Formation of Microclimate in Individual Parts of Public Premises

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Abstract. Human activity is of a collective and individual nature, since people often spend their working and free time in groups. Modern standards in the Russian Federation determine the parameters of the microclimate depersonalized and on average, the accepted parameters are suitable for 75\% of people, and 25\% would like to have a warmer or cooler ambient air temperature around them, which is associated with the peculiarities of each person's metabolism. The creation of collective and individual engineering systems in the collective space of the building to the needs of a specific person will create a temperature at the workplace or in places of recreation of the person that will improve the quality of life and productivity, will reduce the incidence. The collective and individual nature of the engineering systems that form the microclimate in the premises will allow you to spend energy resources more economically. The parameters of human metabolism change over time during the working day, day, season and throughout life, which requires constant and periodic adjustment of the temperature regime in an individual space in a collective room.

1. Introduction
The collective and individual nature of people's activities is associated with a socio-cultural factor that determines the parameters of society's development for the implementation of large and bright goals and projects, which is based on a competent organization of the environment [1], which helps people achieve their goals, reveal their creative capabilities [2, 3]. A person's personal space is important for the development of both the individual and the team as a whole [4,5]. The parameters of a person's metabolism in a room are related to the need for a microclimate, the parameters of which are fixed in the norms. However, each person can have their own preferences for the indoor air temperature, since the human body temperature is usually within the range of known values, but it is individual in nature and the variety of subjective sensations between "very cold" and "very hot" must be taken into account, since they are very important for a particular person. If in a room with one person you can create the desired air temperature, then in a room where there are many people, this task is more difficult to solve because of the variety of options. In most situations, the organization of human life in the room should be places where the person is constantly during the working [6,7] or free time.

2. Problem statement
Energy saving in multi-apartment residential buildings [8] is associated with stable values of microclimate parameters with the existing variety of outdoor temperature fluctuations [9,10], taking into account the massiveness of enclosing structures [11], which affects the right time to create a
specific temperature necessary for a specific person right now, and not after 1 hour or another time interval. Monitoring the parameters of the microclimate in the building [12] while taking into account the heat and mass transfer processes occurring in it [13] will allow achieving stable and required parameters for each person. If there is a variety of desired indoor air temperatures in an individual living space, the required temperature range can be set in the range of 15-30 °C, but with this temperature range, it is necessary to provide thermal insulation of internal walls and floors to prevent cooling of the building premises, reduce the incidence of residents and reduce heat flows between rooms with different temperatures through the floors and internal walls. Other variants of the temperature regime with colder or hotter indoor temperatures are possible with increased thermal insulation of internal walls and ceilings for single-and multi-apartment buildings, taking into account the requirements and capabilities of the customer.

For example, a person is at home in the living room among family members of 6 people, if people are too close to each other, the individual temperature for each is impossible to create, and if people disperse around the area of the living room, you can create individual temperatures, favorable for every person. And also if a person is in the office among colleagues consisting of 6 people and their workplaces are dispersed over the office area, which allows you to create an individual temperature regime at each workplace, taking into account the individual needs of a particular person.

Figure 1. Floor plan with zones with different contours of the floor heating system.

Figure 2. Floor plan with zones with different air temperature values.

It is possible to create a floor heating system (Figure 1) that additionally heats the air in the hotel parts of the room to the temperature required by a particular person (Figure 2). A person has a remote
control, he takes it in his hands and selects the desired temperature, or a person has a smart bracelet on his hand, which itself removes the parameters of a person's metabolism and forms the temperature regime that a particular person needs.

The contours of the floor heating system should be separate for each of the zones into which the room is divided with different air temperatures necessary for a particular person are shown in Figure 1. differently heated floor spots with the temperature necessary for a particular person are conventionally shown in Figure 2.

3. Result of calculation
Consider the living room size 6×5 meters and 3 meters in height with one window and one outer wall in the apartment or residential building where the system of heating is organized as follows: primary heating system with a radiator under the window forms the base of the temperature inside the living room and additional heating system-Underfloor heating with separate circuits for 6 zones brings the room temperature to the required all residents of the state, and in some areas of the room forms the temperature required in it to a specific person.

