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IMPACT OF THE INSTALLED INLET VENTILATION UNIT IN THE WINDOW ON ITS OVERALL AERODYNAMIC AND THERMAL PROPERTIES

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ABSTRACT

The article deals with the issue of ventilation of modern low-energy buildings, where on the one hand there are hygienic requirements for the required air exchange in the building and on the other hand the requirements of energy efficiency of buildings. A frequently used system in Slovakia in the present is a hybrid vacuum ventilation with air inlet through the ventilation unit situated in the window construction or in the facade construction and with air exhaust through the shaft with exhaust fan. The subject of the article are the supply ventilation units installed in the window construction. On the examples of two particular above-window ventilation units, it performs their laboratory experimental aerodynamic quantification, expressed in volumetric air flow depending on the pressure difference, necessary for designing of the ventilation system. The laboratory experiment also assesses the influence of the ventilation unit on the overall thermo-technical properties of the window, expressed by the heat transfer coefficient.

INTRODUCTION

When designing and realization current low-energy buildings, there are two basic requirements. On the one hand, it is the energy efficiency of buildings with the aim of significantly reducing the energy requirement for their operation, and on the other hand, it is the hygiene requirements of the required air exchange in buildings. The largest heat losses in buildings are those due to heat transmission and unregulated ventilation. We can eliminate those losses by increasing the thermo-technical properties of the envelope of the building and by increasing its airtightness. This leads to the need of transforming of the uncontrolled ventilation by infiltration into controlled ventilation systems (optimally by using heat recovery from the exhaust air to preheat the supply air in the heat recovery unit).

CONTROLLED VENTILATION SYSTEM

The ventilation system can be regulated on two ways. First way of regulation of the ventilation system is with the influence of a subjective factor - a man based on his subjective feeling and preferences, either by mechanical opening or closing, or by motor regulation of air supply and exhaust. Second way of regulation of the ventilation system is without subjective factor influence by automatic regulation based on evaluation of indoor climate quality, humidity, CO_2, chemical properties of air or detectors for the presence and movement of persons. The automatic ventilation control system is more efficient in achieving a balance between hygiene requirements and the energy efficiency of buildings.

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If the dynamics of the movement of the ventilated air is based on natural forces (a combination of wind effect and natural convection), we are talking about natural ventilation. If the movement of the ventilated air is ensured by fans, this is forced mechanical ventilation. Due to the inconstancy of natural forces, it is difficult to ensure the necessary air exchange by natural ventilation. A suitable solution seems to be its combination with forced ventilation, which comes into operation when natural forces are not able to provide the necessary dynamics of air movement. Then we talk about hybrid ventilation.
At present, a frequent solution of hybrid ventilation is the supply of air to the living room via the air inlet dampers installed in the window construction or in the perimeter wall, ideally above the heating device. The movement of air from living room to rooms where the deteriorated air is extracted (usually bathroom and toilet) should be made possible by a design solution in the form of a threshold-free door or interior slots installed in the door or partition wall. The suction itself is ensured naturally, by the shaft effect with the help of a solar chimney or a ventilation head. If necessary, to ensure the required air exchange, the fan is activated when at the exhaust shaft - Fig. 1. In the heating season, the heat from the exhaust air can be used by mean of forced ventilation using a heat pump for heating of the DHW.

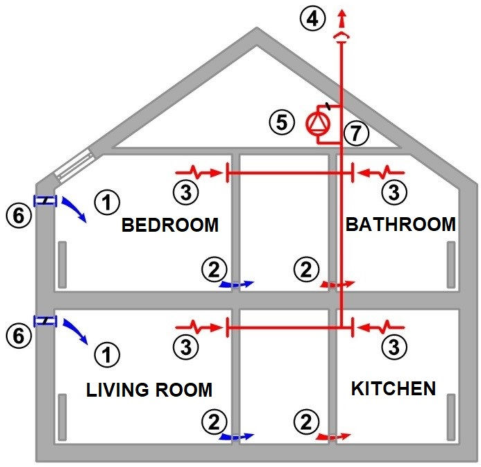

Figure 1. Diagram of hybrid shaft ventilation. 1- supplied outdoor air, 2- interior grille in the door or wall, 3- extracted air, 4- waste air, 5- active element of mechanical ventilation (fan), 6- self-regulatory air inlet ventilation unit, 7- ductwork

