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**PAVLENKO V., VOLIANYK O.**
Kyiv National University of Technologies and Design

# INVESTIGATION OF RECUPERATOR EFFICIENCY USING IN RESIDENTIAL PREMISES

***Purpose.*** *Investigation of ventilation and conditioning systems for residential premises in order to ensure a healthy atmosphere and maintain a comfortable temperature in such premises.*

***Methodology.*** *Analytical investigation of the ventilation systems, recuperation technologies which can be applied in residential premises.*

***Result.*** *In this paper are considered the microclimatic features of residential premises and public premises. Constructions of air recuperators and air conditioning systems are explored. The possibility of using recuperator systems of heating and cooling for the observance of sanitary norms, determined for residential premises, is substantiated.*

*It is noted that in the case of using ventilation and air conditioning systems in residential areas, it is important to ensure the intensity of the input and output of air at various temperatures and natural conditions. In order to ensure the temperature regime, the observance of the required humidity of air and its speed in residential premises, it is proposed to use a plate recuperator and an appropriate control system. Calculations were made to compare the amount of energy consumed and its cost for the real consumer during the heating period.*

***Scientific novelty.*** *An analysis of the calculations of tidal units with different types of heaters was conducted, and showed that the most effective way to heat the cold tidal air, to feed it into the room, is the electric heater in conjunction with the recuperator.*

***Practical significance.*** *The functional scheme, the system of ventilation and air conditioning with the use of plate recuperators are developed, which is the basis for creation of experimental complexes and laboratory installations.*

***Key words:*** *energy efficiency, energy-saving technologies, heat utilizers, life support systems, recuperation.*

**Introduction.** One of the main characteristics of energy efficiency of buildings is considered to be the specific energy consumption of heating and ventilation systems per year. Unfortunately, we are significantly behind the majority of European countries from these indicators. Lowering the specific energy consumption of heating and ventilation systems can be predicted. Lack of massive construction of modern energy-saving technologies leads to high energy costs.

**Setting problem.** Considering the urgency of the issue ensuring the conditions of the internal environment in living premises, the research task is to evaluate the efficiency of using the heat recuperator to improve comfortable in-apartment conditions.

**Results of the study.** According to the applicable standards, premises for living in houses, apartments etc. should be equipped with heating, air conditioning, or forced and ventilated system.

In those kind of premises at homes, there are optimum parameters of the microclimate are to be ensured: temperature, relative humidity and air mobility in accordance with norms and rules [1].

According to [2], in home premises the air temperature should be 22-25° C, the relative humidity of the air - 40-60%, the speed of the air - not more than 0,1 m / s. When exceeding the permissible values, apartments and living premises should be immediately closed and provided urgent repair of ventilation systems.

In order to maintain the permissible values of the microclimate and the concentration of positive and negative ions, it is necessary to provide installations or devices for hydrating or artificial ionization, air conditioning. In Ukraine, there are no legally approved maximum levels of carbon dioxide in the air for personal, office and public buildings. However, taking into account its impact on residents, builders and landlords should pay attention to this issue and take preventive measures.

In addition, the result of modern technological advances is the growth of each year of power consumption and increase of the load on cables, which in turn leads to an increase in the intensity of electromagnetic fields, the adverse effects of which can lead to deterioration of the health of residents. Thus, builders and rental should be aware that the reason for the lower sales is very often because of the unsatisfactory microclimate parameters.

One of the high-tech aggregates that provide energy-saving are recuperative heat exchangers, the use of which represents a great practical interest as the most affordable means of introducing energy-saving technologies in the reconstruction of ventilation systems. The use of a recuperative heat exchanger is possible without replacing the main components of the existing ventilation system. Depending on the design, they are divided into plate, rotary, recirculation water recuperators [3].

Ventilation recuperator is a device in which the warm air, that is removed from the room, is heated by the cold air coming from the street. There are recuperators with copper plate or aluminum heat exchangers (coefficient of performance – 65-80%) and with regenerative ceramic plates (coefficient of performance – 75-91%). The disadvantage of plate heat exchangers is the complexity of manufacturing, respectively, a higher price, and regenerative - low performance. In summer, the use of a recuperator will reduce the need the installation of an air conditioner, or 2 to 5 times reduce the cost of electricity during its operation. In winter – it will significantly reduce the energy costs of heating the premises [4].

In fig. 1 shows the temperature of air in the recuperator.