![Plan of a room with 6 places for floor heating, where an individual temperature regime is formed for a particular person.](image)

![Graph showing air speed vs. distance from the floor of the room](image)
Figure 4. Velocity change on the axis of ascending convective jets at a distance of 2 meters from the floor from 6 circular sources with surface temperatures of 18 °C, 20 °C, 22 °C, 26 °C, 24 °C and 28 °C.

![Velocity Change](image1)

Figure 5. Change in excess temperature relative to room temperature on the axis of ascending convective jets at a distance of 2 meters from the floor from 6 round sources with surface temperatures of 18 °C, 20 °C, 22 °C, 26 °C, 24 °C and 28 °C.

![Excess Temperature Change](image2)

Figure 6. Temperature Change on the axis of ascending convective jets at a distance of 2 meters from the floor from 6 round sources with surface temperatures of 18 °C, 20 °C, 22 °C, 26 °C, 24 °C and 28 °C.

![Temperature Change](image3)

Let us assume the base temperature in the room is 15 °C, and the necessary temperature in the selected zones is 18 °C, 20 °C, 22 °C, 26 °C, 24 °C and 28 °C (figure 2). Heated spots in the selected areas and the heating device under the window will form ascending convective jets, and the surfaces of enclosing structures if they are colder will form descending convective jets. The interaction of...
ascending and descending convective jets in the room, radiant heat exchange between surfaces and convective heat exchange between air and surfaces in the room will form the air temperature and the resulting temperature, and as a result, the room temperature, which forms the subjective feelings of a person on a conditional hot-cold scale.

Rising convective jets will mix under the ceiling of the room with the formation of a heat cushion, which can eventually fall to the floor forming the room temperature in accordance with the balance of heat input and heat loss.

Figure 7. Heat losses in a room with a main heating system (option 1) and an additional heating system (option 2).

Figure 8. Heat input from 6 heated surfaces of the floor heating system.

The room in question has an external wall and window area of 13.5 m\(^2\) and 4.5 m\(^2\), respectively. The calculation of the heat balance in this area for the calculated values of the outdoor temperature for the city of Moscow for a cold season when the inside air temperature +15 °C. To calculate the heat balance, the heat transfer resistances of the external wall and window are taken in accordance with the requirements of the building thermal protection standards adopted in the Russian Federation. When adding 6 convective jets from 6 sources with a diameter of 0.38 m (figure 3) and a new calculation of
the heat balance, the average internal air temperature for the room under consideration was equal to 17.8 °C. Internal household heat or heat emissions from office equipment were not taken into account in the calculation, but they will increase the temperature of the internal air, which will reduce the temperature in the floor heating system.

The calculation of the axial velocity and excess temperature of a convective jet varying in room height at a height from 0.1 m to 2 meters from the floor for 6 ascending convective jets from round heated surfaces with a diameter of 0.38 m was performed based on data from Professor I. A. Shepelev [14]. The calculation results are shown in figures 4 and 5. When analyzing the results of calculating the excess velocity in 6 considered convective jets, the air velocity was lower than 0.2 m/s, which corresponds to the existing standards for microclimate parameters in residential and public buildings. Analysis of the results of calculating the excess temperature showed that a person's feet will be in a warmer zone near the floor with a gradual decrease in temperature along the height of the room, which corresponds to thermal comfort for a person, and also corresponds to the well-known folk wisdom "keep your feet warm and your head cold". Analysis of changes in temperature on the axis of the ascending currents (figure 6) showed that the distance from the floor of 0.6-0.7 meters the temperature varies in the range of 34-18 °C, and then the temperature of the jets is aligned closer to the value of the average room temperature that occurs due to the increase of volume of the jets at movement by engaging the body of the jet the surrounding air.

Energy saving in the room when using a collective-individual heating system in the cold season occurs when there are no people in the room, since the main or basic heating system is constantly running, and the additional floor heating system works only in the presence of a person. Figure 7 shows the heat losses of the room considered in this article during the operation of basic heating (option 1) and heat losses during the operation of basic and additional heating (option 2).

