AERODYNAMIC PROPERTIES OF NOISE SILENCERS

Pavel Kic
Czech University of Life Sciences Prague
kic@tf.czu.cz

Abstract. All buildings used for intensive animal production (poultry, pig, rabbit breeding) are usually equipped with forced ventilation. Food industry and wood processing industry need also intensive ventilation or air-conditioning to provide a suitable and comfortable indoor environment either for the people or for the technological processes. These buildings are very frequently equipped by axial fans with big air-flows which can cause on the other side the indoor noise problems. The most common air ducts are of round profile. The noise level can be reduced by use of silencers which can have rather negative influence on the pressure drop. The aim of this paper is to present the results of measurements of aerodynamic properties of special noise silencers tested in laboratory of environmental engineering.

Keywords: air ducts, air flows, measurement, ventilation.

Introduction

The sound is one of the principal features of our modern human civilization and, of course, of the operation of all machines and technological equipment performance. The undesirable sound is called a noise. The excessive noise endangers living environment and it is one of the more realized environmental factors controlled from the point of view of human health [1; 2].

The danger of the noise influence on human beings is above all in the small possibility of people to defend against that. That is the main reason why it is necessary to control the noise during the construction of machinery and technology in all production companies. The acoustic environment should be controlled like the other branches of living environment [3; 4]. All buildings used for intensive animal production are equipped with forced ventilation or air-conditioning. These buildings are very frequently equipped with axial fans. The most common air ducts are of round profile. Besides the housed animals, also the principle parts of the ventilation system like fans, air ducts, distribution elements or other components are the main source of noise. Reduction of noise is important in these buildings for suitable indoor environment of the housed animals as well as because of the people working in it [5-8]. The influence of noise to the surrounding housing areas can also be one of the problems. The noise control can be based on information provided by the manufacturer of fans and on theoretical estimation including the calculation of aerodynamic noise generated by airflow in air ducts and other air distribution components [4; 5]. The noise level can be reduced by use of silencers [4; 8; 9].

Different types of silencers are used in ventilation and air-conditioning systems. Cylindrical silencers are usually used as a part of ventilation equipment in conjunction with axial fans or installed together with a round duct system. The aim of this paper is to compare two different constructions of noise silencers. There are three main factors which are expected from the noise silencers: noise reduction, low hydraulic resistance and minimal dimensions. These parameters were used as the criteria for the tested silencer evaluation. The results of measurements of noise reduction were presented in the paper [9]. There was significant difference between the measured values of noise with the standard silencer MAA (reduction from 74.8 dB(A) to 62.8 dB(A)) and the spiral silencer (reduction to 60.4 dB(A)) in the outlet installation. In the inlet installation the difference between the reduction of noise was not significant (with MAA silencer from 75.3 dB(A) to 61.1 dB(A), and with the spiral silencer to 61.0 dB(A). The aims of this paper are to prepare the method of measurements and evaluate the results of measurements of hydraulic resistance of two different noise silencers in the laboratory.

Materials and methods

All measurements were carried out in the experimental room of the Faculty of Engineering equipped with an axial flow fan HCGT/2-315L and short duct for inlet – outlet connection to the outside air, with the electric frequency convertor for control of the air flow. The construction of the fan enables to change the position and direction of the air flow for the inlet and outlet. The measurements were therefore always carried out with both directions of air streams, as the inlet as well as the outlet flow.

The noise level and the hydraulic resistance of the noise silencers were measured first without the noise silencers and later with two different types of noise silencers connected to the duct system. The influence of the noise silencers on the air flow was controlled by the measurements of air velocity.

Fig. 1. **Standard round silencer MAA**

Noise silencers used for the experiments were two types of absorptive silencers. The first silencer is a standard industrial product MAA (Fig. 1) for a circular pipe with an inside diameter of 400 mm, outer diameter 620 mm and length 850 mm. The second tested silencer is a prototype of a special spiral silencer (Fig. 2), which is installed as a supplement to the ventilation duct of circular cross-section with diameter 400 mm and length 800 mm.

