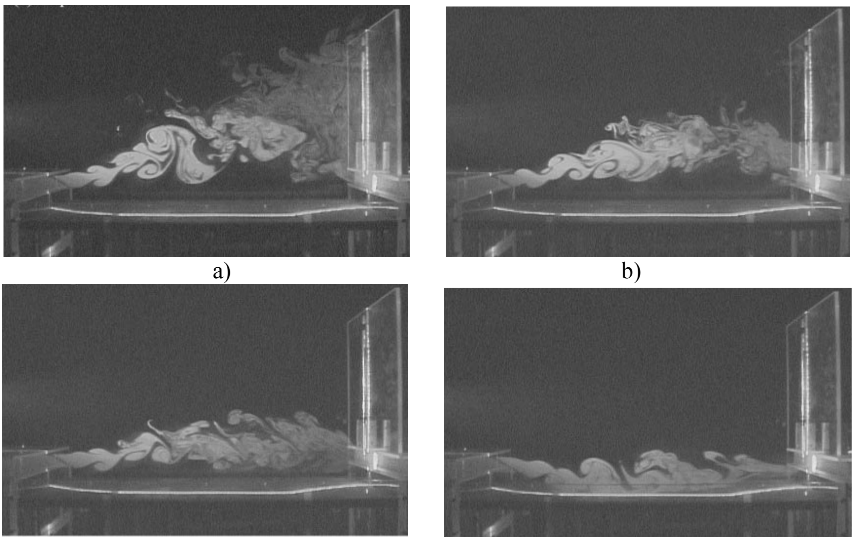


Fig. 1. Photos of typical characteristic flow modes obtained by using smoked-flow visualization method assisted with laser-light sheet scattering. Smoke released with push-jet flow, when v_g = 0.05 m/s, v_b = 0.30 m/s: a) – dispersion mode v_s = 1.55 m/s; b) – transition mode v_s = 2.79 m/s; c) – encapsulation mode v_s = 3.49 m/s; d) – strong suction mode v_s = 4.17 m/s. Shutter speed 1/30 s (Huang 2004)

Aerosols pollution side exhauster under aeroacoustic flow (Fig. 2) is intended for sucking aerosols from surfaces and reducing in amount in the sucked air. It can be used for collection of aerosols from the liquid surfaces in tanks of different size and temperatures. The tanks are used for performing various technological operations and processes. A compressed air flow is delivered to a collector and the stream of increased turbulence is formed by its blades thanks to its twisting. Due to different turning directions between the nearby twisters, the stream of the increased turbulence is formed. Through the branch pipes the twisted stream flows into spherical reflectors which act as the turbulence amplifiers and direct the flow over the pollution source. Flowing over the pollution source the stream of increased turbulence activates the coalescential effect of liquid particles in aerosol and returns a part of aerosol pollution back to the surface. Air flow together with the residual pollution is sucked from the surface by a cylindrical exhauster.

There are flow (4) (Fig. 2–3) twisters (7) and (8) assembled in the orifice. They have an opposite direction of twisted flow (4) and they are arranged in such a way that the direction of twisted flow in the adjacent orifices would be opposite. The blower (1) is fitted on the edge of the source (9) of pollution. On the opposite side of the source (9) of pollution, there is an exhauster arranged, which has a cylindrical form in which pursuant (10) to the tangent – tangentially – over its entire length, formed a suction port of aerosols (11) and it is directed to the source of pollution (9). The air suction nozzle (12) is connected (10) to the exhauster tangentially, the same way as the suction port is formed (11) in the same direction, but in the opposite (10) side of cylindrical exhauster. Air flow outflowing from the nozzle reaches the speed of sound, and when the pressure in the generator reaches the critical pressure, it forms a shock wave. Due to the limit deviation of the flow from the axis of orifice, the interference forms on its edges, which sending together with the speed of sound against the flow, cannot return to the nozzle and declines down the flow forming the structure of the flow from the cells.

In addition, the only possible variable parameter, influencing the size of the cells and together the location of Mach disc, as well as amplitude of the sent sound frequency is air pressure supplied from the orifice. In theory, the structure of the flow should repeat to the infinity; however, due to the turbulence of the flow and mixing at its surface, the fluctuations are suppressed over several periods. Hence, the acoustic characteristics of resonant sound generator's flow, such as sound intensity can be controlled by regulating pressure of the flow and controlling geometric parameters of the device (resonator length and diameter; nozzle diameter; staff-off distance), because the structure of a shock wave and the location of Mach disc depend on them.

