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The methods of climatization of Orthodox churches

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Abstract. The convective flow, the article developed methods for ensuring the deviation of the vertical polluted air flow from the inner surface of the walls and decoration of the worship hall towards the interior of the room for regulation.

1 Introduction

This article conducts research aimed at the implementation of the Decree of the President of the Russian Federation No. 745 of 12.30.2021 in order to popularize folk art, preserve cultural traditions, historical and cultural monuments. The authors found that in the worship hall of Orthodox places of worship, the need to regulate the direction of movement of the vertical near-wall convective flow formed by the heated surface of the stove is caused by the fact that dust, soot, smoke, soot, moisture, etc., are carried upward, sticking to the inner surfaces walls, icons, paintings, gilding, frescoes and other decorative elements, contaminating them with the indicated products of burning candles, causing a destructive effect.

The method for controlling the direction of movement of the convective flow consists in installing a device above the heater in the form of a horizontal guide of the convective flow. The experimental stand has been developed to determine the values of the parameters of temperature and air velocity and the magnitude of the deviation of the convective flow. Experimental studies of air parameters have shown the effectiveness of the methods and the possibility of deflecting the contaminated convective flow from the wall towards the hall. These deviations prevent the adhesion of polluted air to the inner surface of the walls and the decoration of the prayer hall. This allows you to preserve the appearance of the walls and interiors, as well as the historical and cultural heritage.

2 Methods

In the worship hall of Orthodox places of worship, the need to regulate the direction of movement of the vertical near-wall convective flow formed by the heated surface of the

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heating device is caused by the fact that dust, soot, smoke, soot, moisture are captured when air flows from the environment to the convective flow. , which are carried upward in a stream, adhering to the inner surfaces of walls, icons, paintings, gilding, frescoes and other elements of decoration, contaminating them with the indicated products of candle combustion.

To regulate the convective flow, the article developed methods for ensuring the deviation of the vertical polluted air flow from the inner surface of the wall and decoration of the worship hall towards the interior of the room. This flow moves upward together with the ventilation air to the places of the exhaust devices, less contacting with the surfaces of the halls.

Proof of this is the study of air currents in the volume of the worship hall. It has been established that air movement occurs in the form of supply ventilation jets and convective flows from heated and cooled surfaces.

The heated surfaces in the hall of worship are: open flame from burning candles and oil in lamps, heating devices, body surfaces of parishioners, warm floors, heated surfaces from direct sunlight. The cooled surfaces are the inner surfaces of the outer walls, on which the surface temperature is lower than the indoor air temperature.

Let us consider in more detail for the task at hand the change in temperature and air velocity in the convective flow from the heated surface of the heater and on the inner surface of the outer wall above the heater.

In order to develop a method for regulating the direction of movement of a convective flow, let us characterize in more detail the air flows from a heated and cooled surface, which differ significantly from each other. The air from the heated surface of the heating device tends upward, from the cooled surface - downward. This phenomenon has a mutual deceleration of the heated and cooled flows and the effect on the change in temperature and air velocity at the border of the flows.

The method for regulating the direction of movement of the convective flow consists in installing a horizontal guide of the convective flow above the heater. It has been proved that the effectiveness of the method of influencing the deviation of the vertical ascending convective flow is influenced by: heat power and volume of the convective flow, air velocity and temperature in the flow, shape and size of the structure of the horizontal flow guide. To determine the value of the temperature and air velocity, as well as the direction of movement of the convective flow from the heated surface of the heating device, an experimental setup has been developed (Fig. 1).

The experimental stand measured the temperature t, ^{o}C and air velocity v, m/s in the cross-section of the near-wall convective flow from the heated surface of the heater using various options for the installation of the heater without a guide, with a horizontal guide, with a guide with a profile inside along an arc.

