Efficiency of the New Ventilation Device Application for Premises

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Abstract: The paper presents the main results of the effectiveness of the device to create high-quality indoor climate developed by scientific-educational center "Teploengeretika" of Vologda State Technical University. Brief information is given about the device, which can be applied in the standard window unit with minimum energy consumption providing the required ventilation of premises with preservation of up to 50% of the heat energy lost from the airing, as well as reduced consumption of electrical energy for ventilation. It describes the main problems of maintaining the microclimate in modern buildings and structures both in Russia and abroad. Device test in actual practice shows its efficiency, moreover, air, that entered the room, has been heated at a temperature above ambient temperature, which favorably acts on the person and does not create discomfort. Research has social and public importance, ensuring the health of people living and working in buildings with plastic windows and absence of ventilation as such.
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1. Introduction

The problem of microclimate quality assurance is part of the problems of home ecological safety may include such factors as the quality of indoor air, the presence of gaseous pollutants, biological contaminants factors (mold), the radiation in premises, radon concentration level in premises, etc.

Today, in many countries there are two interconnected problems to solve, i.e. the quality of microclimate and energy saving in accommodations. In fact both of these problems are the result of inefficient use of energy. Indeed, the indoor climate is characterized by the indoor air temperature, surface temperature of the inner building envelopes and the quality of indoor air. The third characteristic, that is indoor air quality, is determined by the air ventilation volume, which also has energy content. Thus, each of the characteristics of the indoor climate is part of the energy consumed by environmental control systems of buildings. For proper evaluation of the project essence and its main objectives, it is necessary to look at the problem of ventilation systems of buildings.

Widespread occurrence of airproof windows is a serious problem of the ventilation of accommodations and other small premises. Traditional ventilation system usually includes a system of exhaust fans located in the back rooms: kitchen, bathroom, toilet, and the fresh air inlet through cracks in the open windows and ventlights. Airproof constructions have practically eliminated inflow and made this scheme unworkable [1].

The search for new solutions continue in different directions. Most of them are an attempt to return to the proven scheme in a certain way. But this approach has significant disadvantage, main of that are the following.

In winter outside air temperature is below zero in most parts of Russia, and air supply into premise does not correspond to the notion of comfort. To heat the air, either calorifer embedded in the supply part of the heater, or additional power of heaters is required. In this case, a huge amount of heat is carried away from the premise with the air through the exhaust vents. Even with the modern reduced (but remaining a lot higher than European) standards of ventilation, appeared heat losses are more than all the others in two times. That is, the use of the traditional scheme of ventilation will not lead to reduction of energy consumption or increase of comfort [2].

Gaps in the regulatory framework do not favor the progress either. Thorough design of exhaust ventilation without deliberate decisions on the inflow does not seem consistent. However, the market demands in the sphere of ventilation of flats become more distinct. Evaluation shows that potentially this market does not yield to the market of household air conditioning systems. This facilitates the search for new solutions.

Modern ventilation and air conditioning systems should meet the requirements of energy saving, so the most important task is to ensure the specified values of the energy performance of the indoor climate with minimal energy consumption.

Thus, the task is to provide energy-efficient and competitive devices of ventilation systems that meet the technical requirements, safety requirements, and standards to ensure the quality of the indoor climate. In this case, it is possible not only to find innovative solutions for conditioning systems, but also make the problem more attractive for investors.

In world practice in the developed countries the construction of energy efficient buildings is a requirement applicable to each of the designed building. Moreover, in recent years the practice of assessment (certification) of building projects for energy efficiency, reduction of negative impact on the environment and improvement of quality of the human environment, such as a LEED certificate (Leadership in Energy and Environmental Design Building) became widespread [3]. As a rule, the building project, that received the "platinum", "gold" or "silver" LEED certificate, receive tax breaks and grants.

According to the results of study of the U.S. National Institute for Occupational Safety and Health, "one million of buildings in the United States has poor indoor air quality, as a result labor productivity reduces, and the value of these losses is up to $ 60 billion a year. More than half of the problems with indoor air quality is connected with the lack of professionalism in the design of ventilation and air conditioning systems "[4].

According to the data of the International Conference on Architecture and Environmental Quality, Tyanzhan, China, "every day about 5,000 people die from poor indoor air quality" [5].

According to the data of the Finnish community on indoor air quality control, the National Agency for New Technologies in Finland has published figures of influence of syndrome of "sick building" on people's health and financial loss [5].