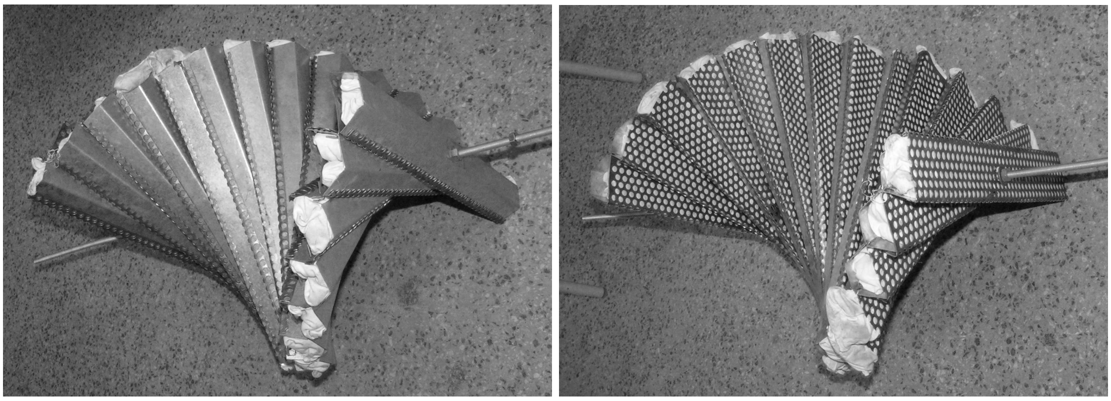

Fig. 2. **Special spiral silencer before installation into the air-duct:**
left view is inlet direction; right view is outlet direction

The instrument for the air velocity measurement was anemometer type CFM Master 8901 with rotating vanes with diameter 70 mm. The air velocity operative range is from 0.4 to 30 $m \cdot s^{-1}$, resolution 0.01 $m \cdot s^{-1}$ and accuracy ± 2 %.

In the air duct system, there are two types of resistance against the airflow: frictional losses and dynamic losses in the duct fittings, such as elbows, diffusers, entrances, contractions and exits or certain equipment (the noise silencers in our case), which create the total pressure loss Δp_t expressed by the equation (1). The loss coefficient of the noise silencer ξ_S can be expressed separately in the equation (2), where the frictional losses of the straight pipe are together with other dynamic losses of fittings expressed for the whole air duct system as a sum of losses by the loss coefficient ξ_D.

$$\Delta p_t = \frac{1}{2}.\rho.v^2.\left(\sum_{i=1}^{k} \lambda_i.\frac{l_i}{d_i} + \sum_{j=1}^{m} \xi_j \right) \qquad (1)$$

where Δp_t – total pressure loss, Pa;
ρ – air density, $kg \cdot m^{-3}$;

v – mean air velocity of airstream at reference cross section, m·s^{-1};
λ_i – loss coefficient for straight air duct;
l_i – length of air duct, m;
d_i – diameter of air duct, m;
ξ_j – loss coefficient for fittings, elbows etc. in the air duct.

$$\Delta p_t = \frac{1}{2}.\rho.v^2.(\xi_D + \xi_S) \qquad (2)$$

where ξ_D – loss coefficient for the whole air duct system without a silencer;
ξ_S – loss coefficient for the silencer.

Results and discussion

The results of air velocity measurements were used for calculation of the loss coefficient of both types of silencers ξ_S which are presented in Tab. 1. The loss coefficients were used for calculation of total pressure losses included in the system curves together with the fan performance curve. The fan-duct system for the air inlet is presented in Fig. 3 and the fan-duct system for the air outlet is presented in Fig. 4.

