Residential Ventilation

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Abstract: Ventilation significantly determines the comfort of a living space. To a certain extent, it

influences environmental safety and energy efficiency. Ventilation of a living space is fundamental to health, comfort, and energy efficiency.

Keywords: ventilation, comfort, ecology, energy efficiency. Air exchange, air duct, exhaust hood, air exhaust.

Introduction

For most people, ventilation in their homes is practically nonexistent: open a window and that's it. However, ventilation is a rather important and crucial process that requires a great deal of attention.

Individual developers only become concerned about this after construction is complete, when the building becomes unusually stuffy and humid.

One of the challenges for construction technologists and architects is to create a ventilation and comfort system in the home using modern materials that will be no less effective than that of a log home—an ideal, comfortable home, but with greater energy efficiency.

Main Part

To create modern home ventilation systems, it's first necessary to understand what they should look like in an ideal situation. Creating such ventilation is a complex task, as its development is closely linked to thermal insulation and vapor barriers in the walls, environmental concerns, and living comfort. Furthermore, this is complicated by a contradiction that is quite difficult to overcome with the traditional approach.

A house with wooden walls addresses environmental and comfort concerns, but not energy efficiency. A stone (concrete) house, on the other hand, is durable, fireproof, and can be insulated to any degree, but it doesn't "breathe," and comfort is achieved only with expensive condensing systems. Modern technologies offer a simple solution to this problem. They are developed with a comprehensive approach to ventilation and energy efficiency, wall insulation, and vapor barriers, ensuring comfort and environmental safety.

To better understand all of this, let's first take a closer look at each of the individual important features.

Considering that most people live in apartments, let's describe the ventilation of residential spaces and how it's organized in city buildings. This will be not only informative but also useful.

The ventilation system of a high-rise building, including its individual components, can be used as a basis for creating ventilation in your own home.

Any ventilation system consists of supply and exhaust ventilation. City apartments utilize natural ventilation. This includes supply ventilation with fresh air, which is provided through a window opening or window, and exhaust ventilation, which removes polluted air to the outside through a ventilation grille or shaft. Typically, an exhaust ventilation grille is located in the kitchen, bathroom, or toilet.

Depending on the apartment's design, the exhaust ventilation shaft is located either inside the apartment or between apartments.

Exhaust ventilation is organized so that fresh air is directed to the living area of the apartment (bedroom, living room). Depending on the level of pollution, air enters the bathroom, toilet, and kitchen through the apartment's interior doors, where air pollution levels may be higher because we spend less time in these auxiliary spaces.

Building codes and regulations establish the volume, nature, and specific features of natural ventilation.

Natural ventilation in residential buildings is calculated based on the difference in density between outdoor and indoor air, taking into account cold season parameters.

Natural ventilation depends on the difference in density between outdoor and indoor air. For this reason, airflow is not a constant value, making it difficult to determine not only heat loss but also the actual air exchange in a building. However, regulations stipulate that ventilation in residential buildings must provide an air exchange rate of at least 3 m^3/h per 1 m^2 of living space or a number of air exchanges of at least:

- Toilet - 25 m^3/h;

- Bathroom - 25 m^3/h;

- Kitchen - 60-90 m^3/h, depending on the stove;

- In rooms with long-term occupancy - 25 m^3/h per person;

- In rooms with short-term occupancy - 16 m^3/h per person;

- In a smoking room - 70 m^3/h;

- In a single-car garage where occupants spend less than 1 hour, 3-4 m^3/h per 1 m^2 of garage space.

Regarding the structural efficiency of natural ventilation elements, there are also certain recommendations.

- In a residential building, key windows, transoms, and other fresh air supply devices must be considered.

- The following ventilation elements (window and other intake devices) must be located at a height of 1 m above the average snow level, but not less than 2 m above ground level.

To ensure natural ventilation, its ducts must have a cross-section that allows for this:

- The living room and bedroom are ventilated through an open window or an adjustable valve in the wall with a cross-section of 100 cm^2;

- Kitchen - 150 cm^2;

- Bathroom with toilet - 150 cm^2;

- Separate shower or toilet - 100 cm^2;

- Laundry room in the apartment - 150 cm^2;

- Basement with closed windows - 3 cm^2 - 1 m^2 of floor area.

- Airflow from the supply ventilation to the exhaust ventilation must be ensured even with closed doors inside the apartment (between rooms, in the toilet, bathroom, and kitchen). Airflow can pass through both door grilles and through the upper and lower door gaps (gap - 1...1.5 cm).