INLET VENTILATION UNITS

To the most important elements of the controlled ventilation belong the already above mentioned inlet vent flaps – Fig.2, which aerodynamic, acoustic, thermal-technical properties, and design significantly affect the functioning of the controlled ventilation system. Because of this reason, the selection of the appropriate inlet vent flaps is important for the proper dimensioning of the controlled ventilation system.

SUBJECT OF MEASUREMENT

In the laboratories of the Faculty of Civil Engineering of Slovak University of Technology in Bratislava we tested inlet vent flaps installed on the window frame structure. Specifically, there have been measured inlet vent flaps type Renson INVISIVENT EVO AK Basic and AKD MAX from Belgian firm Renson attached through the anchoring clips and compression tapes on the 6-chamber window profile Rehau Geneo PHZ glazed by triple glazing system 4-16Ar-4-16Ar-4 and 12-12Ar-6-12Ar-8 which we got for our measurements from the company Sulko in cooperation with the company Rehau – Fig.3, Fig.4. In the large pressure chamber – Fig.5, was measured air permeability expressed by the volumetric air flow Q_v (m^3/h), which are at various pressure differentials able to release inlet vent flaps. In the large climate chamber – Fig.6, were measured thermal properties expressed by the heat transfer coefficient U_w ($W/(m^2.K)$).

Figure 2. Variants of the installation of the inlet ventilation flaps. A - in the wall, B - in the glazing, C - in the frame, D - above the frame, E - integrated with the shading device, F - in the pitched roof in the loft.