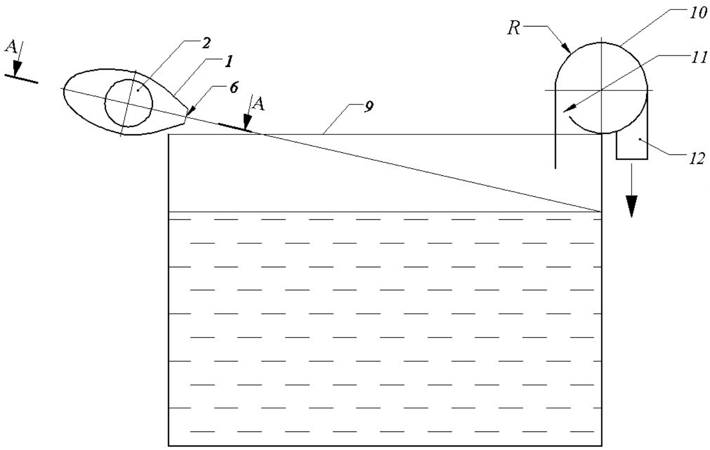


Fig. 2. Scheme of aerosols pollution side exhauster under aeroacoustic flow

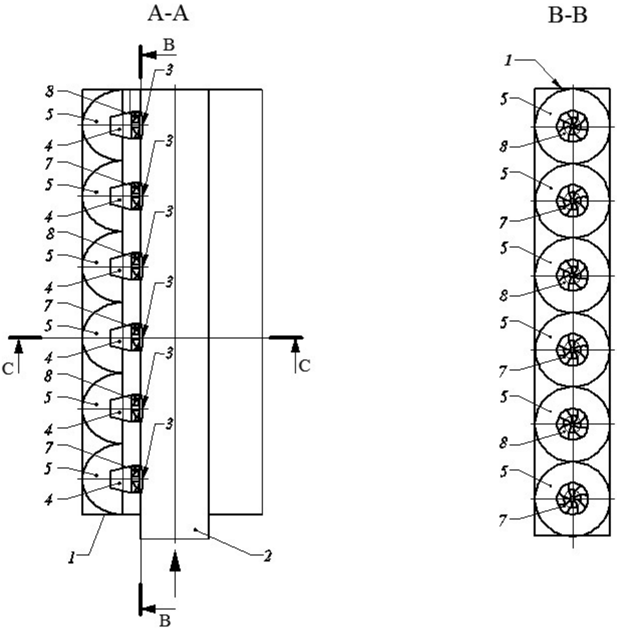


Fig. 3. Scheme of push of aerosols pollution side exhauster under aeroacoustic flow

2. Investigation of parameters of side exhauster under aeroacoustic flow

Particle environment forces generated by the Navier – Stokes equation, which is expressed in the so-called Basset-Boussinesq-Oseen equation describes the movement of particles outpatient viscosity of the gas flow.

In order to determine the amplitudes of fluctuations displacement of particle and sound source, the dynamic coefficients and densities of viscosity of non-stationary viscous liquid flow. Therefore, the theoretical and experimental studies of all the flows have been conducted depending on the temperature of the liquid (hydrochloric acid HCl solution) and concentration of the substance.

The results of the theoretical study shows, when temperature is 40–70 °C by change of concentration of HCl from 20 to 34%, the change in the density of HCl vapour contains from 6.1 to 23.4%, however, when there is the same concentration, the vapour density, depending on the temperature, varies on the average 9.1%. The maximum value of dynamic viscosity coefficient of the vapour is $1.8707 \cdot 10^{-5}$ Pa s received at 50 °C and 28% concentrations of solution strength, but at least $1.6827 \cdot 10^{-5}$ Pa·s at 70 °C and 34% concentrations of solution (Fig. 4). First, the optimum frequency range was analysed, depending on the size of aerosol particles. As mentioned above, the acoustic impact is suited best for coagulation of aerosol particles, which size is less than 10 µm.

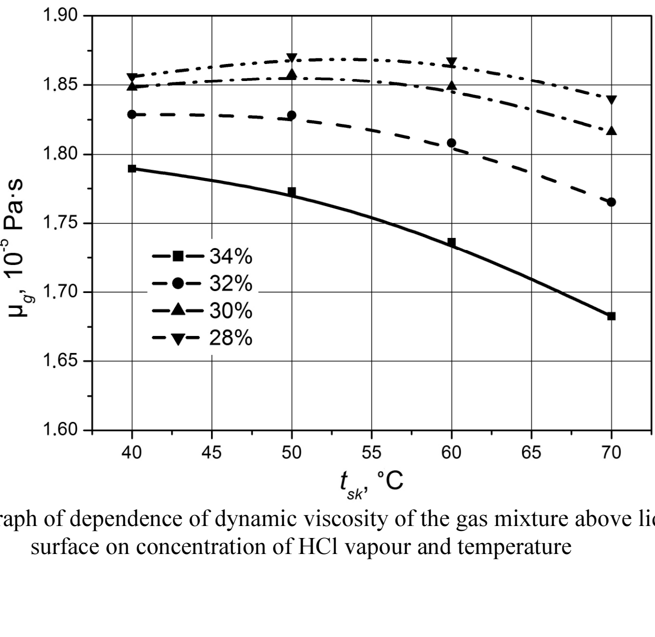
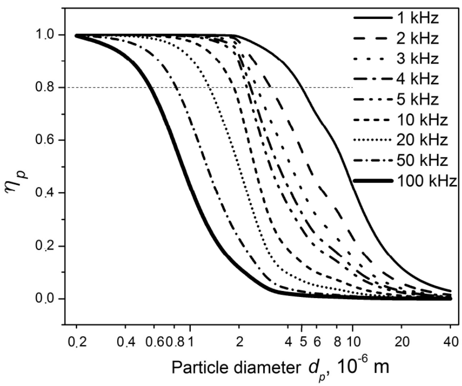


Fig. 4. Graph of dependence of dynamic viscosity of the gas mixture above liquid surface on concentration of HCl vapour and temperature

Figure 5 shows the dependency of entrainment factor and aerosol particles on the diameters of the particles exposed to the different frequency of sound at the maximum and the minimum coefficient of dynamic viscosity.

During the determination (Fig. 4) of acoustic field characteristics of side exhauster activated by aero-acoustic flow, it is needed to evaluate and determine how determines the parameters of sound generator. Sound generator (Fig. 6) of aeroacoustic flow is assembled in the blower, which consists of nozzle 1 diameter *d* preceded by cavity 2 diameter *D* and length *L*, arranged at a staff-off distance *S* of one axis, which open edge is directed into the gas stream.