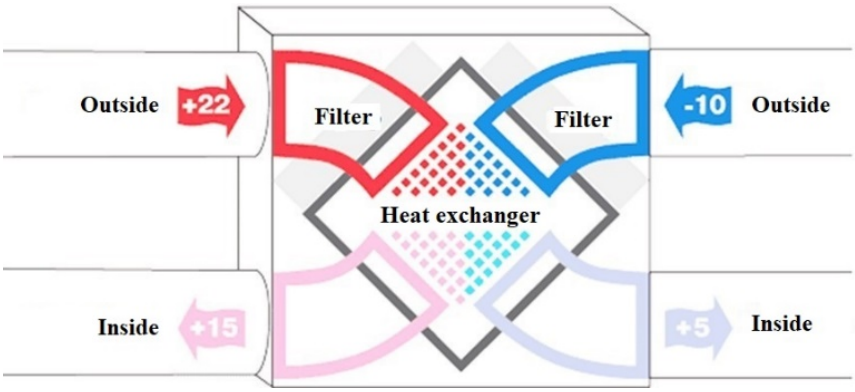


Fig. 1. **Temperature and air flow in the recuperator**

Heat exchange in the recuperator is carried out continuously through the wall separating the heat carrier. Plate recuperator - one of the types of air recuperators. It is the most popular, due to its simplicity of design and functioning. They transmit heat through their plates, which in turn heat up from passing through them warm air from the room and give it the heat of air flush. In this case, the air flows in the plate recuperators are completely sealed relative to each other. That is, they do

not mix air by transmitting heat through metal plates. The most popular materials for lamellar recuperators are aluminum, plastic, stainless steel and paper.

In fig. 2 shows the scheme of recovery efficiency.

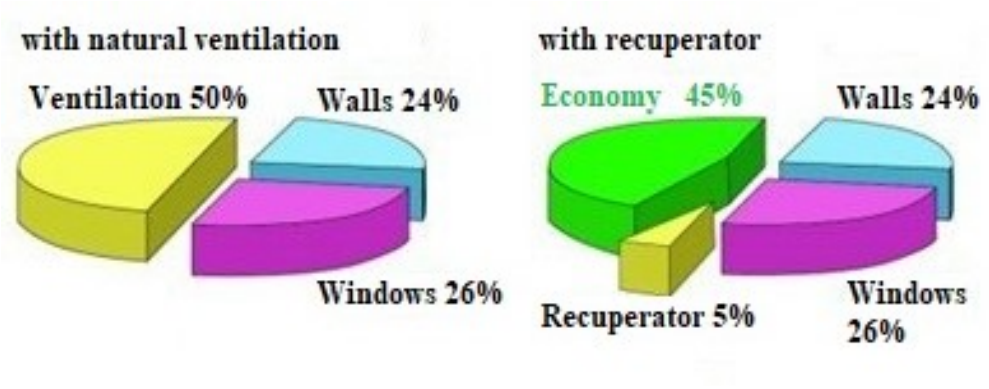


Fig. 2. **Efficiency of the recuperator**

Heat recovery in ventilation is a way of transferring heat energy from the flow of exhaust air to the flow of the tidal stream. Recuperation is used in the presence of a temperature difference between the removable and the inflow of air, to increase the temperature of fresh air. This process does not mean mixing air streams; the process of transferring heat occurs through any material.

In order to increase the efficiency of the lamellar recuperator of ventilation air, it is necessary to use its maximum possibilities for returning the heat of exhaust air at optimal operating modes [5].

Devices that carry out heat recovery heat recovery are called heat recuperators. Recuperator is a superficial type heat exchanger utilizing the heat of exhaust gases.

Rotary recuperator (Fig. 3) is structurally quite different from the plate. The main acting mechanism in it is a drum that rotates between the tidal and exhaust zones. Transmitting heat at the expense of rapid movement. This heat exchanger is heated by rotating in the zone of the exhaust duct, and then cooled in the area of the inflow channel. As a result, the heat from the exhaust air is transmitted to the tributary. Also, part of the moisture is returned as a result of condensation from the exhaust air and evaporation in the stream of tidal air from the street. It is more suitable for severe winter conditions, because due to constant rotation, the rotary recuperator does not have time to mist and it is not required to drain condensate [6].

Unlike lamellar, rotary recuperators show a high efficiency (70-85%), and also differ by a fairly high price. There are both for industrial and household applies.