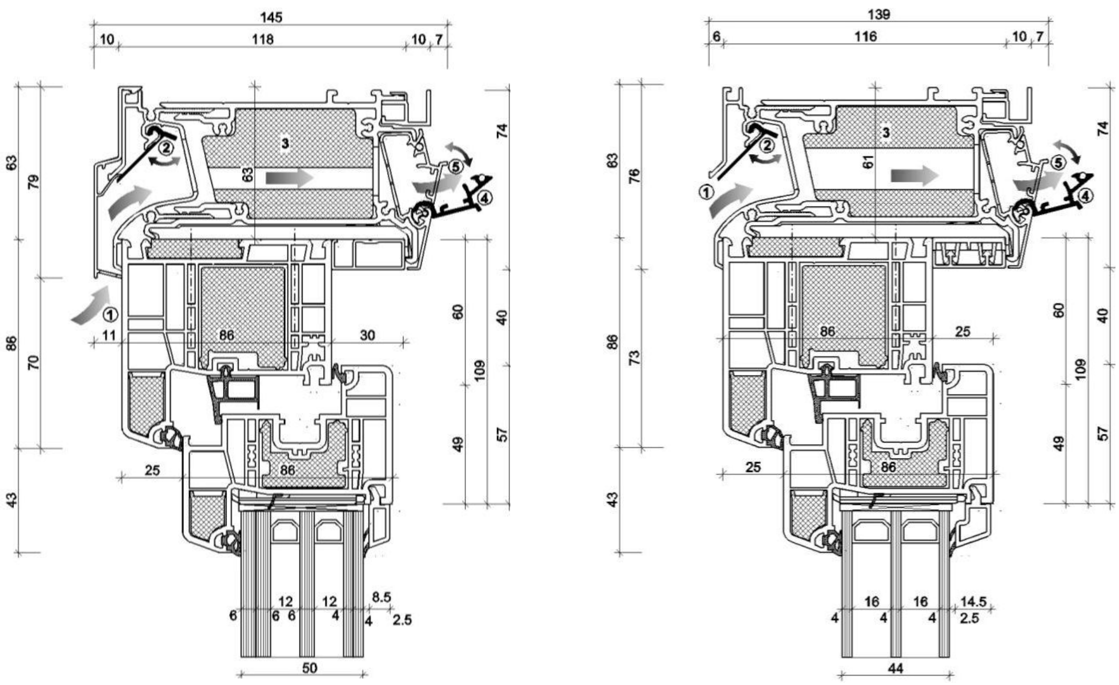

Figure 3. Vertical section of 6-chamber window profiles REHAU Geneo PHZ with installed inlet vent flap, the left Renson INVISIVENT EVO AK Basic and right Renson INVISIVENT EVO AKD Max.
1 - air supply from the exterior, 2 - internal overpressure relief flap, 3 – integrated noise reduction,
4 - interior closable reclining (5 positions) flap, 5 – entry of air into the interior.

Figure 4. Exterior view of the inlet vent flap installed on the window frame where you can see the inlets of the vent flap type Renson Invisivent AKD Max (left) and Renson Invisivent AK Basic (right).

Figure 5. Scheme and view of large pressure chamber and view of the window with inlet vent flap installed to the masking panels in a large pressure chamber. 1 – test sample, 2 – mounting frame, 3 – large pressure chamber, 4 – barometer, 5 – four-way valve, 6 – fan.

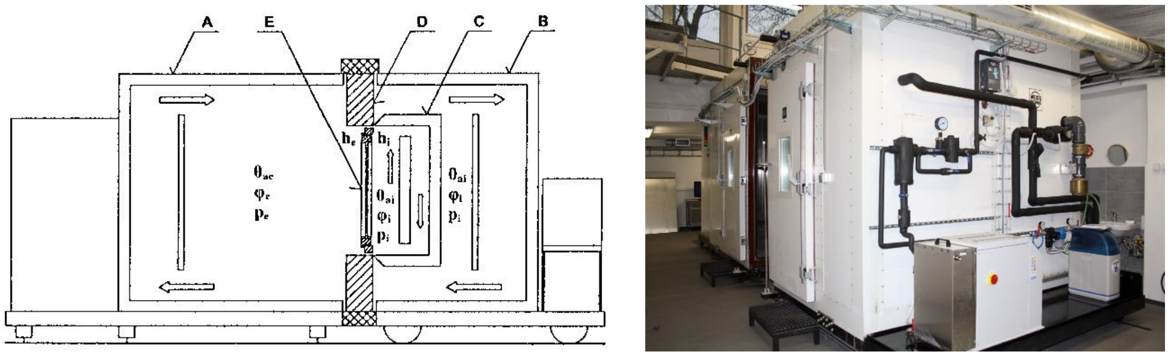

Figure 6. Scheme and view of large climate chamber. A - fixed climate chamber with programmable conditions of outdoor climate, B - mobile climate chamber with programmable conditions of indoor climate, C - small mobile climate chamber - Hot box with programmable conditions of indoor climate, B + C - protected warm chamber, D - masking panel of known physical properties, E – measured sample.

This type of inlet vent flaps can be fitted on PVC, wood or aluminium window profile constructions of depth from 50 to 184 mm and a maximum length of 6 m. This flap has five positions for opening and thus for the air flow control. From the fully closed position the flap can be gradually folded up to the last fifth position that is already fully opened position. The air flow through this inlet vent flap can be controlled mechanically

or remotely by motor. The internal overpressure relief flap that automatically closes itself at an elevated pressure difference prevents the draft feeling occurrence by the influence of the increased air velocity – Fig.3.
Advantage of the AKD Max ventilation flap compared to AK Basic may also be that from the outside it can be covered by the contact insulation system, as the intake of the vent flap is located from the bottom. This application does not weaken the architectural expression of the facade. On the other hand, inlets have smaller areas that are capable, at the same pressure difference, release less the air volume compared to the vent flap AK Basic.