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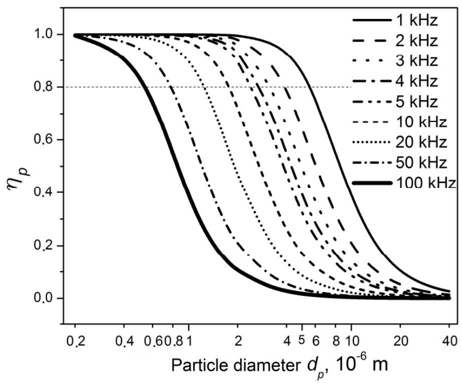
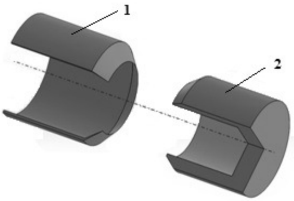


b)

Fig. 5. Entrainment factor η_p for particles of varying diameter presented with acoustic frequency at coefficient of dynamic viscosity: a) – 34% concentration of HCl vapor and 70 °C temperature; b) – 28% concentration of HCl vapor and 50 °C temperature



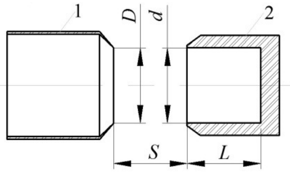


Fig. 6. Scheme of Hartmann whistle: 1 – nozzle, 2 – cavity

At the amplitudes ratio of sound source displacement greater than 0.8 the coagulation practically does not happen. The calculations are carried out at 120 dB level of constant sound pressure. The results of variation of stand-off distance *S* with nozzle diameter *d* and variation of frequency with cavity length and nozzle diameter *d* are shown in Figures 7–8 .

The scientists have researched the trends of fluctuations in accordance with the primary flow frequency at the staff-off distance *S* with respect to the pressure and have noticed that in practice, all the minimums appear at a certain distance. The minimum of such frequency does not depend on the length of resonator. This phenomenon can be explained on the basis of the shock wave structure, i.e. the formation of expansion and compression zones.

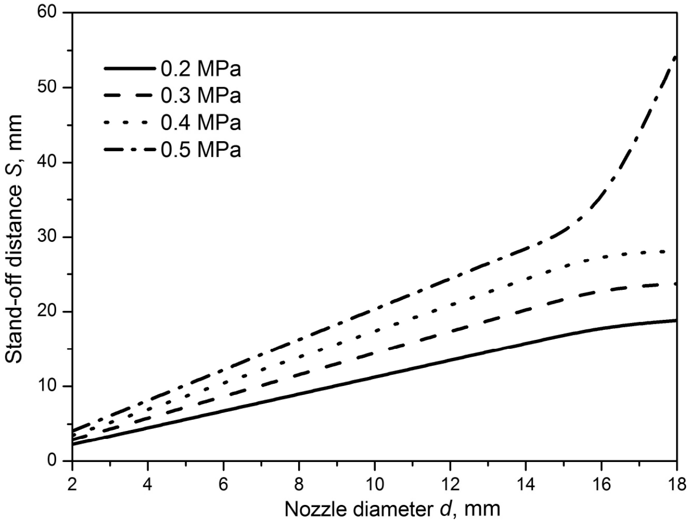


Fig. 7. Variation of stand-off distance *S* with nozzle diameter *d*

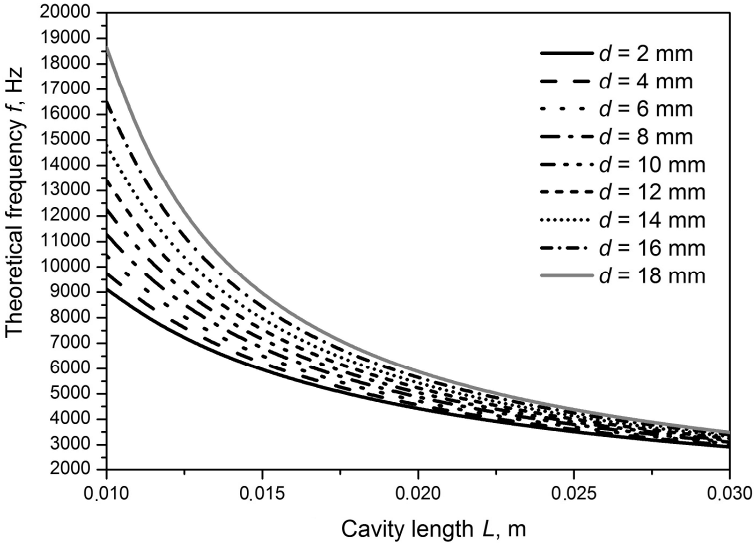


Fig. 8. Variation of frequency with cavity length and nozzle diameter *d*

By increasing the distance from the resonator, its edges appears in the different zones, which in turn affect the frequency value. When the position of resonator coincides with the flow expansion zone, the frequency gradually increases and reaches the maximum. By further increasing the distance, resonator's position coincides with the zone of flow compression zone, and then the frequency starts to decrease and reaches a minimum value. After the study of geometrical parameters of sound generator and characteristics of acoustic field, it was found that the maximum effect will be achieved when the staff-of distance ranges 2–10 mm, while the overpressure is 0.2–0.3 MPa and the length of resonator is 12–25 mm.