Profound scientific study of the influence of microclimate in residential and business premises on the condition, labor productivity and health of people began in the first half of the last century with the development of large-scale housing and industrial construction and is conducted up to now. Summarizing briefly everything set forth in the works of Russian and foreign authors [1-6], there is great attention to the problem of creating high-quality indoor climate. It may be noted that there is a great choice of fans, room terminals, air distribution and control equipment, small air handling units, silencers, etc. at the domestic market of ventilation equipment (see [7, 8]).

As a rule, they all perform their basic functions, but have differences in some of the technical and quality characteristics depending on the manufacturer.

The simplest device is valve mounted in the wall, window frame or transom, which protects from the rush of wind and supplies air to the premises by the vacuum created by the exhaust devices. However, the volume of air through these valves is out of control, and the quality does not meet sanitary standards, created effect of the dew point promotes the condensation of moisture on the surface of windows. Moreover, as practice shows, such valves are often out of order, so most consumers dismantle them or block the air duct of the valve mechanically [9].

The analysis of the technologies shows the following devices that can partially solve the problem of ventilation of small premises: air conditioners Lossnay VL Mitsubishi Electric (Japan), M-WRG Meltem GmBH (Germany), DL 60 WR Glen Dimplex GmBH (Germany), EcoVent KWL EC Helios Ventilatoren GmBH (Germany). However, the market does not offer solutions that are suitable for the Russian climate. Available equipment is either bulky and cannot be placed in a flat or does not work at temperature below -10 ° C. Also all devices have a high price for an average man and low energy saving efficiency.

Patent Research has shown that today a device for ventilation of premises [9] consisting of a fresh air intake duct placed in the wall, electric heater elements with thermal protection, internal heat-insulated housing, filter installed in it, fan and valve, changing the ratio of supply air and indoor recirculating air. The disadvantage of the device is the additional energy consumption for electric heater work as well as the cost for device installation in the supporting wall, that makes the unit barely acceptable for an average consumer according to its capital and operating costs.

In addition, Russian scientists developed the ventilation system unit [10] consisting of two ventilation devices located in different premises and working out of phase, and there are fixed regenerator and reversible fan in the housing of each device. Devices pump fresh air into premise in turn alternately, and then remove indoor air from premise, exchanging heat between the flows through the regenerator. Each unit is additionally equipped with an air valve with electric drive, fan speed and temperature sensors and a separate control unit, allowing to set and maintain the speed for forward and reverse rotation of the fan for each device separately, to control the supply air temperature and, adjusting the valve and fan, to compensate the impact on the wind loading unit work and other negative factors.

However, when using this device there is the effect of noise at the maximum fan performance

because of the large cross section in the air. Moreover, it is required to make reach-through working hole in the main wall, which is associated with great consumption of time, material resources and is unacceptable to the already-built premises, where the interior finish is made. These operations are only possible using a diamond heads. In addition, the installation of such a device is required project documentation, agreed in different instances.

The analogue of the proposed solutions can be considered a device for ventilation [11], developed by researchers of the Vologda State Technical University, which is built into the window frame and contains insulating body, which has a heat exchanger with cold and warm developed parties respectively. The butt ends of the heat exchanger are connected to the insert tube holes with removable adjustable valve. Insert tubes have branch pipes for air inlet and outlet in the process of premise ventilation. The removable adjustable valves have sound-proof filter inserts respectively. Removable adjustable valves can be equipped with fans for forced ventilation.

The disadvantage of this invention is complexity of the air flow organization because of high local resistance of heat conductive plates or tubes, the possibility of condensation, icing and, as a consequence, blocking of the air duct, as well as the inability to control the process air preheating.

Therefore the engineering task of this utility model is to simplify the device design and manufacture technology.

2. HYPOTHESES

Premise climate control in general, and air ventilation in particular, can be made in various ways. The review has shown that the most effective are the devices that provide fresh air into the room and exhaust air to the outside, thus heating the cold heat carrier through the wall of the device, as well as through regenerative nozzle.

Preliminary research has shown high efficiency of regenerative nozzles [7, 8]. The paper sets targets for the development of such a device, as well as its test in a real premise with the definition of its work efficiency.

Theoretically, the operation of the device can be represented as a harmonic between the regenerative nozzle temperatures in the premise for a certain period of time. In this case, the cycle of work will depend largely on the time of air flow change nozzle design and heat carrier temperature.

