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Determination of Pressure Loss of Silencers Used in Air Conditioning

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Abstract : When designing air conditioning systems, it is necessary to pay attention to the level of noise generated during the operation of such a system. Each of the components of the air conditioning system either absorbs or generates noise. Noise in pipes and fittings can be reduced to the required level by dimensioning the pipes. However, noise generated by the fan itself must be eliminated in another way. To eliminate fan noise, silencers are used in the duct just behind the air handling unit. For the correct design of the silencer, it is necessary to pay attention not only to its acoustic attenuation, but also to the pressure loss. If the pressure drop of the muffler is too high, noise will occur directly in the muffler. The pressure losses of the dampers are determined mainly experimentally. Based on the performed measurement, a CFD model of the selected damper was constructed, where the influence of various parameters on the value of the pressure loss of the selected damper was investigated.

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1 Introduction

At present, great emphasis is placed on reducing the noise associated with the operation of air conditioning systems, so components are built into the pipeline network, the task of which is to dampen and absorb this noise. However, for the correct design of the system, it is necessary to know the pressure loss of individual components of the pipeline network. In the practical design of a silencer, the pressure drop of this component is often forgotten and only its acoustic attenuation of the sound is evaluated. Today, an integral part of various measurements and experiments is a computational model constructed using CFD methods. The created computational model must be verified by measurement. This proven model can greatly facilitate further experiments, as it can be used to solve similar tasks.

2 Silencers in air conditioning

Air conditioning systems must meet strict hygiene standards that set maximum values noise in the room. Therefore, it is necessary to eliminate noise and vibration propagating from sources to other structures. The devices must be equipped with various dampers, inserts, etc., as the partial natural noise attenuation in the pipes and fittings is not sufficient [1-3]. In addition to noise attenuation using various elements used to attenuate noise, it is also possible to use the so-called passive elements. These are divided into the following categories:

- Reduction of the source - the value of the acoustic noise of the fan depends on the fan speed, therefore it is necessary to design the fan correctly,
- Disposition - it is necessary to pay attention to the distribution of individual noise sources,

- Sound insulation - by stripping the equipment and improving the acoustic properties of structures that separate noise sources from protected areas,
- Sound absorption - materials with good absorption properties, used as e.g. tiles or anti-vibration coatings increase the absorption of the structure. [4-8]

2.1 Modeled silencer

A link silencer was selected as the model damper. This type of shock absorber is one of the most commonly used shock absorbers in air conditioning. This type of silencer consists of a set mounted in a square pipe. The individual scenery consists of a sheet metal frame into which mineral wool wrapped in fabric is inserted. According to Gebauer [7], it is possible to regulate the acoustic performance of the system muffler by changing the number and dimensions of mounted scenes. A joint damper was selected as the model damper. This type of shock absorber is one of the most commonly used shock absorbers in air conditioning. This type of silencer consists of a set mounted in a square pipe. The individual scenery consists of a sheet metal frame into which mineral wool wrapped in fabric is inserted. According to Gebauer [7], it is possible to regulate the acoustic performance of the system muffler by changing the number and dimensions of mounted scenes.

The designed silencer consists of six backdrops. The dimensions of the damper are shown in Fig. 1. The spacing between the individual flanges is 66 mm, the spacing between the outer walls of the pipe and the flaps being 33 mm.

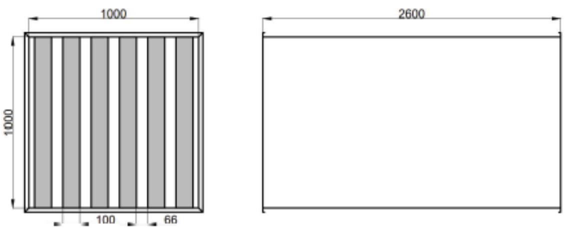

Figure 1 Cross section of modeled silencer

Each of the fitted links will be attached to the duct with rivets. The dimensions of the slide are shown in Fig. 2.

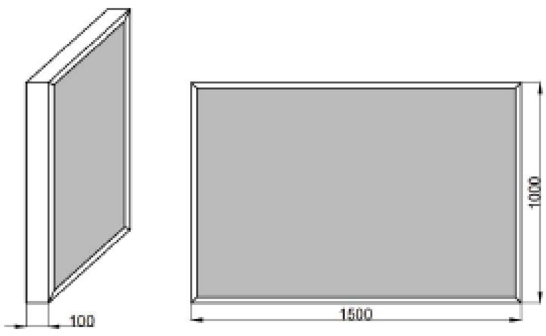

Figure 2 Backdrop inserted in silencer

3 CFD model

Based on the actual model damper, a CFD model was constructed using Ansys Fluent. To use numerical methods to calculate the pressure drop, it was necessary to construct a three-dimensional model of the real damper on which the measurement was performed. The geometry (see Figure 3) was made using Ansys Design Modeler software.