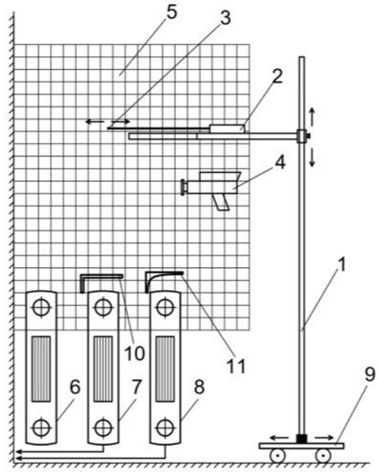

Fig. 1. The experimental stand for measuring the temperature and velocity in the cross-section of air in the near-wall convective flow from the heating device: 1 - focal point; 2 - hot-wire anemometer; 3 - hot-wire anemometer sensor; 4 - thermal imager; 5 - coordinate grid; 6,7,8 - heating device; 9 - trolley of the coordinator; 10 - unit for installing a heater with a horizontal guide; 11 - unit for installing a heater with a horizontal guide with a profile inside along an arc.

Measurements of temperature t, velocity v, m/s and flow rate l, m^3/h of air in the cross section of the flow were carried out in accordance with GOST RF 12.3.018079. A TKA-PKM hot-wire anemometer (60) and a Testo-882-4 thermal imager were used as measuring device for t and v in the convective flow. Thermal imaging control was carried out in accordance with the requirements of GOST RF 26629-85. Experimental studies were carried out in the worship hall of the Church of the Holy Primate Apostles Peter and Paul in Penza, in places freely installed along the outer walls of aluminum and cast-iron radiators. In the study of the convective flow, t and v of air were measured horizontally in the cross section every 10 cm, starting from the wall surface vertically upwards. The estimation of the error in measuring t and v of the convective flow was carried out using the methods of processing the measurement results. When measuring v, the errors were 13.4%, and when measuring t in a convective flow - 12.8% with a reliable probability interval of 0.95, which is considered an acceptable error for these studies. Experimental measurements of t and v were carried out with various design shapes and sizes of a horizontal guide and without a convective flow guide.

3 Results

Measurements of t and v were carried out at values a = 150, 200 and 250 mm, and b = 50, 100, 150 mm. The results of experimental studies of t and v are presented in the graphs with the optimal installation dimensions of the flow guides at a = 250mm and b = 100mm. A preliminary analysis of the movement of the air flow from the heated surface of the heater has been carried out. A contaminated heated convective flow with a temperature of up to 20 °C is directed vertically upward along the heat-absorbing surface of the wall, then, with distance from the wall, the air temperature rises and reaches 24.3 °C above the heating device.

The structure of the near-wall convective flow is complex, its thickness continuously increases due to the leakage of polluted air from the environment from the side of the room. As a result, in the cross-section, the air temperature in the flow decreases to 19.4 °C and reaches the air temperature in the room. At the same time, the temperature on the inner surface of the wall is 18.3 °C, which is higher than the dew point temperature. As a result of the combined action of air speed and temperature, the movement of a polluted convective flow is intensified, which slides along the inner surface of the walls on which the decoration of the hall of worship is located, contaminating them with soot, soot, smoke, moisture and other harmful substances. To eliminate the negative impact on the decoration of the worship hall, this article provides for measures in which the polluted ascending convective flow is deflected and directed from the wall surface towards the interior of the room to the places where air is removed from the worship hall. The results of experimental studies of the air temperature in the cross-section of the near-wall upward convective flow with a horizontal guide above the heating device are shown in Fig. 2.

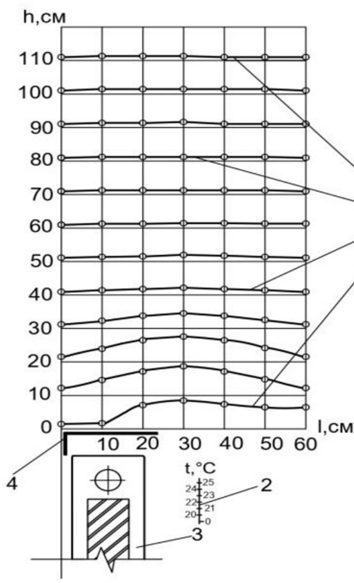

Fig. 2. Profile of air temperature change in the cross-section of the near-wall upward convective flow from the heated surface of the heater with a horizontal guide of the convective flow: h — height of the near-wall upward convective flow, cm; l - distance from the wall towards the room. cm; 1 - profile of temperature changes; 2 - temperature scale; 3 - heating device (radiator); 4 - convective flow guide.

