Regulation systems for the air and heat and humidity modes in the interior design of Orthodox churches

T B Gadaborsheva†*, A A Chernushchenko†, S N Torgashina†, K O Chicherov‡, Ju V Startseva†

†Volgograd State Technical University, 28, Lenin Ave., Volgograd, 400005, Russia
‡Penza State University of Architecture and Construction, 28, German Titov Str., Penza, 440028, Russia

E-mail: adaudzurab@gmail.com

Abstract. This article discusses the method for removing the harmful substances and excess heat from the stationary candle holders in niches. The method is designed to remove the excess heat and dust during the candles’ burning and stationary candlesticks near the icons and paintings in the niches of monasteries and temples. It is carried out by removing the heated contaminated air through the slotted gratings, which enters the ventilation ducts, from where it is thrown out through the valve outside.

Introduction
In Russia over more than a thousand-year history of Christianity, a variety of architectural styles and forms of Orthodox churches were created and embodied. They represent the invaluable cultural heritage of Russia, emphasizing its rich past, the identity of the people and the time that gave rise to them [1].

The problem of preserving this heritage is becoming more and more urgent every year, both in terms of preserving the temples’ appearance and maintaining the required microclimate parameters that require solving the issues related to the temples’ heating and ventilation. In the old days, comfort in the places of worship was not given much importance to. Moreover, there were people who considered freezing in the church to be an additional form of humility and repentance [2].

The architectural features of the temple buildings include a high internal space and a small, relative to the height, free space area. The volume of the working area, where it is required to maintain the specified microclimate parameters, is a small part of the total volume. There are many art paintings of designs, frescoes, icons, objects of religious rites, structural design of the altar, having architectural and artistic value in the temple.

When choosing a ventilation system in a church, it is necessary to take into account many nuances, of which the last but not the least role is played by the need to preserve the current church structure and the artistic values’ storage conditions. In fact, the design of heating systems for churches and cathedrals involves the adoption of many compromises.

The ventilation or air conditioning systems’ arrangement is determined by the requirements for the meteorological conditions necessary for the functioning of this building. The latter are appointed depending on the purpose and creation of the necessary parameters for the building preservation itself and the church or museum values.
When designing heating, ventilation and air conditioning systems for temples, the extraordinary structure of their internal space should be taken into account: the volume of the room, elongated upwards, often divided into separate compartments by pillars and arches, as well as the reduction in the thickness of the chapter drum walls, in which the temperature is distributed unevenly along the height of the temple. The account of air flows in the complexly divided room of the temple is carried out when choosing the locations of heating devices and ventilation openings.

Improving the microclimate in the rooms with a large number of people, in which the harmful substances are allocated, remains an urgent issue today. In our article we will consider the internal structure of Orthodox churches. The release of harmful substances and excess heat increases several tens of times during daily and festive services, negatively affects the well-being of the clergymen staff at the church and parishioners.

Natural ventilation in Orthodox churches has several advantages over the mechanical ones, such as: the low cost of installations, the cost of their installation and maintenance, as well as the natural ventilation system do not consume electricity. However, the natural ventilation system is not effective enough at the moments of maximum temple’s occupation, therefore, choosing a ventilation scheme and a constructive choice of ventilation systems for such a complex multi-level and multifunctional object as a temple, it is more advisable to use the combined ventilation systems.

Below we have proposed an invention that will improve the efficiency of the existing installations for the pollution removal.

The invention relates to the ventilation industry, and in particular to a method for removing the excess heat, carbon monoxide (IV), soot, dust, etc. when burning candles / stationary candlesticks next to icons / paintings in niches of monasteries and / or temples.

There is a method of removing the excess heat from a room (RF patent No. 2375643, IPC F24F 7/10, published December 10, 2009), in which the supply air from the outside through the supply air duct enters into a niche where the incoming supply air is mixed with the excess heated air in the created niche, and then, due to the temperature difference, the supply air goes down through the holes in the suspended ceiling, and the warm air goes up and is removed through the exhaust duct using an exhaust fan and an exhaust check valve [3].