- Gas pipelines, cables, electrical wiring, and sewer pipes are not permitted inside the air duct or within 50 mm of its wall. The air duct must also not intersect with these utilities.

- The materials used to construct the air duct in a residential building are not regulated by either environmental or fire safety regulations.

Poor or absent ventilation (with plastic windows or tightly closed doors) completely interrupts the entire ventilation process. Imagine an apartment in a new, modern building, quite expensive per square meter. The windows are modern plastic, the doors are beautiful and tight-fitting. The kitchen cabinets are beautiful, air conditioners are installed in every room, and a beautiful air purifier in the kitchen is connected to the ventilation system, etc. The apartment is truly extraordinary.

Now let's consider this ideal from a ventilation perspective.

- Plastic windows block the supply ventilation;

- As for the exhaust ventilation, windows are located in the bathroom, toilet, and kitchen. Solid doors without a groove at the bottom impede the free flow of air to the exhaust ventilation.

Air conditioning systems most often maintain the proper temperature and humidity levels in a building, but not the chemical composition. The air is comfortable, but polluted.

An air purifier in the kitchen helps the ventilation system of the kitchen and the apartment as a whole, but only when it is running. When the air purifier is turned off, this ventilation is blocked because the air purifier's air intake is located not at the ceiling, but at the bottom (especially if the air purifier is switched to filtration mode).

Poor building ventilation, combined with the finishing materials used, prevents the building from achieving the required level of environmental safety.

No matter how high-quality the finishing, wallpaper, paint, and furniture used in an apartment, it's important to remember that the permissible level of harmful substances emitted by these materials will only be achieved with adequate ventilation. Without ventilation, air pollution in the apartment will exceed the permissible level due to these materials alone.

Please note that according to building standards, the ventilation level of a residential building should provide one air exchange per hour.

According to European standards, the volume of fresh air supplied increases by almost 1.3 times.

It's also important to ensure the stable operation of the exhaust ventilation (a piece of paper placed near the ventilation duct should "stick" to it). If the ventilation ducts are clogged with construction debris or if someone on the upper floor has managed to use them to expand their kitchen, this incompetence should be immediately reported, and this incompetence should be promptly corrected by the person responsible for building maintenance. Problems often arise with forced ventilation (air purifier in the kitchen, exhaust fan in the bathroom and toilet).

If the kitchen has a gas stove and an air purifier, an additional vent in the ceiling is necessary. This way, when the air purifier is turned off, gas will not accumulate near the ceiling and form an explosive mixture, and when the air purifier is running, air will not return to the kitchen through the second vent.

- An overly powerful fan is not needed in a bathroom or toilet. Natural ventilation ducts may not be able to handle the strong air flow; they will become blocked, and the odor from the toilet or bathroom may reach, if not the kitchen, then the neighbors. An apartment can be thoroughly ventilated by opening the doors and windows and running the air purifier for 1-1.5 hours. It's best to combine this process with vacuuming.

Exhaust fans will only create adequate draft if there is adequate ventilation (windows not closed or sealed). Otherwise, undesirable air flow patterns may occur in the apartment, or if the system is running, toilet odors may permeate the kitchen, or subtropical humidity from the bathroom may spread throughout the apartment.

If a gas water heater is installed in the kitchen in addition to the stove, the air purifier with a filter should be installed so that it returns air to the kitchen (recirculation mode), so that the kitchen exhaust air is shared by the stove and water heater.

According to the air exchange scheme, ventilation can be:

- mixed;
- exhaust.

By the forced ventilation factor:

- natural;
- forced.

Mixed ventilation is typical for brick and concrete buildings with airtight walls. In such buildings, supply and exhaust ventilation is provided through small vents or through window and door openings. This category also includes "Jelur"-type buildings, whose outer enclosing walls are equipped with airtight insulation. The relatively high airflow velocity leads to effective mixing of fresh and stale air, followed by exhaust. Achieving zero concentrations of harmful substances in the air is virtually impossible, especially if the building contains numerous unventilated, stuffy areas.

Exhaust ventilation is typical for buildings with permeable (ventilated) walls. The "Jelur"-type building is the most striking example. Fresh air is supplied from the entire enclosing wall. In this design, airflow speeds ideally range from 3 to 6 m/h. After exiting the wall, the air becomes contaminated with household products, slowly permeates the building, and exits through the stove, chimney, or attic vent. In such a house, a complete air exchange occurs within one hour.

Exhaust ventilation systems in construction are the most promising from all perspectives (environmental friendliness, comfort, energy savings).

However, only those houses whose walls "breathe" fall into this category. Moreover, it's not just the fact that they allow air to pass through that is important, but also how and to what extent.