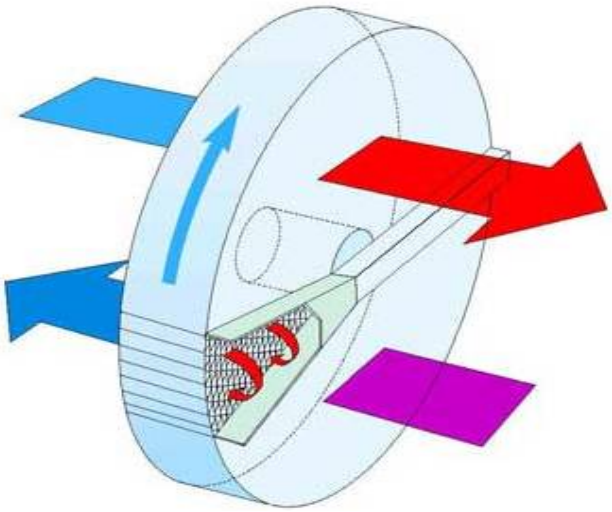

Fig. 3. **Rotary recuperator**

Let's consider the ventilation system, with a flow of 750 $m^3$/hour. Calculations will be made for the heating period in Kyiv, Ukraine. Agreed that the duration of the period with the average daily temperature of air from +8 °C to -6,9 °C is 223 days. Calculate the required average thermal power. In order to heat the air from the street to a comfortable temperature of 20 °C, it will take:

$$N = G\, G_p\, p\, (t_{in} - t_m) = 750 \cdot 3600 \cdot 1{,}005 \cdot 1{,}247 \cdot \cdot [20 - (-6.9)] = 7{,}023\ kWh, \quad (1.1.)$$

where G – air flow ($m^3$/hour);

$t_{in}$ – comfortable air temperature of the room;

$t_m$ – the minimum value of air temperature from the outside.

This amount of heat per unit time can be transmitted to the boost in several ways:

– heating of the inflow air by an electric heater;

– the heating of the fuel coolant is removed through the recuperator, with additional heating by an electric heater;

– heating the street air in a water heat exchanger, etc.

A. The inflow air is heated by an electric heater. Cost of electricity in Kyiv is S=1,68 UAH/(kWh). Ventilation works around the clock, during 223 days of the heating period, the amount of cash in this case will be:

$$C_1 = S \cdot 24 \cdot N \cdot n = 1.68 \cdot 24 \cdot 7.023 \cdot 223 = 63146\ UAH/(heating\ season), \quad (1.2.)$$

where S - price for electricity (kWh);

n - days of heating period.

B. Modern recuperators carry out the transfer of heat with high efficiency. Let the air be heated by the recuperator to 60% of the required heat. It follows that the electric heater consumes power:

$$N_{(el.heat)} = Q - Q_{(rec)} = 7{,}023 \cdot 0{,}6 = 2{,}81 kWh \quad (1.3.)$$

where Q - amount of electricity for heating the air from the street to the premises (kWh);

$Q_{(rec)}$ - heating the air by recuperator (%).

Provided that the ventilation will work throughout the heating period, we will receive an amount for electricity:

$$C_2 = S\ 24\ N_{(el.heat)}\ n = 1.68 \cdot 24 \cdot 2.81 \cdot 223 = \\ = 25265\ UAH/\ (heating\ season) \quad (1.4.)$$

*C.* For heating the building it is used the water in a heat exchanger. Estimated cost of heat from technical hot water for 1 Gcal in Kyiv:

$$S_{h.w} = 834\ UAH/Gcal, \\ kcal = 4{,}184\ kJ \quad (1.5.)$$

For heating we will need the following amount of heat:

$$Q_{h.w.} = \frac{24Nn3600}{S_{h.w.}106} \\ Q_{h.w.} = \frac{7{,}023 \cdot 223 \cdot 24 \cdot 3600}{4{,}184 \cdot 106} = 30{,}51\ Gcal \quad (1.6.)$$

When working with ventilation and heat exchanger during the heating period of the year, the amount of cash for the heat of technical water:

$$C_3 = S_{(h.w.)}\ Q = 834 \cdot 30.51 = \\ = 25445\ UAH/\ (heating\ season) \quad (1.7.)$$

The results of calculations of expenses for heating of the inflow air during the heating season of the year are given in Table 1.