OBJECTIVE OF MEASUREMENT

The objective of measurement was to evaluate the measured values of the air permeability of the inlet vent flaps and to assess how their installation worsened thermal properties of the window.

METHODOLOGY OF MEASUREMENT

Our measurement methodology was based on the two combinations of windows Rehau Geneo PHZ and inlet vent flaps Renson Invisivent EVO.

- The combination K1: We decided to install inlet vent flap Renson Invisivent EVO AKD Max on the window profile Rehau Geneo PHZ glazed by triple glazing system 12-12Ar-6-12Ar-8, which, according to the manufacturer should reach the level of sound reduction index R_w = 47 dB – Fig.3. This combination is interesting from this point of view for use in the facades of buildings close to the sources with higher levels of external noise. In the large pressure chamber we measured the air permeability at the pressure difference Δp = 2, 4, 8, 10, 20, 25, 50, 75, 100 Pa in the opened and closed position of the ventilation flap. In the climate chamber we measured window thermo-technical properties without and also with the installed inlet vent flap on the window, so we could assess to what extent the installation of the ventilation flap deteriorates window thermo-technical properties, expressed by the value of heat transfer coefficient U_w (W/(m^2.K)).
- The combination K2: We installed the second inlet vent flap Renson Invisivent EVO AK Basic on the window profile Rehau Geneo PHZ glazed by common triple glazing system type 4-16Ar-4-16Ar-4 with a value of sound insulation index R_w = 34 dB - Fig.3. This combination should be suitable for use in the environment with normal levels of external noise. In the large pressure chamber, in this case, it was possible to measure air permeability at pressure difference of Δp = Pa 2, 4, 8, 10, 20, 25, 50, 75, 100 only in the closed position of the inlet vent flaps. In the opened position, the ventilation flap has a larger area of inlet openings, it was possible to measure the air permeability at pressure difference of Δp = 1,2,4,8 and 10 Pa only in the first position of the smallest tilt flap. In the second tilt position we could measure values regarding to the increased airflow only for the pressure difference of Δp = 1 and 2 Pa. In 3, 4 and 5 fully-open position, we were able to measure the air permeability values only at a differential pressure of Δp = 1 Pa. We also assessed the impact of the inlet vent flap on thermo-technical properties of the window U_w measured in the climate chamber.

RESULTS OF AIR PERMEABILITY MEASUREMENTS

The results of measurements of air permeability in the opened position of inlet vent flaps are expressed in volumetric air flow Q_v (m^3/h) at a pressure difference of Δp (Pa) and displayed in graphs – Fig.7, Fig.8 and Fig.9. The inlet vent flap Renson Invisivent EVO AKD Max of length of 1.18 m we measured at a differential pressure of Δp = 2 Pa air flow rate Q_v = 5,6 m^3/h, at Δp = 4 Pa => Q_v = 7,5 m^3/h and at Δp = 8 Pa => Q_v = 10,6 m^3/h. In order to ensure the necessary air exchange rate of approximately 90 m^3/h for 4-member family in a 2-bedroom apartment, it would be necessary to install in the rooms total of 9 units or 8.5 m length of this type of ventilation flap (90 m^3/h / 10,6 m^3/h = 8,5). For relatively small area of inlets, only 8 x 200 = 1600 mm^2 it reaches air flow rate 10,6 m^3/h at the pressure difference of 8 Pa, but on the other side, its manufacturer claims excellent thermo-technical properties have the value of U = 1,2 W/(m^2.K) [2].

