Updating the practical classes on acoustic safety

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Abstract. The paper presents the development of learning technology on acoustic safety. The possibilities of automating the practical tasks to increase students’ readiness level in project and expert activities are noted. As the result of master’s degree students questioning the interest in effectively disinfected silencer designs was identified and difficulties with tuning such devices were revealed. For practical class on acoustic safety the practical task on noise control of the ventilation system was adjusted and the silencer algorithmic model that is invariant to its dimensions and configuration was created. The control group of master’s degree performing a project task have composed silencers for ventilation systems with wide main air ducts and required broadband noise reduction. The following was established in the control group: students tuning the transformable device acquired the skill of composing the silencers for specific ventilation systems; students discussing the developed silencers have noted an increase in their level of readiness for project and expert activities in the field of acoustic safety; automating the calculations ensures the complete the project task in full without additional costs of training time. The modernized practical lesson on acoustic safety can be recommended for usage.

1. Introduction
In the course of practical classes in students can both form the necessary competencies and control competencies formation [1-6].

Automating the practical integrative tasks allows students to increase their readiness for project and expert activities independently assessing the reached results [7-10].

Within the iterationness of developing the practical classes on acoustic safety the questionnaire survey of master’s degree students was implemented.

The questionnaire survey showed:

- Students point out the prospects of silencers not containing sound-absorbing material because such devices are effectively disinfected in ventilation systems.
- Students are not fully confident that they are ready to recommend the silencer variant not containing sound-absorbing material for specific ventilation system due to difficulties with tuning such devices.

The available data suggest that adding the automated calculating the transformable silencer to the content of practical classes on acoustic safety will create conditions for students to get the skill of
composing the silencers for specific ventilation systems, and as a result, to increase the level of students readiness for design and expert activities.

The purpose of the paper is to develop practical lessons on acoustic safety by design automation of silencers not containing sound-absorbing material in various ventilation systems.

Objectives of the paper are as follows:

- Adjusting the practical task on noise control of the ventilation system.
- Development the silencer algorithmic model that is invariant to dimensions and configuration.
- Designing the silencer in the control group.

2. Modernizing the practical classes on acoustic safety

2.1. Design assignment
The task of ventilation noise control which involved the calculating the only standard expansion chambers effective in a limited frequency range in narrow ducts was supplemented by the requirement of composing the silencer effective in the entire normalized frequency range in a wide duct [11-14].

As a basis for composing the silencer the device formed by dividing the air duct by curved partitions into rows of expansion chambers narrow in one direction of the cross section and wide in the other direction of the cross section was proposed (table 1).

**Table 1. Forming the silencer.**

| Type of partitions | Rows of expansion chambers |
|-------------------|---------------------------|
|                   | horizontal row | vertical row |

Depending on the chosen dimensions and configuration the basic device can transform [15]: contain a standard chamber in a narrow duct; contain one row of differently configured chambers in a narrow or wide duct; contain several horizontal or vertical rows of chambers in a wide duct; contain silencers with oppositely oriented rows of chamber.

2.2. Simulation of the basic transformable device
The basic device is described by electroacoustic analogy methods (table 2) taking into account at least 100 modes.

An algorithmic model of the silencer is developed by Simulink.

Each silencer’s S-model contains modules that combine blocks from the library sections of Math, Sources, Links, Signals and Systems, Matrix Inverses and Matrix Operations.

Using the principle of modularity provides the construction of various S-models.
Table 2. Structure of the silencer model.

| Components of the model | The scheme of acoustic system | The scheme of equivalent multidimensional chain |
|-------------------------|--------------------------------|-----------------------------------------------|
| Air duct                | ![Air duct](image1)            | ![Air duct](image2)                          |
| The tie between         | ![Tie between air duct and    | ![Tie between air duct and silencer output   |
| air duct and silencer   | silencer input](image3)       | and air duct](image4)                        |
| The tie between         | ![Tie between silencer         | ![Tie between silencer output and air duct](image5) |
| silencer output and     | output and air duct](image6)   |                                               |
| air duct                | ![Element](image7)            |                                               |
| The element             |                                |                                               |
| (narrowing, expansion)  |                                |                                               |
| in the row of the       |                                |                                               |
| silencer                |                                |                                               |

For example, based on the S-model of the single-row device (figure 1) the S-model of a two-row device is obtained (figure 2): INPUT DATA – input and transmission of data by the S-model; K * – calculating the components of the wave number; Z * – calculating the impedances of elements in the row; Y* FIRST SPLIT and Y* SECOND SPLIT – calculating the conductivities of the rows for each mode; FOUR POLE 1 and FOUR POLE 2 – forming the matrices of rows’ acoustic conductivities; SEWING – combining the two-row device with an air duct; ST – calculating the energy loss; NR – calculating the noise reduction by device.

Figure 1. S-model of the single-row silencer.
Figure 2. S-model of the two-row silencer.

Separately arranged blocks FREQUENCY and dB are responsible for visualizing the result of the calculation at certain frequency which is necessary to clarify the design of the silencer.

2.3. Implementation of the modernized practical class

The control group of master’s degree students performing the project tasks composed silencers for ventilation systems with wide main ducts and the required even noise reduction in the frequency range 125-8000 Hz:

- Students determined based on the smallest length of propagating waves the required number of rows of expansion chambers.
- Students determined by tuning the expansion chambers to specific frequencies the lengths of narrowings and expansions in rows,
- Students calculated noise reduction by the silencer variant in the established frequency range.
- Students clarified the dimensions of silencer’s rows to achieve the required noise reduction.

The results of the control group are as follows:

- Students tuning the basic device taking into account the propagating waves and self-found optimal indicator of changes in the lengths of elements in the rows of expansion chambers have developed the skill of composing silencer for specific ventilation systems,
- Students discussing the developed silencers have noted an increase in their level of readiness for project and expert activities in the field of acoustic safety.
- Automating the calculations have allowed to complete the design task in full without additional costs of training time.

Thus, the assumption about feasibility of automated calculation of a transformable silencer was confirmed.

3. Conclusion

It is recommended to introduce into acoustic safety practicum the automated calculation of the transformable silencer not containing sound-absorbing material.
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