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Studying the parameters of indoor air in premises with infrared heaters

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Abstract: The main causes of human heat loss are convection, conduction, radiation and evaporation. Conductive heat loss is so small that it can be considered alongside convective heat loss. The most characteristic factor of heat loss is radiation. As a result of experimental studies, a graph of air temperature in the work area was plotted showing the mobility of air at different heat capacities of the emitter. There was a significant increase in air temperature in the working area during air flows. The research findings can be used to design infrared heating in industrial buildings.

Keywords: infrared heating, air temperature, working area

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Introduction

The issue of comfort in infrared-heated premises has been extensively studied (Bakowski, 2002; Brown et al., 2016; Dudkiewicz et al., 2013; Shepitchak et al., 2016). Comfort is largely defined as the temperature of radiation surfaces, and forced convection inside a closed room caused by air movement. Even with carefully designed radiation surfaces, thermal discomfort may still be prevalent in indoors areas. It is generally accepted, if only 20% of people indoors feel minimal discomfort, the heating is considered acceptable. In radiation heating, the degree of discomfort is usually less. The main way of human heat loss is through convection, conduction, radiation and evaporation. The conductive heat loss is so small, it can

be considered alongside convective heat loss. The ratio of the three methods of heat transfer in a heated space under normal circumstances is usually as follows:
- convection 30-35%,
- radiation 40-45%,
- evaporation 20-25%.

It is noticeable that the most significant factor of heat loss is radiation. Radiation losses occur when the environment, firstly, the inner surfaces of the exterior protections of the home are cooler than the human body. If the average ambient temperature is increased (for example, by installing infrared emitters), then the heat loss due to radiation falls and it is possible to achieve a feeling of heat, without increasing the air temperature. In this way, the heating effect is achieved without changing the air temperature, and therefore increasing the heat loss in the building. According to the occupant's perception, the room temperature has increased.

To create a comfortable atmosphere, standard convective heating must heat the whole interior of the room, with most of the heat rising to the ceiling. Infrared heaters, however, only heat the surfaces that further transfer heat to the air, focusing first of all, on the working area. This eliminates the need to compensate for space heat losses above the height of the person, and, accordingly reduces energy expenditure. In buildings with higher ceilings than domestic buildings, the volume that is not heated above the working area is increased, consequently, the efficiency of infrared heating systems increase. Surface heat transfer from the floor and surrounding objects heated by radiators in domestic premises is on average 5-10 times higher than the surface heat transfer of traditional heating appliances. Therefore, the volume of air in the occupied area can be heated to a temperature set by the consumer much faster than with conventional convective heating systems.

The temperature gradient in premises equipped with convective heating systems is significantly different from the temperature gradient of infrared heating systems (Fig. 1).

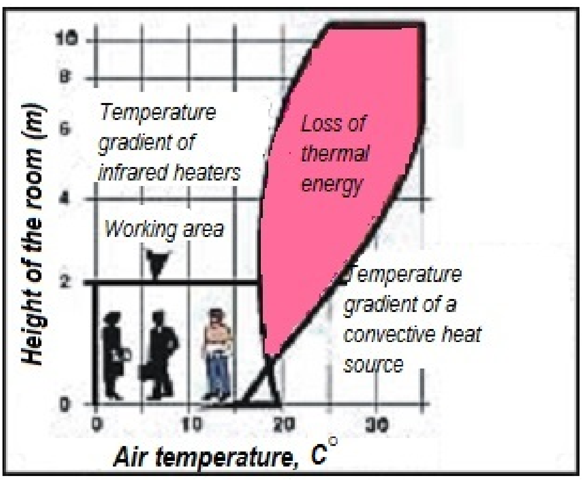

Fig. 1. Temperature gradients of the heating systems (Zhelykh et al., 2016)

For example, for convective systems, the air temperature at the human head level is approximately equal to 20°C, while at floor level the temperature is 17°C. Infrared heating systems with the same comfort conditions maintain a temperature at head level of 17°C. This again saves thermal energy.

Experimental studies

Figure 2 presents a diagram of the installation where the studies were conducted. The experiment was carried out as follows: Heater 4 was switched on at 400 W and the stationary mode of its operation was set (15-20 min). The air temperature in the laboratory was measured. An Infrared pyrometer 10 measured the temperatures at points 1-A ... 7-I on the surface 5. The temperature anemometer 9 and coordinate 8 measured the temperature in air at points 1-1′-A ... 7-7′-I.

