TECHNICAL SCIENCES

OPTIMISATION CLIMATE COMFORT AND ENERGY EFFICIENCY: THE ROLE AND APPLICATION OF RECUPERATORS IN RESIDENTIAL VENTILATION SYSTEMS

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Introductions. Good ventilation in an apartment or house is a guarantee of well-being and excellent health of its inhabitants. Such a room is comfortable and easy to breathe in. It is also very important to maintain the optimum room temperature, saving energy resources and money, that's why this article is dedicated to the devices that solve important comfort and energy-saving issues.

Aim. Given that most energy and resources are not renewable and may eventually be exhausted, and the use of renewable energy sources requires large costs at the installation and development stages that not everyone can afford, it is optimal to use devices that will create comfort and help reduce energy costs – recuperators. By the way, these devices are not very popular in Ukraine, so this problem should be addressed.

Materials and methods. A favorable microclimate in the room is created with the help of an air recuperator, is a ventilation and air conditioning device used for energy saving. Its main function is to exchange heat between the air extracted from the room and the fresh air drawn in from the outside.

In the case of natural indoor air exchange, outside air is brought into the room and contaminated air is exhausted. During the cold season, the exhaust air takes some of the heat out of the room, which means that some of the heat is lost. This is the difference between the operation of a recuperator and natural air exchange.

The recuperator is a heat exchanger with two chambers located close to each other. Two air streams pass through them simultaneously: exhaust and supply air. They do not mix, but heat is exchanged due to different temperatures. This device can be called a kind of heat exchanger: the room air is cooled in it, and the outdoor air, on the contrary, is heated – this process is called recovery.

This approach allows you to reduce energy consumption and maintain optimal indoor conditions, which makes recuperators popular in ventilation and air conditioning systems for buildings.

Before choosing the optimal recuperator model, you should take a closer look at what an air recuperator for a private house or apartment is and how it functions. The choice of a specific type of recuperator may also depend on the requirements of the ventilation system, temperature conditions, energy efficiency and the amount of air exchange that must be provided.

The most important parameter by which an air recuperator is determined is its performance. It is measured in m^3/h, that is, it shows how much air the recuperator passes through itself per unit of time. According to the state norms of requirements for ventilation of living and sleeping spaces, there are two norms of ventilation air consumption: in relation to the total area of the room and in relation to the number of people in the room. These standards are listed in Table 1 [3, p. 15].

Table 1

State regulatory requirements for ventilation of residential and sleeping premises

Conditions	Consumption rate person, m^3/h	Consumption rate person 1 m^2 of area, $m^3/(h*m^2)$
Acceptable	15	2,2
Optimal	25	3,6
Increased permissible	36	5,0

To determine the required productivity, it is necessary to calculate two air exchange values: for the total area of the room and for the number of people, after which choose the larger of these two values.

1. Calculation of air exchange by room area [1; 3, c. 115-117]:

$$L = n * S * H, (1)$$

where L – necessary performance of supply ventilation, m^3/h; n – the rate of air exchange (for living rooms – 1, for office rooms – 2,5); S – area of the room, m^2; H-room height, *m*.

2. Calculation of air exchange by the number of people [1; 3, c. 115-117]:

$$L = N*L_{norm.}, (2)$$

where L – necessary performance of supply ventilation, m^3/h; N – number of people; $L_{norm.}$ – rate of air consumption person.

In terms of the principle of operation, recuperators can be divided into the following types, namely: plate, rotary, combined or regenerative, heat pumps. In plate recuperators, air passes through a series of thin plates, and heat is exchanged through these plates. They are efficient and compact, but may have limited ability to withstand high temperatures.

A plate recuperator, also known as a plate heat exchanger, is a device for transferring heat between two air streams that flow on either side of metal plates. The basic principle of operation is to exchange thermal energy between hot and cold air without direct mixing.

