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NEW APPROACH TO MICROCLIMATE PARAMETER SELECTION FOR THE PRODUCTION AREA WITH HEAT SUPPLY SYSTEMS BASED ON GAS INFRARED RADIATORS

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Abstract. There presented experimental research results for the heat transfer behavior in the areas with the radiant heating systems based on the gas infrared radiators. The model of heat-gravitational convection is formulated, that conforms to the transformation conditions of radiant energy coming from the radiators. A new approach to the parameter selection of the indoor climate with the radiant heating systems is developed based on the analysis and collation of experimental data for the temperature patterns and that of the heat flows of the object of research.

Heat supply systems based on gas infrared radiators (GIR) are increasingly used to create routine microclimate in the production area with the on-site spaced work stations [1, 2]. Such heating option is the most effective when a small part of the production areas of large workshops is utilized. In the latter case, it is unfeasible to use the traditional systems of “convection” heating of the entire room. However, the wide use of gas infrared radiators for this purpose is constrained due to the missing general theory of heat transfer under subject conditions of local heating. There performed the experimental study of temperature fields in the work areas using gas infrared radiators [3]. There defined a mathematical heat transfer model of conjugated arrangement [4] under GIR operation, which is based on the process theory of natural convection, developed for the closed-looped gas space with the thermally-conductive walls and local sources of heat release [5 - 7]. But the model [4] based on a partial differential system is too complex to be widespread used for the parameters’ selection of production area microclimate with the heat supply systems based on gas infrared radiators. There is an objective need for development of less complex selection procedure. The aim of this study is to develop a new approach to the parameter selection of the radiant heating system for the local production areas which differs from [4] by using the information on heat flows and temperatures of the work area derived from the preliminary experiments results.

The modeling performed using the theory [4] demonstrated that the most crucial factors determining the thermal conditions of heat supply facility are air temperature and heat flows in specific sections of the work area. Air temperatures for GIR normal operation modes are determined in experiments [3] with high confidence.

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A special experiment was planned and performed to determine the values of the heat-flux density q, being formed under operation of the gas infrared radiators. Figure 1 presents an experimental design performed in the model area with one or more infrared radiators under operation. q values were defined by torque-to-balance instrument (thermographic imager) “ARGUS-03”, ensuring sufficiently small error measurement of heat flux.

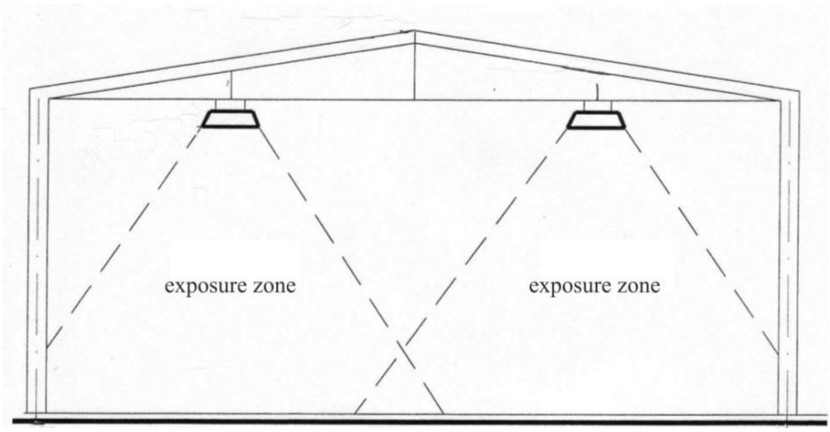

Figure 1. Diagram of the model object used in the experiment.

Figures 2 and 3 show typical results of experiments for the conditions of one radiant heater under operation at different distances of the model object to floor surface. A good measurement repeatability q (random errors stayed within limits of ± 4%) is established under identical experimental conditions.

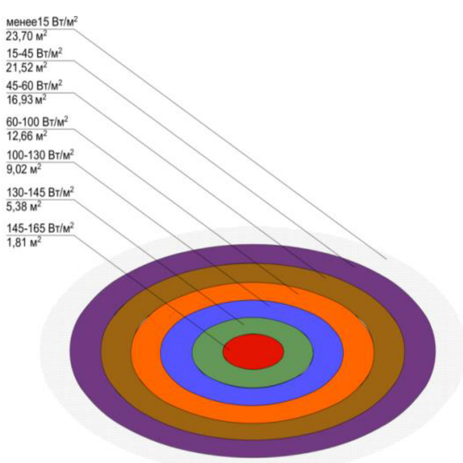

Figure 2. The diagram of exposure from the 12 kW gas radiant heater under suspension at 5m height.