*Table 1*

| Electrical heater | Electrical heater + Recuperator | Water heater |
|---|---|---|
| 63146 UAH/(heating season) | 25265 UAH/(heating season) | 25445 UAH/(heating season) |

The cross-accurate recuperative heat exchanger (Fig. 4), in which the air flows of the inflow and the exhausters are mixed, flow on numerous channels with common walls for different flows. For a plate type heat exchanger, the heat recovery according to various data can be from 40 to 70%, depending on the ratio of external costs and is removed, and the difference in temperature at the inputs to the heat exchanger. The air permeation at a given operating point of the fan is from 1 to 3%. A plate heat exchanger is manufactured, usually from aluminum plates, which create a system of channels. Exhaust air passes through each second channel of the heat exchanger and heats the plates, it forms. The tidal air passes through other channels and is heated when collided with heated exhaust air walls of the channels.

Fig.4. **Plain recuperator**

The modular design of heat exchangers allows you to combine the heat utilizer with any performance according to the specifications. Several heat exchangers can be installed in order to increase the heat utilization efficiency (one after another) [7]. The efficiency of the heat transfer process for heat exchangers is estimated by the relative temperature difference (temperature efficiency) for the exhaust and tidal air direction.

According to the results of the study, a functional diagram of the ventilation and air conditioning system (Fig. 5) was developed, in which there is an external temperature sensor, an inflatable air temperature sensor, a room temperature sensor, a plastic cross-type recuperator that provides a constant exchange of air and prevents excessive moisture, the appearance of mold, odors. Ventilation units ensure the purity and freshness of the air we breathe. Constant exchange of air significantly reduces the concentration of bacteria, dust and other harmful substances in the environment and increases the comfortable working conditions.

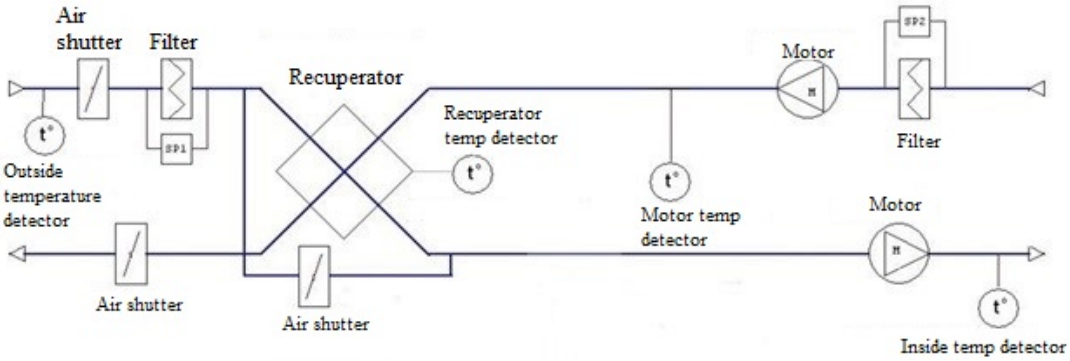


Fig. 5. **Functional scheme of the ventilation and air conditioning system**

In the general case, the following main components of the inflow and exhaust system are used:

• Two fans of different types that determine the cost of the installation.

• Heat exchanger recuperator - heats the tidal air through the transfer of heat from the removed.

• Electric heater - heats up the supply air to the required parameters, in the event of a lack of heat flow from the exhaust air.

• Air valves with electric drives - can be installed in front of the outlet ducts for additional airflow control and overlapping of the channel when the equipment is switched off.

• Bypass - due to which the air flow can be directed by the recuperator during the warm period of the year, thus not heating the tidal air, and submit it directly to the room.

• Recirculation chamber - ensures the mixing of air that is removed in the tributary, thereby ensuring air circulation recirculation

In addition to the main components of the inflow and exhaust system, it also includes a large number of small components, such as sensors, automation system for control and protection, etc.

**Conclusions.** At present, there are many factors that affect the comfortable stay of people in the premises. One of these factors is the temperature-humidity microclimate. Its maintenance requires high energy costs. Modern technology allows to reduce these costs by preserving, or even increasing efficiency. An analysis of the calculations of tidal units with different types of heaters showed that the most effective way to heat the cold tidal air, to feed it into the room, is the electric heater in conjunction with the recuperator. In addition, the amount of cash needed to heat the tidal air is significantly reduced, compared with the use of an electric or water heater.

The use of recuperators, together with other methods that increase energy efficiency, will save from 50 to 80% of the heat coming out of the room along with exhaust air. Efficiency of energy-saving technologies is sharply increased with the use of automatic climate control system in the room.