3. RESEARCH METHODOLOGY

The essence of this device is that in the ventilation device containing a body in the glazing window, in which the axial fan, the regenerating header and the electronic operation control unit of the fan are mounted. The fan is installed in the body with the possibility of the air movement overlapping with blades, and the control unit provides the alternate work of fan in the forward or reverse rotation by set time period. Moreover, the filter and the distribution grid are mounted in the channel case. The device body is installed in the glazed window and fixed with sealers. At least two fans with the variable possibility of rotation can be placed in the body.

Due to the periodic work of reversing fan, at first the heating of regenerating header 3 with the warm outlet air is occurred, and after its cooling occurs with the simultaneous heating of the cold air fed to the premises, what ensures the creation of the warm supply air flow without any additional power consumptions. Fig. 1 shows a schematic diagram of the described device.

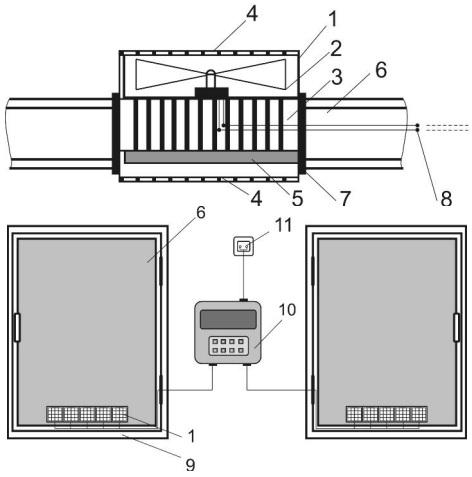

Fig. 1 – Structure diagram

The device consists of a body 1, a reversing fan 2, a regenerating head 3, and intake grilles 4. Inside the body is placed an air filter 5, which provides an air filtration against dust and noxious gases. At least one device is mounted in the double-glazed window layer 6 sealed by sealers 7 which in its turn, are the absorbers and the elements for connecting several such devices. The power supply terminals 8 of this device are fixed in the frame of glazed window 9. Control of the device operation is performed with an electronic control unit 10 connected to the power mains 11. The device operation consists in the following.

An air blown by the fan 2 from the premises flows into the body 1 through the air inlet grille 4and passing sequentially through the regenerating header 3 by heating it to a specific temperature, an air filter 5 by cleaning it due to the impact with the air flow to

the soiled surface, and a second air inlet grille 4, and after that it is emitted to the environment. After the time set by the user in the control box the fan stops and starts to rotate in the opposite direction. Sucked air from the atmosphere enters into the body 1 by passing successively through the air inlet grille 4, an air filter 5, wherein it's dedusted and purified from harmful gases, and through the regenerating header 3 in which it is heated to a certain temperature, and through the second air inlet grille 4 is distributed in the premises.

The sealers 7 made from an elastic material allow to fix at least one device in a specially designed glazed window aperture, to ensure a reliable connection of the housing 1 two or more devices, exclude air from entering the glazed window opening. Thus, due to sealers 7 the relative movements in the opening of the device's body 1 are completely excluded, as well as the shock and vibration loads that are transmitted from the body 1 to the glazed windows are reduced.

As a result of the air flow opposing motion from the premises, the air filter layer will be cleared of settled dust from the outside air. This allows you practically to remove the dust load to the filter 5, and thereby to eliminate the necessity of its frequent cleaning. In its turn, the organization of the cold and warm air alternating passage through the regenerating header 3 and the outside air heating to a certain temperature before its inlet to the premises allows you to keep the thermal power indoors up to 50%, which is lost into the environment during the usual ventilation through the specially arranged devices (air gates, air valves, etc.).

Work on the settlement and the experimental determination of the device effectiveness for improving the indoor micro-climate and energy saving in the conditions of existing heating system was conducted in the office premises.

Monitoring of changes in the temperature data of climate cells was carried out using a system Celsius (produced by the FSBEI HPO "VoGTU", Vologda). The instrumental monitoring organization scheme is presented in Figure 2. The information retrieval on the outdoor temperature, the air before and after the devices, the radiator and also the indoor temperature is carried out using the temperature sensors. The temperature data are transmitted to the PC using a special board, where a database of temperatures over time is formed.

The experiment was conducted within 5 days for 9 hours: from 03/11/2010 to 08/11/2010, at the following characteristics shown in the Table 4.5.