3. Exerimental research of aerosol pollution exhauster

The scheme of stand is shown in Figure 9. The acoustic field of the tested air flow forms above the tank (1) with the liquid, which is warmed by the heater (2) and its changes of temperature and humidity are observed by multifunctional meter (12) of humidity and temperature with IR and Bluetooth Extech MO297. Side exhauster (4), which was assembled next to the edge of the tank (1) and connected with the fan (5), removes the vapour and aerosol formed on the surface of the liquid. The flow rate of removed air can be adjusted by frequency gear (6).

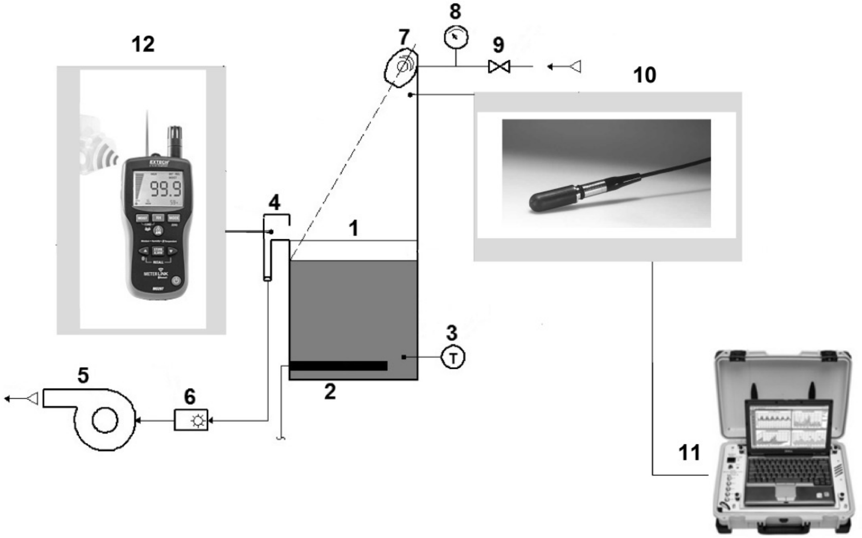


Fig. 9. Scheme of stand of aerosols pollution side exhauster under aeroacoustic flow: 1 – open-surface tank, 2 – heater, 3 – meter of temperature, 4 – side exhauster, 5 – fan, 6 – frequency gear, 7 – push nozzle, 8 – gauge, 9 – valve, 10 – microphone TC 4013, 11 – Bruel & Kjaer oscillation measurement system Type 9727 and PC Dell, 12 – Pin less Moisture/Humidity Meter with IR Thermometer + Bluetooth EXTECH MO297

The blower (7) of vapour and aerosol is assembled over the steaming liquid so that its axis of the blown air flow would be directed to the surface of the liquid next to the edge of the tub. The compressed air is supplied to the blower through the valve (9) and its pressure is determined by manometer (8). During the blowing time, the blower generates the stationary acoustic wave. A microphone (10) was used to measure the parameters of the floating acoustic waves, while data was collected in the data storage (11) of sound parameters and processed by a computer.

In order to explore the acoustic field characteristics formed by the device, the resonators of the different constructional parameters were designed and manufactured. At the time of the first survey, the resonator has been selected, which length was L = 12.7 mm. During the supply of 0.3–0.4 MPa compressed air to the generator, the pressure of emitted sound was up to 154 at 1–21 kHz frequencies. The given results (Fig. 9) show that at the frequencies up to 5 kHz, the maximum level of sound pressure obtained by testing the device, when ratio between nozzle and cavity diameter was 1.66 and the distance between nozzle and resonator was 2 mm, is equal to 139.8 dB at 1228 Hz frequency.

At the higher than 5 kHz frequencies, the maximum level of sound pressure obtained by testing the device, when ratio between nozzle and cavity diameter was 15 and the staff-off distance was 2 mm, is equal to 135 dB at 7492 Hz frequency.

In a second experiment, the resonator was studied, the length was $L = 15.7$ mm. From the sound pressure level frequency dependence graphs (Fig. 10). Seen that at frequencies up to 5000 Hz, the most effective sound pressure results were seen for the device in the nozzle and the cavity sphere diameter and the ratio of 1.66, and the distance between the nozzle and the cavity of 2 mm is equal to 135 dB at 3692 Hz. At higher frequencies of 5000 Hz, the most effective level of sound pressure results were seen in the device at nozzle and cavity diameter was ratio of 1.66, and the staff-off distance was 10 mm and is 134 dB at 5440 Hz.

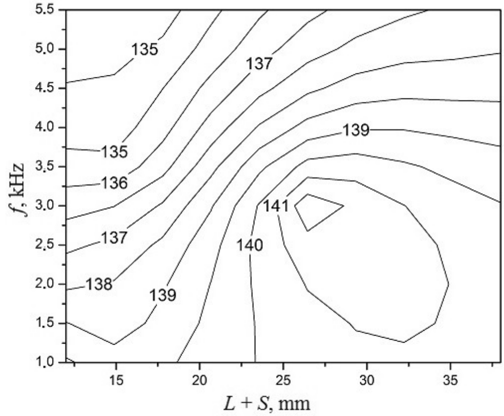
At the time of the third experiment, the resonator has been selected, which length was L = 26.6 mm. The given results show (Fig. 10) that at the frequencies up to 5000 Hz, the maximum level of sound pressure obtained by testing the device, when ratio between nozzle and cavity diameter was 1.66 and the staff-off distance was 2 mm, is equal to 142 dB at 3040 Hz frequency. At the higher than 5 kHz frequencies, the maximum level of sound pressure obtained by testing the device, when ratio between nozzle and cavity diameter was 15 and the staff-off distance was 2 mm, is equal to 136 dB at 6400 Hz frequency.