Table 1

Calculated loss coefficients ξ_S of the ventilation system and silencers

Part of ventilation system	Loss coefficient ξ_S	
	Air inlet	Air outlet
Air duct with fittings without silencers	4.8	0.354
MAA silencer	0.5	0.8
Spiral silencer	5.8	17.6

There are big differences of air flows obvious in the air inlet as well as outlet in the case of air-ducts equipped with the special spiral silencer. Reduction of the air flow in comparison with the air flow without a silencer was for the air inlet by MAA silencer only to 97 % and by spiral silencer to 70 % and for the opposite air stream direction (air outlet) by MAA silencer to 95 %, by spiral silencer to 46 %.

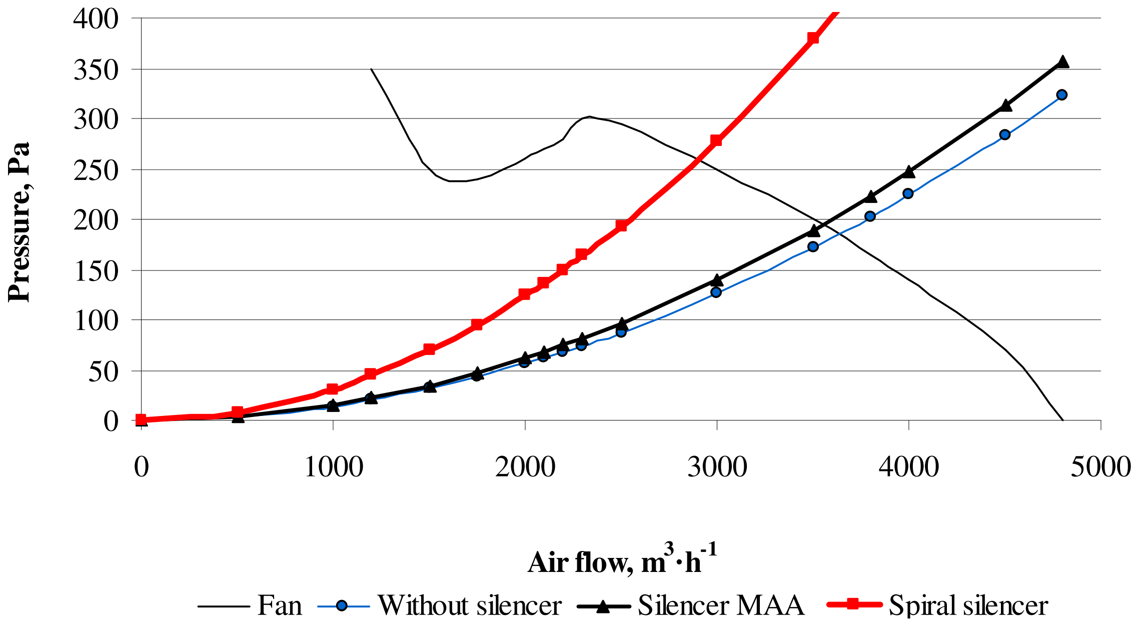

Fig. 3. **Fan-duct system for air inlet**

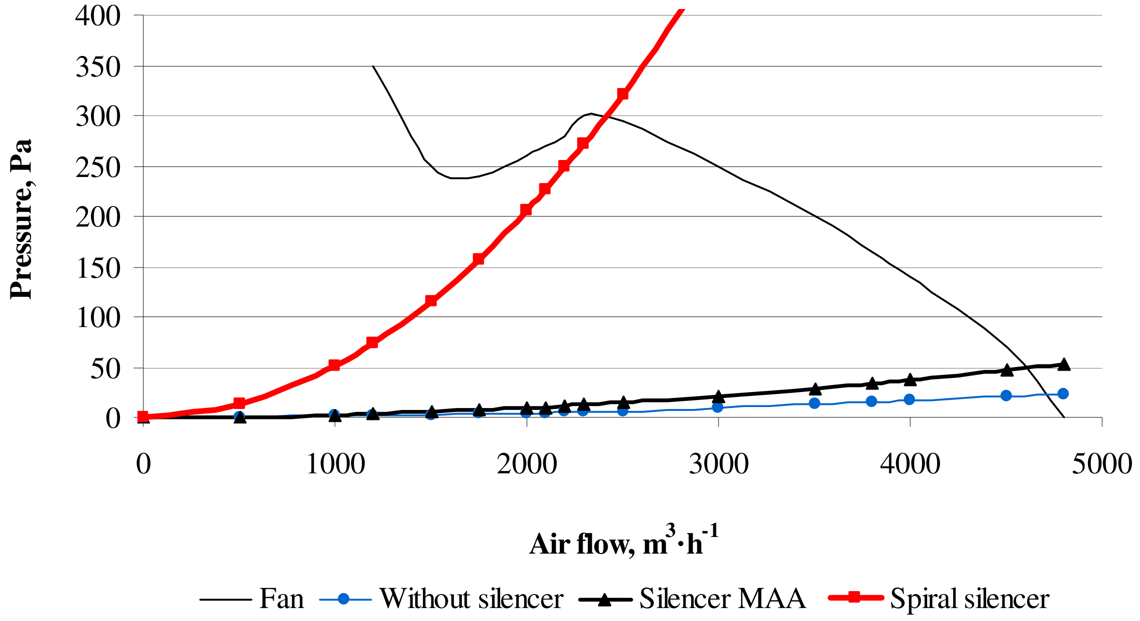

Fig. 4. **Fan-duct system for air outlet**

Conclusions

1. The used method of measurement and evaluation of the results is suitable for tests of aerodynamic properties of noise silencers.
2. The tested spiral silencer has advantage in the small dimensions and easy installation inside the air ducts, which is important in some cases for reconstruction of ventilation systems. The use in inlet arrangement makes the same noise reduction as the standard silencer. The noise reduction in outlet arrangement is better than the standard industrial silencer. Disadvantage of a tested spiral silencer is the high loss coefficient which results in high dynamic loss of pressure.
3. The tested spiral silencer should not be used for reversible performance of a ventilation system because the loss coefficient is three times higher for the opposite direction of the air stream.

