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Installing Local Recirculation Air Diffusers during Building Deep Renovation Reduces Energy Consumption of Ventilation Systems

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Abstract

Capital repairs of public buildings and, in particular, insulating external wall increase the proportion of heat consumption by the ventilation system in the total building energy consumption. Surplus internal heat can be observed in rooms with high heat generation values (over 30 W/m^2) even during the heating season. Using surplus internal heat to heat the outdoor air during the heating season can help reduce the heat consumption of the ventilation system.

The probability of excess internal heat occurrence in public buildings during the heating season has been analyzed. To this end, changes in specific thermal losses in buildings of various volumes occurring over the heating season in various Russian regions with different climate conditions have been compared with specific internal heat generation values typical of public buildings. Specific heat losses have been identified on the basis of rated values of the building's specific heat insulation value. The application area of ventilation systems with local recirculation air diffusers is outlined based on the outcomes of the analysis; it is concluded that these systems have a huge energy saving potential, both in case of reconstruction or deep renovation of an existing building, and when new public buildings are designed.

On analysing the characteristics of ventilation systems with local recirculation air diffusers, it has been established that these have an advantage over traditional through-flow ventilation systems, or central recirculation systems.

A local recirculation air diffuser delivering outdoor air inside the building at a low temperature (from +6 °C) has been designed. The supply air is heated to the comfort temperature as it enters the working area by mixing the outdoor air with the internal air, thus assimilating internal surplus heat.

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A design solution for the recirculation air diffuser is proposed. Computer simulation of air flows generated by the recirculation air diffuser has confirmed that comfort parameters of the supply air jet can be reached at the inlet to the work area when outdoor air is supplied at temperatures starting from +6 °C.

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Keywords: ventilation, local recirculation, diffuser, LRD, energy efficiency, analyse, surplus internal heat, reconstaruction, deep renovation.

1. Introduction

Maintaining a high quality of air in the room, and reducing energy consumption are the two tasks that engineers have to solve in choosing internal ventilation schemes both when they design new buildings [1, 2] and reconstruct or deep renovate existing ones [3, 4]. In view of this, more and more attention is paid to researches into existing schemes of ventilation systems and designing new ones [5-10]. The authors have developed ventilation system with local recirculation diffusers. The proposed system's main functionality is assimilation of surplus internal heat in the cold and transition seasons by means of underheating the outdoor air in the input system. Optimal parameters of the supply air jet flowing into the work area of the room are attained by mixing underheated intake air with the room air (recirculation air) in the local recirculation diffusers.

2. Analysing applicability in office buildings

To identify the application area of ventilation systems with the local recirculation diffuser, the possibility of indoor excessive heat generation was analysed for the existing building and the building undergoing capital repair or deep renovation. To this end, the indoor heat balance was analysed in the heating season in various regions of Russia by comparing indoor heat emissions and heat losses via the building envelope.

Average indoor heat emissions in Russian office buildings are 27.46 W/m^2, including 5.4 W/m^2 from people, 12.8 W/m^2 from lighting, and 9.26 W/m^2 from office equipment.

Heat losses occurring via the building envelope depend primarily on the building's specific heat insulation characteristic k, W/(m^3·°C). Its standard values, regulated by Russian standard SP 50.13330.2012 [11], are similar for newly built and capitally reconstructed buildings, and are determined according to the following formula:

$$k = \begin{cases} \dfrac{4.74}{0.00013 \cdot GSOP + 0.61} \cdot \dfrac{1}{\sqrt[3]{V_h}} \; if \; V_h \le 960 \\ \dfrac{0.16 + 10/\sqrt{V_h}}{0.00013 \cdot GSOP + 0.61} \; if \; V_h > 960 \end{cases}, \quad (1)$$

where:

V_h is the heated building volume, m^3;

GSOP is the climatic characteristic of the building construction area, °C·days, derived by the formula:

$$\text{GSOP} = (t_{in} - t_{m.out})z, \quad (2)$$

where:

t_{in} is the indoor air temperature maintained in the building in the heating season, °C;

$t_{m.out}$, z is the average temperature, °C, and length of the heating season, in days; the two values are given for every Russian regions in standard SP 131.13330.2012 [12].

Fig. 1 shows the graph of behaviour of the normalized value of the building's specific heat insulation characteristic depending on the building volume (from 6,000 to 200,000 m^3) for three Russian cities, Archangelsk, Moscow, and Samara.