The small particles cause the sound waves by periodicity fluctuating. According to the Stokes forces between the particles and gas particles, the speed can be expressed as follows (Sheng 2005):

$$u_p = \frac{U_g \sin(\omega t - \varphi)}{\sqrt{1+\left(\omega\tau_p\right)^2}} + \frac{\omega\tau_p U_g}{1+\left(\omega\tau_p\right)^2} e^{-t/\tau_p}. \tag{1}$$

From the experimental results by formula (1) for particles of 5 and 10 μm diameter formed velocity amplitude change over time (Fig. 11), when the dynamic viscosity coefficient of $1.8707 \cdot 10^{-5}$ Pa·s shows that the maximum particle velocity amplitude is obtained when the sound intensity 95 W/m² and frequency 1228 Hz.

During the experimental studies, the investigation of extracted air was carried out and determined the change above the steaming liquid depending on its temperature: when the vapour from the surface of the liquid in the tank are steaming freely and all the equipment, designed for the removal of the vapour is disconnected; when vapour from the surface of the liquid in the tank are removed by the exhauster; when vapour from the surface of the liquid in the tank are removed by the blower and exhauster; when the vapour from the surface of the liquid in the tank are removed by the exhauster, using the blower, which generates acoustic wave. During the investigation, the temperature of the liquid was warmed up from 50 to 85 °C, values of humidity were determined by using the multifunctional meter of humidity and temperature with IR and Bluetooth Extech MO297. The received data of experiment were represented graphically (Fig. 12).



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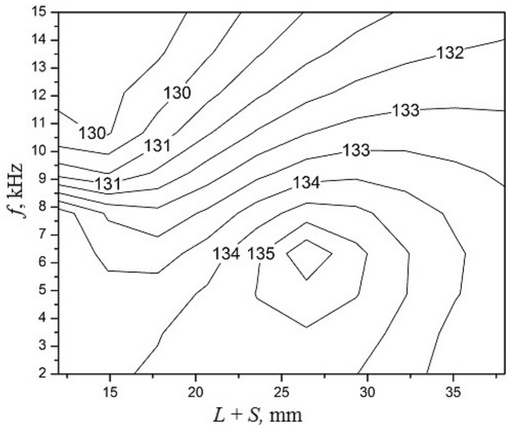
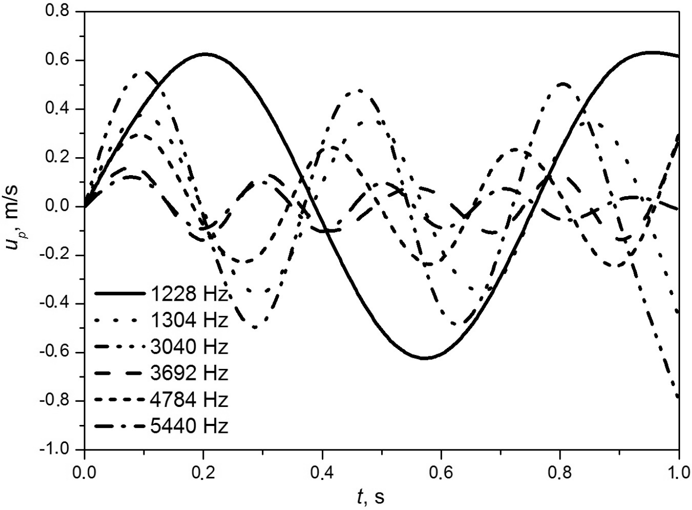


b)

Fig. 10. Variation of frequency and sound pressure level with cavity length and staff-off distance when: a) – nozzle and diameters ratio was equal is 1.66, b) – nozzle and diameters ratio was equal is 15



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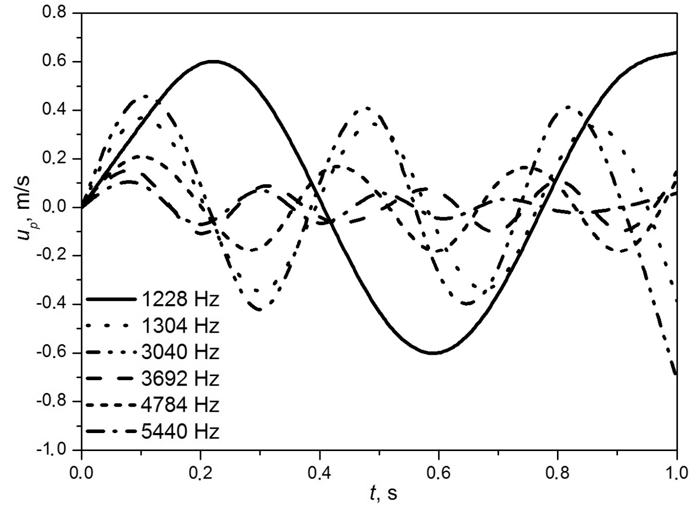

b)

Fig. 12. Velocity of aerosol changing over time on the frequency of sound, when dynamic viscosity coefficient $1.8707 \cdot 10^{-5}$ Pa·s and ratio of nozzle and cavity diameters 1.66: a) – particle diameter 5 μm, b) –particle diameter 10 μm

When temperature of the liquid was rising, the curve (Fig. 12–13), representing the investigation without any equipment, shows the highest values of humidity, regardless temperature of the liquid. In practice, all methods of vapour removal at up to 60 °C temperature of the liquid were effective; however, at temperature from 60 °C temperature of the liquid the minimum value of humidity were reached by using equipment with acoustic wave generation. In other words, the higher initial concentration of aerosol particles, the better reduction of a mist above the liquid.