Creating "breathing" walls for a stone house is quite a complex task. If a wall "breathes" well, then heat will also be effectively dissipated (infiltration), but it's theoretically impossible to find that fine line where air

A more visual comparison of the two ventilation schemes is presented graphically

permeability is adequate. Ventilation is affected by weather conditions, which vary widely both day and night, and throughout the year. Furthermore, any wall covering, either inside or outside, can dramatically alter or completely negate the effect of a "breathing" wall. How do log walls "behave" in this case? Wood has an anisotropic structure; it "breathes" along the grain 40 times better than across it. This is why log walls perform well in natural conditions: they are not blown away by the wind, and they "breathe" well through their trunks. Moisture, along with polluted air, escapes through the stove or through a hole in the roof. Thus, the walls "breathe" from the inside. According to the law of thermodynamics, in a log wall with an anisotropic structure, there is a separation between the heat flow (heat escapes through the log) and the material flow (air flows from the log trunk inward).

Therefore, by separating the material and heat flows, we can create a wall that "breathes" and is not blown away by the wind.

There is a mathematical model for comparing the two ventilation systems, expressed in a fairly simple formula:

$$K_{н}/K_{ф} = -\ln \xi/(1-\xi),$$

Where $K_{н}$ The air exchange rate during mixed ventilation is:

$K_{ф}$ – Air exchange rate during exhaust ventilation.

ξ – Concentration of harmful inclusions. (Fig. 1).

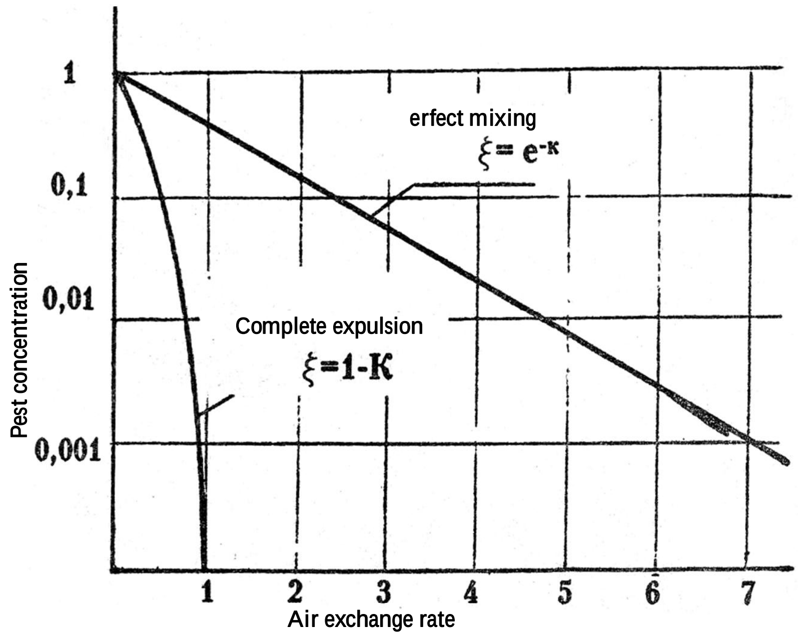

Fig. 1. Dependence of the concentration of harmful substances on the air exchange rate and ventilation scheme

When the harmful substance content (HSC) is 0.1% (concentration 0.001) of most anthropogenic toxins, such as phenol, formaldehyde, and styrene, which are eliminated from the human body, the mixing system requires 7 air changes, while the exhaust system requires approximately 0.9 air changes.

The eightfold difference between the systems indicates that achieving the same level of purity requires eight times less ventilation with the exhaust system.

With a carbon dioxide content of 0.1%, the efficiency is almost 6 times higher! This is why a log house is so comfortable and easy to breathe, and not because it's made of wood.

Based on the calculations above, we can immediately conclude that exhaust ventilation is highly effective, especially in removing low-level pollutants. These include carbon monoxide, radon, styrene, tobacco smoke, and many other substances emitted by building and finishing materials, furniture, etc.

Of course, this is theoretically true; in reality, exhaust ventilation in a log house is only 2-3 times more effective, since air mixing in the building still occurs through conventional heat exchange (cold windows, warm radiators, incandescent lamps, household appliances).

Conclusion

The efficiency of the exhaust ventilation system can be increased by 4-5 times. This is achieved by installing modern double- and triple-glazed windows and reliable fasteners, as well as efficient wall insulation and appliances that operate at low temperatures. This is fully consistent with the development trends of energy-saving technologies.

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