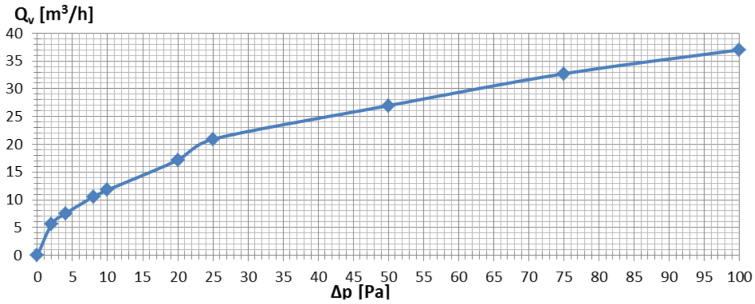

Figure 7. The measured volumetric air flow of combination K1 consisting of inlet vent flap Renson Invisivent EVO AKD Max in the open position and installed on window profile Rehau Geneo PHZ glazed by triple glazing system type 12-12Ar-6-12Ar-8.

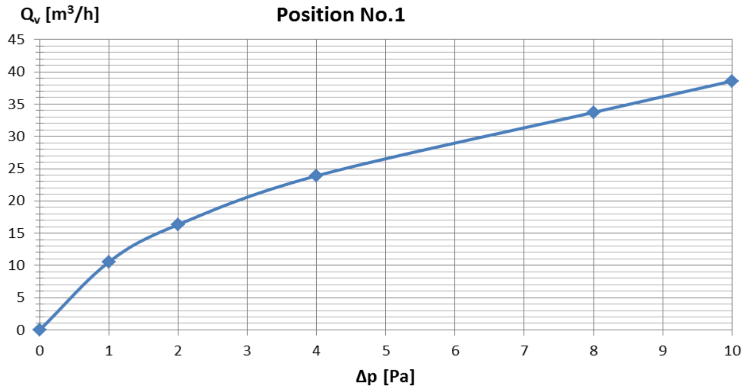

Figure 8. The measured volumetric air flow of combination K2 consisting of inlet vent flap Renson Invisivent EVO AK Basic in the open position No.1 and installed on window profile Rehau Geneo PHZ glazed by triple glazing system type 4-16Ar-4-16Ar-4.

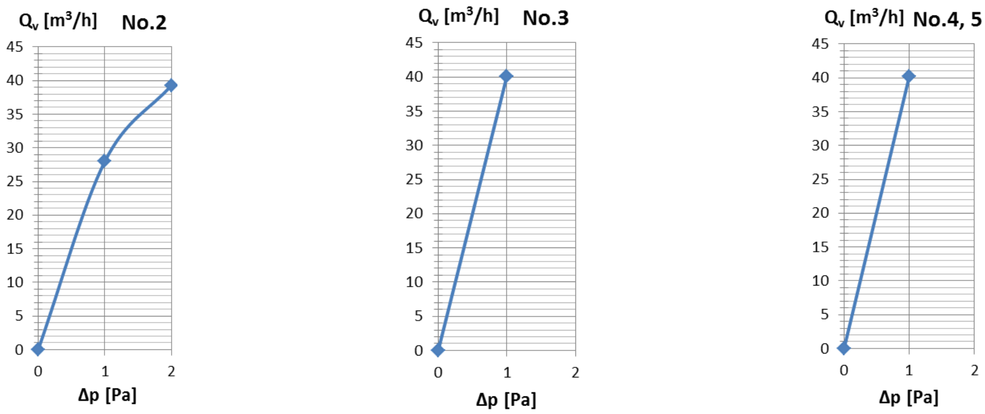

Figure 9. The measured volumetric air flow of combinations No.2 consisting of inlet vent flap Renson Invisivent EVO AK Basic in the open position No.2,3,4,5 = completely open, and installed on window profile Rehau Geneo PHZ glazed by triple glazing system type 4-16Ar-4-16Ar-4.