Table - Climate cells characteristics

Index	Value
Heating area, m^2	13,6
Ceiling height, m	2,7
Type of glazing	Double
Type of heating devices	MS-140
Number of sections, pcs.	8

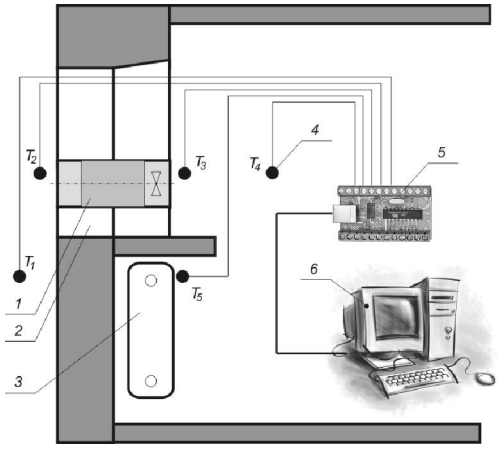

Fig.2 –Scheme of the temperature changes monitoring:

1 – device, 2 – window opening, 3 – heating device, 4 – temperature sensor, 5 – electronics board, 6 – PC, T_1 – outdoor temperature, T_2 – air temperature outside the device, T_3 – air temperature inside the devices, T_4 – inside air temperature, T_5 – surface temperature of heating device

4. RESULTS

According to the temperature data given in the Fig. 3, we could receive the following conclusions:

1. For the time period between 00:00 in November, 6 and 9:00 in November, 8 in year 2012 the outdoor temperature oscillations were - 1. +4 °C, except for the sharp temperature change (a fragment highlighted with a red frame), where it is noted an increase from 0 to +7°C. Since the sharp temperature change was not expected, this change of temperature can be defined as the domestic heat liberation (up to 5 hours) from the outdoor air. The temperature of heating devices was periodically varied in the range of 44. 47°C. The internal air temperature in the room was in the range of 26. 27°C, except the moment of the outdoor overheating as described above. The oscillations of air temperature on the device outside with two amplitudes are measured: a constant fluctuation component that determines the temperature drop

of 4. 6°C, and the periodic fluctuation component of 5. 13°C with a repetition period T = 90 ± 3 min. Air temperature fluctuations on the inside of the devices are committed in a range of 23. 27°C.

2. For the time period between 00:00 in November, 6 and 9:00 in November, 8 in year 2012 the clear changes in the natural conditions of outdoor air did not take place; the sharp heat input noted from the outdoor air side and is characterized as a short-term domestic; the temperature fluctuations in the heating system are estimated as periods of temperature regulation in the heat unit of the building. Such data characterize the operation period of the device by the simple operating conditions with minor deviations. The operation mode switching periods of the device to warm up the outer side, according to the programmed algorithm, is explicitly tracked.
3. It is noted that the indoor air temperature has slightly reacted to the sharp heat input from the street, due to the thermal energy accumulation with the device, which is reflected in the charts shown in blue, green and wine-red. We can see here the clear change of the outdoor air temperature and the same clear change at the device input. In this case, the inlet air temperature charts are smoothed, and the indoor air temperature changes are almost negligible.
4. The persistent correlation of the outdoor air temperature with the air temperature from two sides of the device is checked, while the correlation with the smoothing effect. We can say that the device in question is a so-called the thermal buffer, which smoothes the heat input fluctuations.

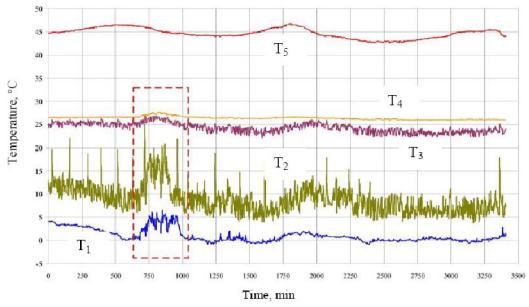

Fig.3 – Diagram of the air temperature changes dependence

5. CONCLUSION AND RECOMMENDATION

The calculation of heat flows based on experimental data has shown the following relationship: 51% of heat loss with the air removed from the premises, 49% of thermal energy, perceived by the regenerating header and transferred to the air directed to the premises. This way, it is experimentally determined that the proposed ventilation device for premises saves up to 50% of leaving heat energy, what in its turn, proportionately reduces the energy consumption for heating premises by the heating devices.

The device is compact and discreetly in the interior, does not occupy place either indoors and on the building facade, has a wide range of application: apartments, rooms, offices and medical facilities, hospital wards, small stand-alone buildings of shopping destination, transportable housing of builders, oil- and gas producers (beams), etc. The device has the high consumer flexibility: it can be used in the new construction and renovation, to equip one room, one apartment or block of flats. Thus, the main purpose of the device is the energy efficiency in the HUS in that region, where the energy conservation measures are traditionally difficult, and the energy losses are enormous.

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