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ENERGY-SAVING INFRARED HEATING SYSTEMS IN INDUSTRIAL PREMISES

The highest energy indicators in the operation of heating systems of industrial premises are achieved in the maintaining the required temperature in the service area. The most effective systems that are able to provide the local heating of industrial premises are infrared heating systems. The purpose of the study is to achieve the required temperature parameters in the working area of the industrial premises using infrared heaters.

Keywords: service area, infrared heater, thermal capacity, microclimate parameters

INTRODUCTION

One of the most critical concerns of EU and USA energy policy is saving energy sources in technological processes in various industrial and agricultural sectors. [1, 2]. The main requirement of heating systems in industrial premises is to maintain the microclimate parameters within the service areas.

Analyzing the current state of existing heating systems of industrial premises it can be concluded that proper attention is paid to highly effective and energy-efficient heating and ventilation systems [3]. These include the infrared heating systems, which are becoming increasingly common in the European Union and the United States. The use of infrared heaters allows providing comfortable conditions at the lower temperature of air indoors, maintaining required temperature conditions in the service area by radiation component of the infrared heater. The share of thermal energy which is transmitted by radiation changes in wide ranges and depends on the type of infrared heater (gas, electric).

According to the results of studies conducted by laboratory DVGW of German Institute of Standards and European standards 419-2, for heaters of firm Schwank, heat flows distributed as follows (Tab. 1) [4].

Table 1. **The distribution of heat flow from Schwank infrared heaters company**

Heater type	Share of heat [%]		
	Radiation	Convective	Heat loss
ecoSchwank	50.4	44.6	5.0
primoSchwank	69.5	25.5	5.0
supraSchwank	80.9	14.1	5.0

1. EXPERIMENTAL SETUP

In the application of infrared heaters convective heat is released in the upper area of premises and does not participate in providing temperature mode in service area. For efficient using of infrared heating in industrial premises it should be placed above an infrared heater the axial fan for direction of the convection heat flow in the service area. This decision can increase air temperature in the service area, thus lowering the heater capacity and thus increase the energy efficiency of infrared heating systems.

Figure 1 shows the scheme of the experimental setup, where the research of air temperature in the service area was carried out.

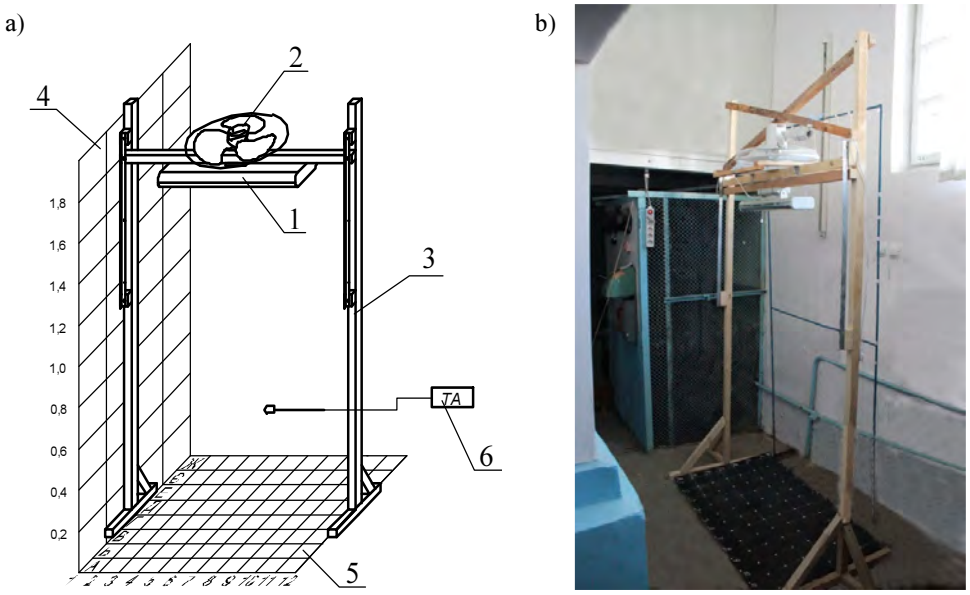

Fig. 1. Schematic of the experimental setup: a) scheme of experimental setup, b) photo of experimental setup: 1 - infrared heater NL - 12R, 2 - axial fan, 3 - tripod, 4 - vertical coordinate grid, 5 - horizontal coordinate grid, 6 - thermo-anemometer ATT-1004

Experimental setup consisted of an infrared heater 1, intended for local heating of the service area, and axial fan 2 designed for directing convective flows in the service area. Temperature measurements were made using thermo-anemometer 6. It uniform definition used coordinate grids 4 and 5, which allowed making measurements at fixed intervals in both vertical and horizontal planes.