According to the curves, the regression equations can be created by using Origin 6.1 software package. The regression of a curve obtained in the second experiment was exponential: $y = y_0 + ae^{x/t}$, in the third experiment functional dependence $y = ax + b$. After the results analysis, the regression equations can be written down:

$$R_1 = 51.93106 + 0.000038e^{t_{sk}/6.1566} \,, \tag{2}$$

$$R_2 = 44.68571 + 0.13929 t_{sk} \,, \tag{3}$$

here R_1 – relative humidity when running blowing and vacuuming without acoustics, R_2 – the relative humidity of the suction and blowing works with acoustics, t_{sk} – liquid temperature.

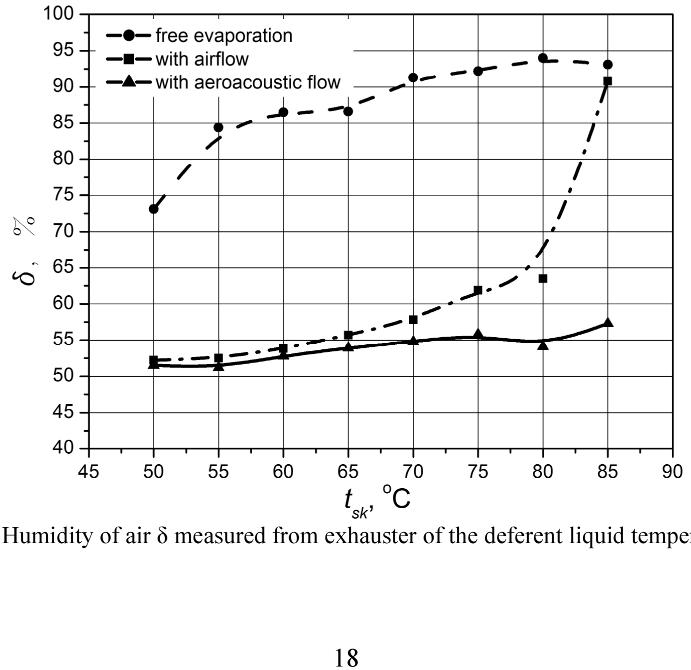

Fig. 12. Humidity of air δ measured from exhauster of the deferent liquid temperature t_{sk}

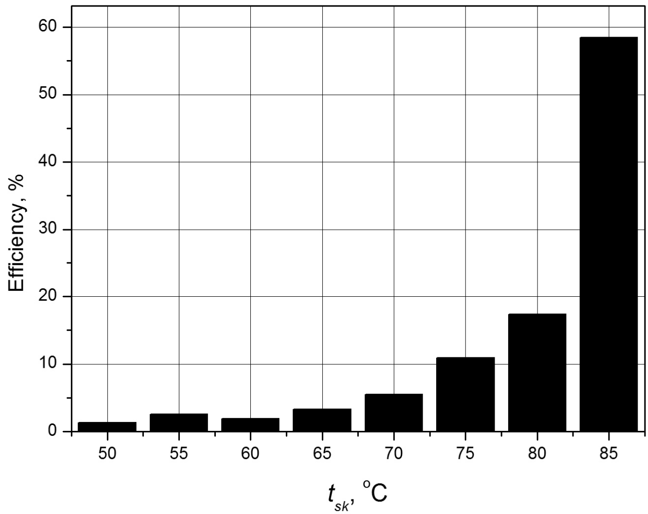

Fig. 13. Collection efficiency of pollutant of air of the deferent liquid temperature

In order to make aerosol removal effective in the traditional devices of pollutants disposal and treatment plants, the removed air flow rate must be increased depending on the temperature of the liquid. In this work, after the evaluation of aerosol reduction efficiency, when equipment without acoustic and with acoustic were used, it has been determined that due to its exposure to aerosols above the surface of the liquid, it can be achieved even higher efficiency up to 58.5%, i.e. to reduce aerosol concentration and so to reduce the flow rate of removed air, as well as costs of disposal equipment.

General Conclusions

1. After the analysis of scientific literature sources has been carried out, it was noted that there were many theoretical and experimental investigations performed in the field of aerosols collection; however, a lack of attention was dedicated to a search of new ways and methods to solve aerosol collection problems and completely unexamined usage of exhausters with acoustic pulsation.
2. Changes in patterns of dynamic viscosity coefficient above the steaming surface of hydrochloric acid solution were estimated, such as: during the increase of concentration and temperature, dynamic viscosity coefficient

decreases. At 40–70 °C temperature of the liquid and 28 to 34% concentration, the change in density contains from 6.1 to 23.4%; however, at the same concentration, the vapour density, depending on the temperature, varies on the average about 9.1%.

3. The newest construction of side exhauster was proposed, which is based on the principles of aeromechanics by forming acoustic flows. The parameters analysis of aero-acoustic sound generators were carried out by applying half analytic method. The parameters of sound generator which ratio of nozzle and resonator diameters are 1.66, while cavity‘s length 12.7 mm and staff-off distance 2 mm of the exhauster were estimated, while creating higher than 120 dB level of sound pressure.

4. After the analysis of aero-acoustic flow parameters of side exhauster, it has been estimated that the maximum displacement amplitude 91.5 µm of sound source is created by sound generator, the level of sound pressure at 1228 Hz frequency is equal to 139.8 dB.

5. The comparison of the efficiency of proposed and traditional side exhausters has shown that the efficiency of side exhauster activated by acoustic air flow is up to 58.5% higher than traditional.