It was found that the horizontal guide changes (deviates) the direction of the convective flow from the inner surface of the wall towards the premises of the worship hall more than 30 cm. This distance is sufficient so that the polluted air in the convective flow does not adhere to the surface of the wall and elements of the decoration in the worship hall. As a result, the maximally heated convective flow up to 24.3 °C picks up the leaking polluted air and carries it up to the places where ventilation and air conditioning systems are removed, at the level of 120 cm the temperature evens out and corresponds to the temperature of the internal air in the worship hall. This process of deflection of the convective flow is confirmed by the velocity profile, shown in Fig. 3.

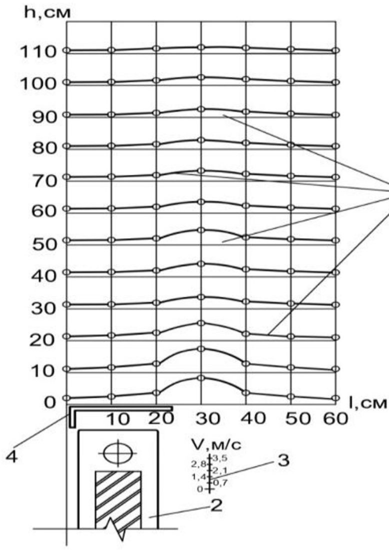

Fig. 3. Profile of air velocity change in the cross-section of the near-wall ascending convective flow from the heated surface of the heater with a horizontal guide of the convective flow: h — height of the near-wall ascending convective flow, cm; l - distance from the wall towards the room. cm; 1 - profile of speed change, m/s; 2 - heater (radiator); 3 - speed scale, m/s; 4 - convective flow guide.

4 Discussion

From the analysis of the profiles of the convective flow velocities, it follows that the cooled polluted air from the worship hall flows to the heater, heats up, forming a convective flow, which rises to the top of the heater and then rests on a horizontal guide, turns 90 degrees towards the room, forming an ascending stream with an initial speed of up to 3 m/s, deviating from the wall up to 30 cm.

As the upward movement and the development of the flow volume due to the leaking of internal air, the speed, starting from a height of 120 cm, decreases to 0.2-0.4 m/s. thus, the use of a horizontal guide ensures a sufficient deviation of the contaminated flow up to 30 cm from the inner surface of the wall and surfaces of the decoration. At the same time, the temperature on the inner surface of the wall remains above the dew point temperature and is 17.8 °C.

As a result, the convective flow polluted with smoke, soot, sweat, dust, moisture does not reach the surface and does not pollute them, this allows preserving the historical and cultural heritage in the hall of worship in the form of gilding, murals, paintings, icons, frescoes, icon painting and architectural elements.

5 Summary

The theoretical and experimental studies presented in this article allow us to draw the following conclusions. When the heated convective flow deviates from the wall up to 40 cm, the temperature on its inner surface is above the dew point, as in the analysis of the velocity profile. The maximum heated air in the range from 30 to 40 cm reaches 24, 9 oC. In the vicinity of the cooled wall, the air temperature is 19.1 °C, and on the surface of the flow periphery from the room side, due to leakage to the flow, it corresponds to an air temperature in the room of 19.9 °C. Further, the heated convective flow, together with the polluted air, rises, while the temperature decreases from 24.9 °C to the air temperature in the room at a height of 120 cm and above.

As a result of the analysis of the air velocity and temperature profile in the cross-section of the convective flow, it can be concluded that this method of using the horizontal guide in Fig. 2 and Fig. 3 ensures a stable deviation of the contaminated flow from the inner surface of the walls and decoration of the hall located above the heating device. preserving the historical and cultural heritage and reducing restoration costs.

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