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***PAVLENKO VOLODYMYR***
*ORCID: https://orcid.org/0000-0003-2163-8508*
*ResearcherID: B-7133-2017*
*Kyiv National University of Technologies & Design*

***VOLIANYK OLEKSII***
*ORCID: https://orcid.org/0000-0002-7278-0910*
*ResearcherID:I-7967-2018*
*Kyiv National University of Technologies & Design*

# ДОСЛІДЖЕННЯ ЕФЕКТИВНОСТІ ВИКОРИСТАННЯ СИСТЕМ РЕКУПЕРАТОРІВ У ПОБУТОВИХ ПРИМІЩЕННЯХ

**ПАВЛЕНКО В. М., ВОЛЯНИК О. Ю.**
*Київський національний університет технологій та дизайну*

***Мета.*** *Дослідження систем вентиляції та кондиціонування житлових приміщень з метою забезпечення здорової атмосфери та підтримки комфортної температури в таких приміщеннях.*

***Методика.*** *Аналітичне дослідження вентиляційних систем, технологій рекуперації, які можна застосовувати в житлових приміщеннях.*

***Результат.*** *У даній роботі розглядаються мікрокліматичні особливості житлових приміщень та загального користування. Досліджено конструкції рекуператорів та систем кондиціонування повітря. Обґрунтовано можливість використання рекуператорних систем опалення та охолодження для дотримання санітарних норм, визначених для житлових приміщень.*

*Зазначається, що у разі використання систем вентиляції та кондиціонування у житлових приміщеннях важливо забезпечити інтенсивність введення та виведення повітря при різних температурах та природних умовах. Для забезпечення необхідних кліматичних умов, а саме: температурного режиму, дотримання необхідної вологості повітря та його швидкості в житлових приміщеннях пропонується використовувати пластинчастий рекуператор та відповідну систему управління. Були проведені розрахунки для порівняння кількості споживаної енергії та її вартості для реального споживача протягом опалювального періоду.*

***Наукова новизна.*** *Проведено аналіз розрахунків припливних агрегатів з нагрівачами різних типів і показав, що найбільш ефективним способом нагрівання холодного припливного повітря, подачі його в приміщення, є електричний обігрівач спільно з рекуператором.*

***Практична значимість.*** *Розроблено функціональну схему, систему вентиляції та кондиціонування із застосуванням пластинчатих рекуператорів, що є основою для створення експериментальних комплексів та лабораторних установок.*

***Ключові слова:*** *енергоефективність, енергозберігаючі технології, відведення тепла, системи життєзабезпечення, рекуперація.*

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# ИССЛЕДОВАНИЕ ЭФФЕКТИВНОСТИ ИСПОЛЬЗОВАНИЯ СИСТЕМ РЕКУПЕРАЦИИ В БЫТОВЫХ ПОМЕЩЕНИЯХ

**ПАВЛЕНКО В. Н., ВОЛЯНИК А. Ю.**
*Киевский национальный университет технологий и дизайна*

***Цель***. *Исследование систем вентиляции и кондиционирования жилых помещений с целью обеспечения здоровой атмосферы и поддержания комфортной температуры в таких помещениях.*

***Методика.*** *Аналитическое исследование вентиляционных систем, технологий рекуперации, которые можно применять в жилых помещениях.*

***Результат.*** *В данной работе рассматриваются микроклиматические особенности жилых помещений и общего пользования. Исследована конструкции рекуператоров, систем вентиляции и кондиционирования воздуха. Обоснована возможность использования рекуператорних систем отопления и охлаждения для соблюдения санитарных норм, которые определенны для жилых помещений.*

*Отмечается, что при использовании систем вентиляции и кондиционирования в жилых помещениях важно обеспечить интенсивность ввода и вывода воздуха при различных температурах и природных условиях. Для обеспечения требуемых климатических условий, а именно: температурного режима, соблюдения необходимой влажности воздуха и его скорости в жилых помещениях предлагается использовать пластинчатый рекуператор и соответствующую систему управления. Были проведены расчеты для сравнения количества потребляемой энергии и ее стоимости для реального потребителя в течение отопительного периода для г. Киев, Украина.*

***Научная новизна***. *Разработана функциональная схема, которая описывает систему вентиляции и кондиционирования с применением пластинчатых рекуператоров, что является основой для создания экспериментальных комплексов и лабораторных установок.*

***Практическая значимость***. *Полученные результаты исследований могут быть использованы для разработки конструкций центробежных машин аналогичного типа для различных отраслей промышленности или бытового назначения.*

***Ключевые слова****: энергоэффективность, энергосберегающие технологии, отвод тепла, системы жизнеобеспечения, рекуперация.*