In a common room, you can create individual zones for work and recreation for each individual person, depending on their physio-psychological characteristics. The power of heated floors of the Underfloor heating system should be variable over time, depending on the ambient temperature required for a particular person. Figure 8 shows the heat input from 6 heated zones by the floor heating system for the formation of ascending convective jets. If necessary, the additional heating system can be turned off, and the basic heating system can be set to work to generate the desired room temperature. For plants that enrich the indoor air with useful elements [15] and oxygen and make people and animals happy, you can create separate zones with heating to the required temperature [16].

4. Conclusions

Energy saving when organizing collective and individual engineering systems in a residential or office space may not occur, since the exact ratio of people with their preferences to air temperature is not known. The heat balance of a room with a collective-individual heating system allows you to vary the temperature of individual zones in a certain range, since the average room temperature is desirable so that it does not deviate from the standard values. Overheating of one or more individual zones or overcooling may make it impossible to create the average temperature necessary for all participants in the collective space, then you need to separate people with opposite temperature preferences in different rooms or form semi-closed zones in the room where hotter or colder temperature conditions will be created. There are constant and variable heat flows in the room, the management of which is an important task for the formation of the required thermal regime of all premises of the building.

5. References

[1] Andrey Rymarov 2019 Energy saving in the formation of covered courtyards E3S Web of Conferences EKO-DOK vol 100 pp 00072
[2] Paderin V K, Mitroshina O V, Gatin I D 2017 Individual space as an object of sociological analysis: towards the problem statement Kazan socio-humanitarian Bulletin vol 5 (28) pp 69-73
[3] Alieva E M 2020 Dynamics of changes in the individual educational space of Junior
schoolchildren in the process of self-knowledge of the Problem of modern pedagogical education vol 67-1 pp 282-286

[4] Bezuikladova I Yu 2011 Categorization of individual space as a way of structuring the surrounding world Bulletin of the Tambov University. Series: Humanitarian Sciences vol 7 (99) pp 153-159

[5] Naumova O B 2014 Private space in the system of values of traditional society Ethnographic review vol 4 pp 77-93

[6] Rymarov A G, Agafonova V V 2019 Personalized supply ventilation system in the premises of the office building Water supply and sanitary equipment vol 11 pp 60-64

[7] Rymarov A G, Agafonova V V 2018 Air supply device to the worker's breathing zone Materials Science Forum 931 MSF pp 897-900

[8] Bodrov M V, Kuzin V Yu, Morozov M S 2015 Improving the energy efficiency of systems for providing microclimate parameters for multi-family residential buildings Housing construction vol 6 pp 48-50

[9] Rymarov A G, Botnar M I 2014 Features of changes in outdoor air temperature during a sharp cold snap in the cold period of the year Bulletin of the Irkutsk state technical University vol 10(93) pp 162-167

[10] Rymarov A G, Botnar M I 2014 Dependence of heat consumption on the dynamics of outdoor air temperature during a cold snap Construction: science and education vol 3 p 4

[11] Brukhanov O, Rymarov A, Malysheva A, Titkov D 2016 Analysis of heat losses of underground tunnel for engineering utilities with available methods MATEC Web of Conferences p 04028

[12] Rymarov A G 2014 Monitoring of microclimate parameters and concentrations of harmful impurities in the premises of the building Volzhsky scientific journal vol 1(29) pp 61-63

[13] Rymarov A G 2013 Characteristics of heat-mass exchange modes of mutual influence buildings Natural and Technical Sciences vol 1 (63) pp 380-382

[14] Shepelev I A 1978 The aerodynamics of the airflow in the room (Moscow, Stroizdat) p 144

[15] Rymarov A G, Abramkina D V, Kravchuk V U 2017 Aeroionic conditions in rooms with plenum and exhaust mechanical ventilation Industrial and Civil Engineering vol 5 pp 72-75

[16] Rymarov Andrey, Parfenteva Natalia, Valančius Kęstutis, Sabina Paulauskaite, Violeta Misevičiūtė 2018 Gaseous and thermal analysis of winter garden used for air regeneration throughout office buildings Journal of Environmental Engineering and Landscape Management vol 26 issue 3 pp 195–201