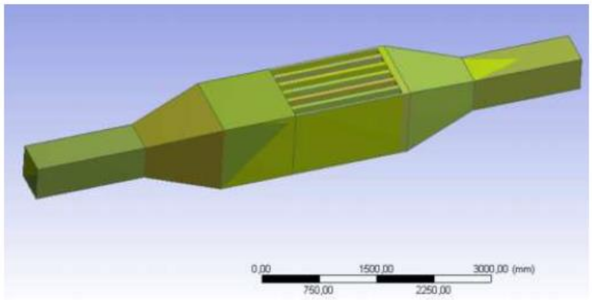

Figure 3 Geometry of modeled silencer

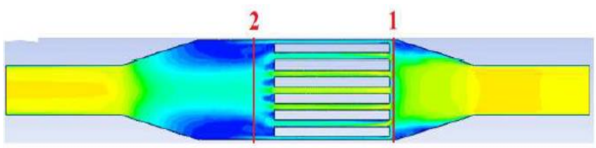

Figure 4 Velocity field in the cross section of the damper

In the model, a boundary condition was used for air entry into the duct (speed-inlet), where the air speed was entered according to the measured values. Next, a wall boundary condition was used to define the slides inserted into the channel. The resulting pressure difference consisted of subtracting the average value from planes 1 and 2, as shown in Figure 4.

According to Lenhard [11] the calculation model k-ε Realizable was chosen for the calculation, using the boundary conditions same as those measured during the measurement. The resulting value of the pressure drop and the local pressure drop coefficient are given in Table 1.

Table 1 Pressure loss values calculated by CFD

Volume flow	Δp [Pa]	ξ
3960	5,0	6,7
4366	6,0	6,7
4770	7,1	6,7
5172	8,2	6,6
5549	9,5	6,6
5972	10,9	6,6
6370	12,3	6,6
6700	13,4	6,4
7187	15,5	6,4
7562	17,7	6,5
7939	18,8	6,5

4 Experiment

The measurement was performed on a real silencer, constructed according to Fig. 6. The experiment consisted of measuring pressure drop, temperature, and flow rate using an ALMEMO 2690-8 measuring device. The flow rate was also measured using a Wilson grid with an Airflow PTSXR-K pressure transducer, to increase the measurement accuracy. The individual measuring instruments were connected as shown in the diagram in Figure 5.

Individual measurements were performed for different volume flow values. The flow control was performed using a frequency converter. The measurement started at a frequency of 20 Hz, which we gradually increased by 2 Hz up to 40 Hz.

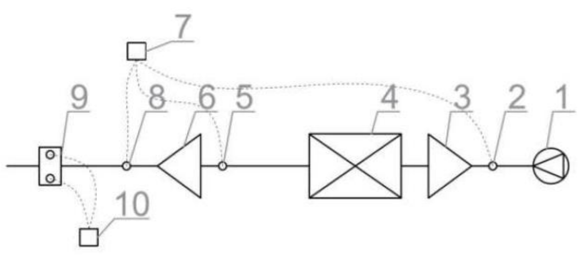

Figure 5 Measurement scheme (1-fan, 2-connection pressure measuring point, 3-pipe transition, 4-silencer, 5-connection point pressure measuring, 6-pipe transition, 7-measuring device ALMENO 2690-8, 8-measuring measuring point speed, 9-Wilson grid, 10-pressure transmitter PTSXR-K)

The measurement of the pressure difference was performed according to Figure 5 in points 2 and 5. The resulting velocity was determined as the arithmetic mean of the Wilson grid measurement and the average value determined by the ALMEMO velocity probe. Based on the resulting velocity, we determined the volume flow passing through the damper.

The results of individual measurements of the resulting pressure loss and the coefficient of local pressure losses are given in Table 2.

Table 2 Pressure loss values measured

Volume flow	Δp [Pa]	ξ
3960	4,5	6,2
4366	5,1	5,8
4770	6,5	6,2
5172	9	7,2
5549	10,2	8,9
5972	11,2	8,9
6370	13,2	8,9
6700	15,4	8,9
7187	16,6	6,9
7562	18,3	6,9
7939	21,9	7,5
Arithmetic mean		7,48

5 Discussion

Based on the performed measurement, mathematical model and CFD, we compared the individual values of pressure losses with the values of these losses calculated using the constructed mathematical model and at the same time with the calculation program for the design of silencers from Technov. A comparison of the resulting values can be found in the graph in Figure 6.

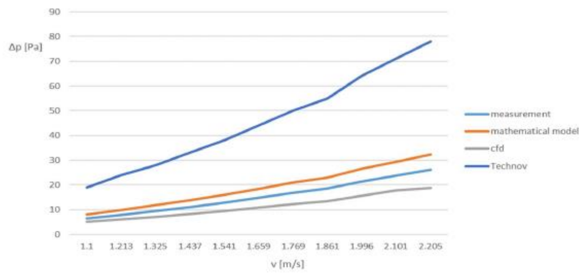

Figure 6 Comparison of achieved results

The above graph shows that the calculated and measured pressure loss values for the model silencer differ slightly. The largest deviation from the measured value is achieved by the calculation program of Technov. Based on this deviation, we can conclude that the program does not report the pressure drop correctly. The difference between the values in the mathematical model and the measurement can be caused mainly by determining the coefficient of local pressure loss using the coefficients given in Chapter 3. In the mentioned literature, the application of the given graphs for use in air conditioning is not precisely determined.

6 Conclusion

The aim of this work was to verify the accuracy of the design program of slide silencers from Technov using CFD methods. In order to achieve the goal of the work, a mathematical model was made, which was constructed on the basis of available literature, but its accuracy is not sufficient.

The CFD model was constructed using the k-e Realizable calculation model, which showed the most accurate results for the given application and at the same time the time required for the calculation was significantly shorter than with other models. However, for thorough verification of the model by experimental, it is necessary to perform measurements for other dimensions of link dampers. However, we were not allowed to experiment further in the current situation.

The result of the work is the finding that the application used for the application of silencers from the company Technov does not show the pressure losses of the link silencers correctly, but with a significant deviation from the measured value.

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