The disadvantage of this method is the high capital costs during construction, high energy costs during operation, insufficient localization of the released harmful substances, the inability to control the contaminated air flows’ movement in the room used, as well as insufficient temperature microclimate in the room used due to its technological features.

The closest in technical essence to the claimed method is a method of the local exhaust ventilation and a device for its implementation (RF patent No. 2428635, IPC F24F 7/06 B08B 15/02, published September 10, 2011), the method is revealed in creating a peripheral jet of fresh air, which is formed in the form of a swirling ring jet extending up to the contaminated stream’s area and is partially involved in the suction stream, in turn, which is untwisted, as a result of which the pollution intake occurs.

The disadvantage of this method, adopted as a prototype, is the low efficiency of the hazards’ intake due to the uncontrolled volume of the intake air, intake and removal of clean supply air, high energy and technological costs [6].

The essence of this method lies in the fact that the heated air from the candlesticks or candles enters the vertical ventilation slotted gratings due to the convection process, i.e., due to the temperature difference between the heated and the surrounding room air. The heated air enters the ventilation slots, where due to the ventilation channels’ cross-sectional area narrowing, there is an increase in the flow rate, which creates the effect of the heated gases “suction” through the slotted gratings. Further, the excessively warm polluted air rises up the vertical exhaust ventilation duct and is removed into the environment with the help of the exhaust check valve [7].

To implement the proposed method, increase its efficiency and expand the functionality, a ventilation design was proposed. The essence of the design is that an exhaust device containing two vertical ducts with a cross-section of 300x200 mm, connected at the bottom with conical ducts of the
same cross section, in which the slotted gratings are arranged with a width of 200 mm and a height of 1500 mm, located at an angle to the horizon of 80-85°. At the same time, both vertical air ducts at the top are connected by the stationary semicircular air ducts R = 90°, from which they exit into a vertical air duct with a cross section of 700x200 mm, which is in turn connected integrally with a horizontal duct with a cross section of 700x400 mm, to which a vertically located external valve is attached, 700 mm wide and 400 mm high.

Results
The proposed ventilation design for the proposed method’s implementation is illustrated by the drawings, where:
- Figure 1 - shows the main view of the device;
- Figure 2 - shows the right view;
- Figure 3 shows a perspective view of the device.

![Figure 1. The main view of the device](image)
The method of removing the excess heat from the room is carried out by the above-mentioned construction as follows: the heated polluted air to \( \approx 76^\circ \text{C} \), at a speed of 0.5 m / s it enters the suction slotted gratings 1, the section 200x1500, located on the cone-shaped ducts 2, 300x200 in size, where the flow velocity increases to 1.4 m / s due to the narrowing of the area, creating the effect of the heated gases’ “suction” through the slotted gratings 1. Then the excessively warm polluted air enters the vertical ventilation ducts 3, section 300x200, and rises up along the vertical exhaust ventilation duct 4, 700x200 in size, and using the exhaust check valve 6, is installed on the point horizontal vent shaft 5 with the cross section 700x400 and is removed into the environment.

**Figure 2.** The right view of the device

**Figure 3.** Axonometric image of the device
Thus, the proposed method for removing the excess heat, carbon monoxide (IV), soot and dust when burning the candles near the icons / paintings in the niches of monasteries and / or temples has the following advantages:

- no supply air required;
- no need for additional complicated ventilation devices;
- minimized operating costs for hazard removal;
- improvement of microclimate parameters in the used room.

The method is characterized by the fact that the heated polluted air enters the slotted gratings due to the difference in the ambient air and the heated air temperature without creating a peripheral stream of the supply air, and then, due to an increase in the air velocity, it enters the vertical channel, from where it is discharged through the valve outside, there is no partial fresh air intake and no clean fresh air emission; no operational costs are required [4-5].