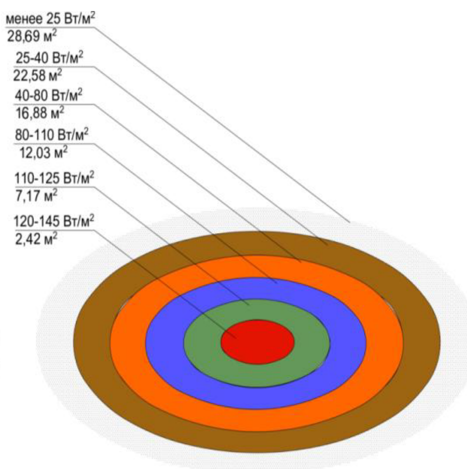

Figure 3. The diagram of exposure from the 12 kW gas radiant heater under suspension at 7m height.

There developed a new approach to selection of microclimate parameters for such rooms on the basis of analysis and generalization of the results obtained in experimental studies of the basic process patterns of heat transfer in production area with heat supply systems based on radiators. The results of theoretical studies [4] of the subject processes of heat transfer were also used in development of this approach.

The essential differences of the defined approach from that accepted when analyzing microclimate in the rooms with the systems of “convection” heating imply the following new provisions:

1. The primary processes are those of heat-gravitational convection in heated air motion, which was considered as diathermic medium for infrared radiation (it is assumed that the air is free of dust particles and water drops).
2. Air movement is an effect of the radiant heating of the near surface layer of the floor of the room.
3. The heat removal into the enclosing structures and the heat accumulation therein result in the temperature variations of the gaseous environment and variations of the heat transfer parameters (local heat-transfer coefficients) in the work area of the room.

Selection of the critical parameter of microclimate, i.e. temperature under such arrangement was made not on the basis of the heat balance analysis in the entire room assuming that all radiation energy was consumed for air heating and the search for empirical coefficient, ensuring correlation between the radiative flow of energy and air temperature. Selection of the surface temperature of the heat supply facility ($T_п$) was based on the results of the iterative procedure of its calculation using the heat balance equation on the surface thereof as a mathematical model of the process.

$$q = \alpha \left(T_{п} - T_{в}\right) + \varepsilon_{п}\sigma\left(T_{п}^{4} - T_{в}^{4}\right) \quad (1)$$

where α - coefficient of heat removal from the surface of the heat supply facility $\varepsilon_п$ – reduced power of emissivity, σ – Stefan's constant, $T_в$ – air temperature.

In statement of problem the basic assumption is the hypothesis of no heat flux through the interfacial area of “air – object” into the interior of the latter. This assumption is well founded due to the fact that the air temperatures corresponding to routine microclimate are much smaller (by 10-15°C) of the actual temperatures of the object.

At that there were the following basic data for computations: the heat flux from radiators in the work area (determined experimentally for typical operation conditions of the radiant heating systems) and the temperature in this area, also determined experimentally for a particular type of infrared radiators [3]. The solution of equation (1) can be done by Newton method or by simple iterations. It is possible to arrange the iterative cycle with any predetermined reliability of the computational results of the surface temperature of the object.

Figure 4 presents an example of the temperature distribution of the surface of clothing at various heat-flux densities for the variety of indoor air temperatures.

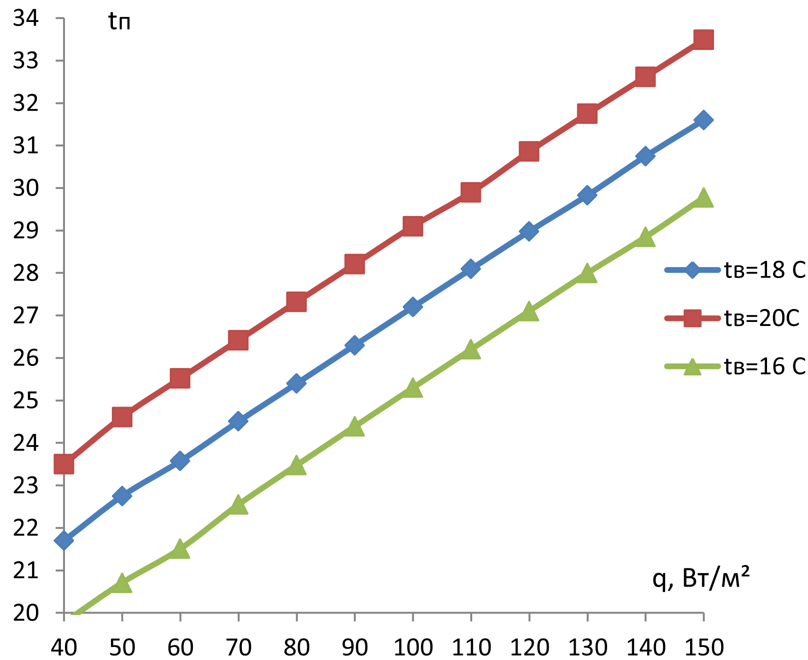

Figure 4. Temperature distribution of the surface of clothing.

Subsequent to the results of numerical investigation of a large group of power options of the used radiators and operation conditions thereof there was presented the possibility of the reliable estimate of the numerical values of the microclimate basic characteristics - temperature of the surface of the object.

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