The principle of operation of the plate recuperator is as follows: it consists of multiple thin metal plates stacked together, creating alternating channels for the hot and cold fluids to flow through; hot and cold air flows on opposite sides of the plates; as the air flows through the appropriate channels, heat is transferred from warm to the cold through the metal plates by thermal conduction; plate heat exchangers, due to their large surface area and numerous plates, provide efficient heat exchange, corrugations or patterns on the plates also increase the turbulence of the air flow; the modular design of these recuperators makes it easy to add or remove plates depending on the specific heat transfer requirements; the plates are connected by gaskets or welding and this ensures that the air flows do not mix with each other. The compactness and versatility of these recuperators make them popular in a variety of applications: industry, heating, ventilation, air conditioning, etc.

Rotors use a rotating fan or disc to transfer heat between the extracted and fresh drawn air. They are usually more effective in withstanding high temperatures.

The rotary recuperator works as follows: air mass flows along the same path through the sectors of a horizontal rotor filled with air-permeable filler are heated and cooled alternately or simultaneously. This increases the heat transfer coefficient and the efficiency of the recuperator as a whole, and completely eliminates the problem of condensation. At the same time, a part of the exhaust air is mixed with the incoming air stream and returned to the room.

Rotary models of recuperators are recommended for use in regions with a cold climate, as they are not prone to icing, and for regions with a warmer climate, it is better to choose plate recuperators.

Combined or regenerative recuperators may use several technologies, such as plate elements, rotating discs, or other designs to optimize heat exchange efficiency.

In a regenerative heat exchanger, heat energy is transferred between two media through an area containing a heat storage material such as a ceramic or metal grid or an array of plates. The process involves two main steps – heating and cooling. During heating, hot gas or liquid passes through the recuperator and transfers heat to the heat storage material. During cooling, the cold medium makes its way through the same recuperator and receives heat from the heat storage material. Regenerative recuperators can be quite efficient because they utilise heat that has already been transferred instead of losing it.

A combination heat exchanger can use different heat exchange principles, such as plate and tube, or others, to improve efficiency. It can also incorporate regenerative elements.

The basic idea is to combine different heat exchange methods in one device to achieve optimum efficiency in specific operating conditions. Combined heat exchangers are often used in processes where it is necessary to optimise heat transfer depending on changing conditions.

Some recuperators, such as Heat Pump Ventilation Systems, can be integrated with heat pumps to supply and extract heat from the room. These ventilation systems

represent a modern approach to ventilation and air conditioning in buildings. The main idea of these systems is the integration of the heat pump into the recuperator for additional energy-efficient management of heat and air conditioning. The main features of these recuperators are: heat exchange, energy efficiency, air filtration, humidity control, equipment with modern intelligent control systems.

Results and discussion. Energy efficiency when using recuperators depends on various factors, such as the type of recuperator, the quality of the building insulation, climatic conditions and proper operation of the system. However, in general, recuperators are designed to reduce energy consumption and increase the energy efficiency of ventilation systems.

The main advantages of the energy efficiency of recuperators include: recuperators allow you to use the heat that is already present in the room for preheating the freshly drawn air in the cold period, this can significantly reduce the need for additional heating; in the summer, the recuperator can remove heat from freshly extracted air before it enters the house, reducing the need for air conditioning; thanks to recuperators, it is possible to reduce energy losses associated with the removal of heat or cold from the room during ventilation; some recuperators can regulate the level of air humidity, contributing to the creation of comfortable conditions; air recovery systems can too.

It is important to consider that correct installation, regular maintenance and proper operation of the recuperator are key factors in achieving maximum energy efficiency.

Conclusions. Having understood the types of recuperators and the principles of their operation, we can conclude that all these devices, regardless of their design and cost, are aimed at improving the heat exchange of the room and maintaining a constant temperature both in summer and winter. It is the installation of recuperators in the room that will save on energy costs, which is actively practiced in Western countries.

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