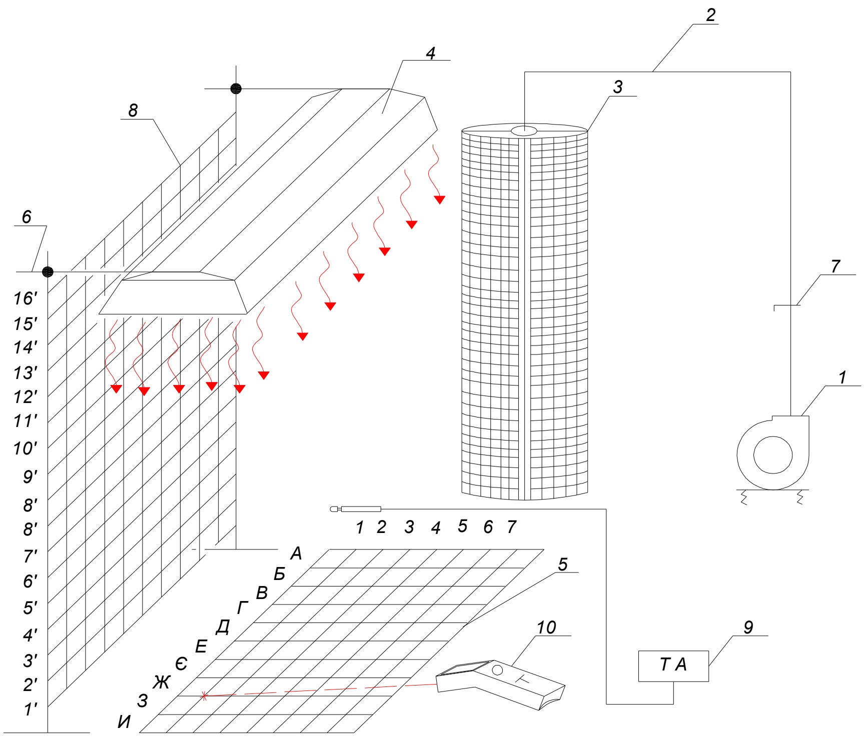

Fig. 2. Schematic of the experimental setup (*own study*): 1 – fan; 2 – air duct; 3 – source type air distributor; 4 – infrared heater; 5 – black surface; 6 – base; 7 – shutter; 8 – coordinate grid; 9 – thermoanemometer; 10 – infrared pyrometer

The experiment was repeated for 800 and 1200 W heater capacities. The fan 1 was switched on and an air mobility of 0.2 m/s was set with the help of a thermo-anemometer 9 and the shutter 7. With the help of the temperature anemometer 9 and the coordinate grid 8, the temperature in air was measured at points 1-1′-A ... 7-7′-I at 400 W. The experiment was repeated for 800 W and 1200 W heater capacities. Without switching off fan 2, an air mobility of 0.35 m/s was set using a thermo-anemometer 9 and a shutter 7. The experiment was repeated.

The measuring tools used during the study and their accuracy, tested using the metrological method, are shown in Table 1.

Table 1. Measuring tools (*own study*)

No	Name of measuring instruments	Characteristic
1	Thermometer, no 20922	Accuracy 0.5°C
2	Infrared pyrometer	Accuracy 1°C
3	Thermoanemometer ATT – 1004	Accuracy 0.05 m/s

Experimental studies of air temperature in the work area with infrared heating have shown that performance is affected by air mobility v [m/s], the thermal output of the heater Q [W] and the height of the installation h [m].

The process of determining the input parameters of the experimental studies are as follows: $Q = [400\ldots1200]$ W, $h = [0\ldots1.8]$ m, $v = [0\ldots0.35]$ m/s.

As a result of the experimental studies, a dependency graph of air temperature in the work area was obtained showing the mobility of the air at different heat capacities of the emitter (Fig. 3). After evaluating dependencies, it is important to note that with the increase in the speed of air movement, the temperature also increases. This proves the influence of convective heat exchange between the heated surface and the air.

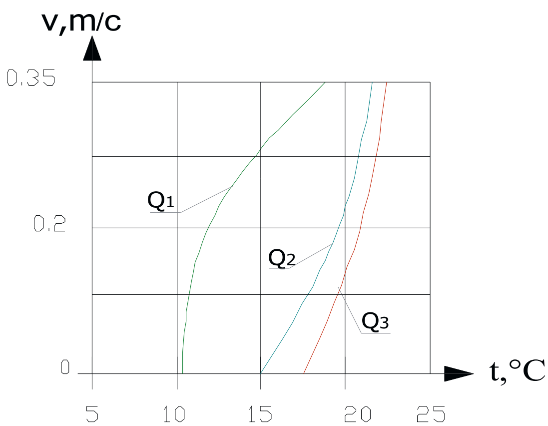

Fig. 3. Temperature dependence on air mobility at different power settings of the heater $Q_1 = 400$ W, $Q_2 = 800$ W, $Q_3 = 1200$ W (*own study*)

Conclusion

In this work, a dependency graph was obtained that presented the air temperature in a work area. The graph shows the dependence of air temperature on the speed of air movement at different power settings of the emitter.

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