List of Published Works on the Topic of the Dissertation

In the reviewed scientific periodical publications

Vekteris, V.; Tetsman, I; Striška, V; Mokšin, V. 2013a. Tribological behavior of aerosol particles in acoustic field. Mechatronic Systems and Materials V. *Solid State Phenomena*. Switzerland: Trans Tech Publications Ltd. Vol. 199, 1392–4044. ISSN 1012-0394. p. 205–208. **(**ISI Web of Science**)**

Vekteris, V.; Tetsman, I.; Mokšin, V. 2013b. Experimental investigation of influence of acoustic wave on vapour precipitation process. *Engineering, technology & applied science research (ETASR)*. Patras (Greece): ETASR. Vol. 3, no. 2. 408–412. ISSN 2241-4487.

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Vekteris, V.; Tetsman, I.; Striška, V. 2010a. Experimental research of suction velocity of side exhausters. In *Mechanika-2010: proceedings of the 15th international conference. Kaunas University of Technology*, Lithuanian Academy of Sciences, IFTOMM National Committee of Lithuania, Baltic Association of Mechanical Engineering (BAME). Kaunas: Technologija. 477–481. ISSN 1822-2951. (ISI Proceedings)

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Patent

Vekteris, V; Tetsman, I; Striška, V; Kilikevičius, A. 2012. *An activated aerosol exhauster.* Patent LT5891. Vilnius. Lithuania.

About the author

Ina Tetsman was born on 20 of March 1973 in Arkhangelsk (Russia). First degree in Mechanical Engineering, Faculty of Mechanics, Vilnius Gediminas Technical University, 2007. Master of Since in Mechanical Engineering, Faculty of Mechanics, Vilnius Gediminas Technical University, 2009. In 2009–2013 PhD student of Vilnius Gediminas Technical University.

AEROZOLINĖS TARŠOS SIURBTUVO, AKTYVINAMO AEROAKUSTINIU SRAUTU, EFEKTYVUMO TYRIMAS

Mokslo problemos aktualumas – tradiciniai aerozolinės taršos šoniniai siurbtuvai šalina aerozolius nuo garuojančių paviršių nepakankamai efektyviai, todėl jie įrengiami tik tose patalpose, kuriose darbuotojai būna trumpą laiką. Siekiant efektyviau išvalyti darbo zoną nuo aerozolinės taršos reikalingi naujos konstrukcijos šoniniai siurbtuvai, kurie be tradicinių funkcijų turėtų ir akustinio lauko generavimo funkciją. Žinoma, kad akustinio lauko poveikis garavimo zonoje ženkliai padidina aerozolių koaguliaciją ir tuo pačiu sumažina patalpos užterštumą. Analizuojant aerozolių sąveiką virš garuojančio skysčio paviršiaus, reikia išspręsti daug mokslinių ir techninių uždavinių. Vienas iš jų tiriamos sistemos modelio sudarymas bei skaičiavimams reikalingų parametrų nustatymas eksperimentiniais tyrimais. Eksperimentiniams tyrimams atlikti ir vykstančių procesų srautuose dėsningumams nustatyti reikalingi naujo tipo siurbtuvai, galintys generuoti aeroakustinius srautus virš garuojančių paviršių. Tad būtina ieškoti efektyvių, bet nebrangių aerozolių mažinimo metodų ir įrenginių.

Darbo tyrimų objektas – aerozolinės taršos šoninis siurbtuvas aktyvinamas aeroakustiniu srautu.

Darbo tikslas – ištirti aerozolinės taršos siurbtuvo, aktyvinamo aeroakustiniu srautu, efektyvumą ir suformuluoti jo tyrimo metodiką.

Darbo uždaviniai. Darbo tikslui pasiekti reikia spręsti šiuos uždavinius:

1. Atlikta mokslinės literatūros analizę apie aerozolinės taršos siurbtuvų tipus, jų tyrimus.
2. Ištirti sukurto aerozolinės taršos siurbtuvo, aktyvinamo aeroakustiniu srautu, garso generatorių parametrų įtaką generuojamam akustiniam laukui.
3. Pasiūlyti aerozolinės taršos siurbtuvo, aktyvinamo aeroakustiniu srautu, eksperimentinių tyrimų metodiką.
4. Eksperimentiškai ištirti garso generatorių akustinio lauko charakteristikas.
5. Eksperimentiškai ištirti aerozolinės taršos siurbtuvo, aktyvinamo aeroakustiniu srautu, darbo efektyvumą.

Tyrimų metodika. Rengiant darbą atlikti teoriniai tyrimai taikant pusiau analitinius metodus, atliekant aeroakustinio srauto akustinio lauko parametrų nustatymus, ir eksperimentiniai tyrimai, taikant naujai sukurtą tyrimo metodiką.

Mokslinis naujumas

1. Atlikta aerozolių mažinimo šoniniais siurbtuvais efektyvumo analizė taikant lyginamuosius jų efektyvumo vertinimo metodus. Gautos siurbtuvo, aktyvinamo aeroakustiniu srautu, akustinio lauko charakteristikos leidžia įvertinti aerozolių koaguliacijos efektą. Nustatyta, kad aerozoliai, kurių dalelių skersmuo 5–10 µm, koaguliuojasi esant žemam akustinio lauko dažniui.
2. Nustatyti šalinamo oro drėgnumo kitimo dėsningumai veikiant siurbtuvo aeroakustiniam srautui ir kylant skysčio temperatūrai. Parodyta, kad siurbtuvo be aeroakustinio srauto kylant skysčio temperatūrai šalinimo efetyvumas sumažėjo iki 58,5 % lyginant su siurbtuvu, aktyvinamu aeroakustiniu srautu.
3. Pasiūlytas aerozolinės taršos šoninis siurbtuvas, aktyvinamas aeroakustiniu srautu, leidžia spręsti darbo aplinkos oro užterštumo mažinimo problemą.