The inlet vent flap, type Renson Invisivent EVO AK Basic due to a larger area of the inlet opening of value up to A_{eqv} ≈ 13 500 mm^2/m was able to let through a larger volume of air flow even at the small pressure differences – Fig.8. Therefore, we had to distinguish the position of the opening flap for which we were able to measure the volumetric air flow as follows. In the first position of the opening the flap has been measured at the pressure difference of Δp = 1 Pa air flow rate Q_v = 10,5 m^3/h, at Δp = 2 Pa => Q_v = 16,3 m^3/h, at Δp =

4 Pa => Q_v = 23,9 m^3/h, at Δp = 8 Pa => Q_v = 33,7 m^3/h and at Δp = 10 Pa => Q_v = 38,6 m^3/h – Fig.8. In the second position of the opening the flap was measured at the pressure difference of Δp = 1 Pa air flow rate Qv = 27,9 m^3/h and at Δp = 2 Pa => Q_v = 39,3 m^3/h – Fig.9. In the third position of the opening we were able to measure the volumetric air flow only at pressure difference of Δp = 1 Pa in the value of Q_v = 40,1 m^3/h – Fig.9. In the fourth and fifth position (the maximum opening position for the ventilation flap), we measured at the pressure difference of Δp = 1 Pa the same value volumetric air flow Q_v = 40,2 m^3/h – Fig.9. The manufacturer of this inlet vent flap declares thermal properties of U = 2,0 W/(m^2.K) [2].

RESULTS OF THERMAL MEASUREMENTS

In the large climate chamber - Fig. 6, the thermal-technical properties of both of the individual windows as well as the windows with installed ventilation units were measured - Fig.10, Fig.11.
The measured heat transfer coefficients of the examined window samples are summarized in Table 1.

Figure 10. View from the outside (from the cold chamber) to the Rehau Geneo PHZ window with an installed ventilation unit mounted in the mask panel of the climate chamber, the Renson Invisivent EVO AKD Max on the left and Renson Invisivent EVO AK Basic on the right.

Figure 11. A view from the interior (from the warm chamber) to the Rehau Geneo PHZ window mounted in the mask panel of the chamber, on the left with the installed ventilation unit and on the right window itself without the ventilation unit.

Table 1. The resulting heat transfer coefficient U_w (W/(m^{2}K)) obtained by measurement in the large climate chamber.

Window Rehau Geneo PHZ with glazing	Window without a ventilation unit	Window with Renson Invisivent inlet ventilation unit	Ventilation unit flap position
			closed
12-12Ar-6-12Ar-8	0,81 W/(m^{2}K)	EVO AKD Max	0,86 W/(m^{2}K)
4-16Ar-4-16Ar-4	0,78 W/(m^{2}K)	EVO AK Basic	0,89 W/(m^{2}K)

The installed Rensom Invisivent EVO AKD Max ventilation system in the Rehau Geneo PHZ window with the 12-12Ar-6-12Ar-8 glass system in the closed position degraded only minimally the thermal properties of the window expressed by the heat transfer coefficient from U_w = 0.81 W/(m^{2}K) to U_w = 0.86 W/(m^{2}K), while the window fulfills the value of $U_w \leq U_{w,r1}$ = 1.0 W/(m^{2}K) required by the STN 73 0540-2.
Similarly, the ventilation unit Rensom Invisivent EVO AK Basic in the Rehau Geneo PHZ window with the 4-16Ar-4-16Ar-4 glass system in the closed position degraded the thermal properties of the window expressed by the heat transfer coefficient from U_w = 0.78 W/(m^{2}K) to U_w = 0.89 W/(m^{2}K), the measured assembly in question complies with the value of $U_w \leq U_{w,r1}$ = 1.0 W/(m^{2}K) required by the STN 73 0540-2.

CONCLUSIONS

When designing a controlled ventilation system the important role is to select the proper inlet vent flaps. It is necessary to take into account the actual conditions of the environment in which the building is located. Any such installation of the inlet vent flap in the window structure affects the thermo-technical and acoustic properties of the window. The aerodynamic design of these air intake flaps alone as well as their accessories (silencers, pollen filters...) have a significant impact not only on their aerodynamic properties but also on their acoustic and thermal properties.

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