References

1. Jokl M. Human performance and environment level. Praha: Academia, 2000. 212 p.
2. Reinvee M., Luik M., Kliimak P. Noise emission from grain dryers and potential noise pollution. Agronomy Research, 2013. 11 (2), pp. 457-462.
3. Reinhold K., Kalle S., Paju, J. Exposure to high or low frequency noise at workplaces: differences between assessment, health complains and implementation of adequate personal protective equipment. Agronomy Research, 2014. 12 (3), pp. 895-906.
4. Szekyova M., Ferstl K., Novy R. Vetrani a klimatizace. (Ventilation and air-conditioning). Bratislava: JAGA. 2006. 359 p. (in Czech)
5. Vranken E., Berkmans D., Vermeir G., Lauriks W. Noise analysis and possibilities for noise reduction of propeller fens in agricultural buildings. Proceedings of 25th International conference on noise and vibration engineering, September 13-15, Leuven, ISMA, 2000, pp. 1565-1571.
6. Gustafsson B. The health and safety of workers in a confined animal system. Livestock Production Science, 1997. 49 (2), pp. 191-202.
7. Guul-Simonses, F., Madsen, P. Laboratory measurements of noise from livestock ventilation units. Applied Engineering in Agriculture, 2000. 16 (1), pp. 61-65.
8. Novy R. Noise in air-conditioning and its reduction. Proceedings of the 14th Conference “Klimatizace a vetrani pro pristi stoleti” (Air-conditioning and ventilation for the next century), 1999, Praha, pp.180-182 (in Czech)
9. Kic P. Silencers for reduction of fan noise. Proceedings of 5th International conference TAE 2013 Trends in agricultural engineering 2013, September 3-6, Prague, Czech University of Life Sciences Prague, Faculty of Engineering, 2013, pp. 314-317.