Praktinė vertė. Sukurtas, ištirtas ir eksperimentiškai išbandytas šoninis siurbtuvas, aktyvinamas aeroakustiniu srautu, naudojimas kartu su garso generatoriumi gerokai supaprastina teršalų šalinimo procesą, jis tampa efektyvesnis, reikalauja mažiau darbo sąnaudų, lyginant su kitais šiuo metu taikomais teršalų šalinimo būdais.

Ginamieji teiginiai

1. Naudojant naują aerozolinės taršos mažinimo metodą, pagrįstą akustinio lauko poveikiu, geriausios akustinio lauko charakteristikos gaunamos, kai garso generatoriaus tūtos ir rezonatoriaus skersmenų santykis 1,66, rezonatoriaus ilgis 12,7 mm ir atstumas tarp tūtos ir rezonatoraius 2 mm.
2. Sukurtas šoninis siurbtuvas aktyvinamas aeroakustiniu srautu leidžia sumažinti aerozolinę taršą darbo aplinkoje net iki 58,5 %.

Darbo apimtis. Darbą sudaro įvadas, trys skyriai, išvados, literatūros sąrašas, publikacijų sąrašas ir priedai. Bendra disertacijos apimtis – 72 puslapių, 29 iliustracijos, 6 lentelės ir 3 priedai.

Pirmasis skyrius skirtas literatūros apžvalgai. Išanalizuotos aerozolinių dalelių šalinimo priemonės ir jų formuojamų srautų charakteristikos. Skyriaus pabaigoje formuluojamos išvados ir tikslinami disertacijos uždaviniai.

Antrajame skyriuje nustatyti taršos šaltinio dinaminiai klampos koeficientai ir tankiai atsižvelgiant į skysčio temperatūrą, teoriškai nustatytas aeroakustinio srauto poveikis aerozolinėms dalelėms, atliktos aeroakustinio srauto garso generatorių parametrų ir generuojamo akustiniam lauko charakteristikų analizės.

Trečiajame skyriuje aprašomi siurbtuvo eksperimentiniai tyrimai, pateikta tyrimo metodika. Įvertintas siurbtuvo darbo efektyvumas, pateiktos statistinės matavimų charakteristikos. Pabaigoje pateiktos išvados ir literatūros sąrašas.

Bendrosios išvados

1. Atlikus mokslinės literatūros šaltinių analizę pastebėta, kad aerozolių surinkimo srityje atlikta daug išsamių teorinių ir eksperimentinių tyrimų, tačiau nepakankamai dėmesio skirta naujų metodų paieškai spręsti aerozolio mažinimo problemas bei visiškai nenagrinėtas siurbtuvų su akustine pulsacija naudojimas.

2. Nustatyti virš druskos rūgšties tirpalo garuojančio paviršiaus susidarusių garų dinaminio klampio koeficiento kitimo dėsningumai. Didėjant druskos rūgšties koncentracijai ir skysčio temperatūrai, jos garų dinaminis klampos koeficientas mažėja. Kai skysčio temperatūra yra 40–70 ºC, o druskos rūgšties koncentracija – 28–34 %, jos garų tankio pokytis sudaro 6,1–23,4 %,

tačiau esant tai pačiai koncentracijai garų tankis, atsižvelgiant į temperatūrą, kinta vidutiniškai apie 9,1 %.

3. Pasiūlytos nauja šoninio siurbtuvo konstrukcija, kuri pagrįstas aeromechanikos principais formuojant aeroakustinius srautus, bei eksperimentinio tyrimo metodika, kuri leidžia įvertinti aeroakustinio srauto poveikį aerozolio koaguliacijai. Atlikta aeroakustinių garso generatorių parametrų analizė, taikant pusiau analitinį metodą. Nustatyta, kad garso generatoriaus, kai jo rezonatoriaus ir tūtos skersmenų santykis 1,66, rezonatoriaus ilgis 12,7 mm ir atstumas tarp tūtos ir rezonatoriaus 2 mm, sukuria daugiau kaip 120 dB garso slėgio lygį.

4. Išanalizavus šoninio siurbtuvo aeroakustinio srauto parametrus, nustatyta, kad didžiausią garso šaltinio poslinkio amplitudę 91,5 μm sukuria garso generatorius, kai garso slėgio lygis 1228 Hz dažnyje lygus 139,8 dB.

5. Palyginus sukurto ir tradicinio šoninių siurbtuvų efektyvumą matyti, kad aerozolinės taršos šoninio siurbtuvo, aktyvinamo aeroakustiniu srautu, efektyvumas net iki 58,5 % didesnis už tradicinio.

Trumpos žinios apie autorių

Ina Tetsman gimė 1973 m. kovo 20 d. Archangelske Rusijoje. 2007 m. įgijo mechanikos inžinerijos bakalauro laipsnį Vilniaus Gedimino technikos universiteto Mechanikos fakultete. 2009 m. įgijo mechanikos inžinerijos mokslo magistro laipsnį Vilniaus Gedimino technikos universiteto Mechanikos fakultete. 2009–2013 m. – Vilniaus Gedimino technikos universiteto doktorantė. Šiuo metu dirba lektore VGTU Mechanikos inžinerijos katedroje.