Also, the device has a simpler and more stable design in operation without the use of an electric fan, swirl, and the plate with coaxial holes and can be performed directly at the construction site.

The main difference between the device implementing the proposed method is the simplicity of design without the complex ventilation devices’ use [8-10].

EFFECT: increased efficiency of the method and improved air exchange conditions in the room.

Summary
The topic of the microclimate parameters and air exchange schemes’ study is relevant in our time.

The temple buildings’ architectural features include a high internal space and a small, relative to the height, free space area. The volume of the working area, where it is required to maintain the specified microclimate parameters, is a small part of the total volume. There are many artistic paintings of designs, frescoes, icons, objects of religious rites, the design of the altar, having architectural and artistic value in the temples.

The distinctive functional features of Orthodox churches are: multifunctionality, uneven attendance by the parishioners, a large number of people praying while standing; a large number of candles during service.

The regulatory documents’ analysis in the field of restoration and construction of Orthodox churches showed that when choosing the air exchange schemes, not all possible parameters of the air environment and features of temple structures are considered [11]. Since the microclimate in newly designed and reconstructed religious buildings is constantly being brought to the new higher levels, the following regulated air parameters were considered:

- Air quality,
- Heat and humidity air parameters,
- Ray exposure to the unclosed body parts,
- The concentration of the harmful substance and the time of its exposure to humans,
- The level of bioavailability perceived by the human sense,
- Ionization level,
- Sound pressure level frequency,
- The level of illumination in the workplace and the level of natural ultraviolet radiation,
- The expected level of human heat perception,
- Specific heat from a person, characterizing the intensity of labor.

After analyzing the various options for designing the ventilation systems according to the priority indicators, using the multi-criteria assessment method, it was concluded that, choosing a ventilation scheme and a constructive choice of ventilation systems for such a complex multi-level and multifunctional object as a temple, it is more advisable to use the combined ventilation systems.

In the process of working on this topic, to maintain the adopted microclimate conditions, the method for removing the harmful substances from the stationary candlesticks and the devices for its implementation has been developed and applied without violating the architectural unity.
References

[1] Bearzi V 2004 Temple building heating and ventilation systems RCI 1.
[2] Bogoslovsky V N, Sizov B T 1988 Principles of choosing the parameters of the temperature and humidity regime of ancient buildings ensuring their safety Scientific research in the field of protection of monuments, Warsaw 297–301.
[3] Kotenko A A 2005 Features of designing heating systems for churches on the example of the Transfiguration Cathedral in Odessa AVOK 1.
[4] Kronfeld Ya G 2000 The principles of the design of heating, ventilation, air conditioning, heat and cold supply in buildings of religious architecture AVOK 1.
[5] Chichirov K O, Melnikova V S, Sagiddinova A N, Samsonov A A 2017 The use of ventilation systems in religious buildings Education and science in the modern world. Innovation 3 275-281.
[6] Shmatova E N, Markin V K 2012 Features of creating a microclimate in the religious buildings of the old building AISI 2 (3).
[7] SP 31-103-99 1999 Buildings, structures and complexes of Orthodox churches. - Enter. 1999-12-27, M.: Archhram, 38.
[8] Kochev A G 2004 The microclimate of Orthodox churches: monograph (NNSACU, N. Novgorod).
[9] Sokolov M M 2013 The influence of external aerodynamics on the microclimate of Orthodox churches (dis. Cand. tech. sciences. N. Novgorod).
[10] SP 50.13330.2012 Code of practice. Thermal protection of buildings, Updated edition instead of SNiP 23-02-2013, M.: NIISF RAASN, 2013.
[11] Barkalov B V, Pavlov N N [and others] 1992 Internal sanitary facilities: at 3 h. Part 3. Prince 2. Ventilation and air conditioning, under the general. ed. N.N. Pavlova, Yu.I. Schiller, 4th ed., Revised. and add (Stroyizdat, Moscow).