The experiment was conducted in two phases with different thermal heater capacity: Q = 500, 1000, 1500 W and a variable height setting heater: H = 1.13, 1.43, 1.73 m. In the first phase measurements of air temperature with the fan off were carried out, the second phase of research carried on with the enabled fan. Thus speed of air in the irradiated area did not exceed standard value and was 0.3 m/s.

2. RESEARCH RESULTS

To compare the results of experimental studies of the temperature regime with using the fan above the infrared heater and without it a graphical dependence of the relative temperature in the service area of the density of heat flow of emitter q [W/m^2] was built (Fig. 2).

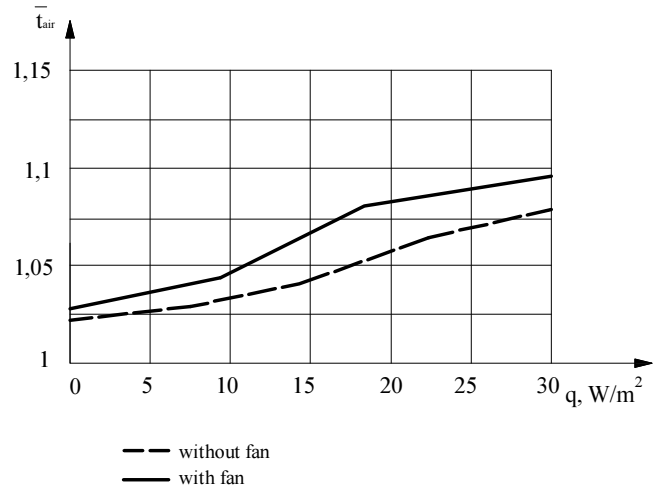

Fig. 2. Graphical dependence of the relative air temperature $\bar{t}_{air}$ of the density of heat flow of emitter q, W/m^2 at an installation height of a heater H = 1.73 m

Analysis of the graphic dependence shows that air temperature in the service area is increased in 2.8% by using an axial fan above an infrared heater.

Relative air temperature in the service area of production premises was determined by the formula:

$$\bar{t}_{air} = \frac{t_{air}}{t_{\infty}} \tag{1}$$

where:
t_{air} - air temperature in the service area determined experimentally [°C],
t_{∞} - background temperature of indoor air [°C].

Density of heat flow of emitter q [W/m^2] was determined by relationship:

$$q = \frac{Q}{F} \tag{2}$$

where:
Q - heat capacity of infrared heater [W],
F - area of infrared heater [m^2].

For determination of temperature mode in the service area using fan above the infrared heater the statistical methods of investigations were applied. As a result of research the graphical dependence of the relative temperature in the service area of thermal infrared heater power Q [W] and height of its installation H [m] was obtained (Fig. 3).

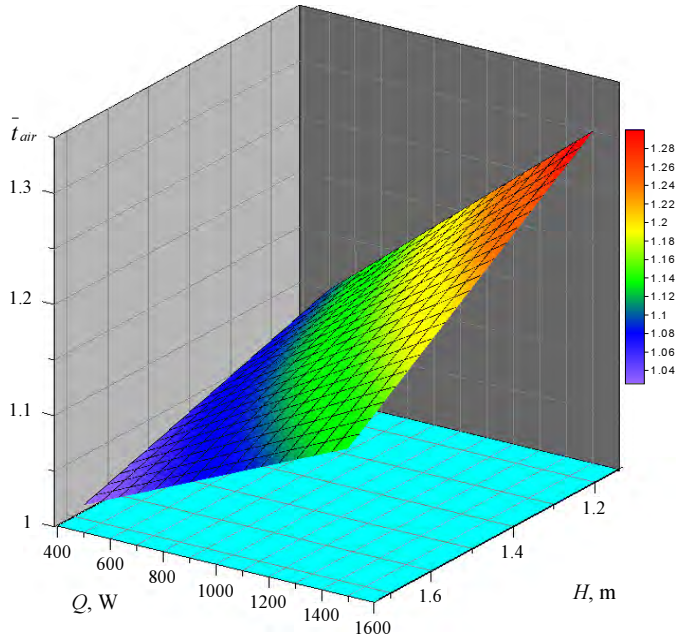

Fig. 3. Experimental dependence of the relative air temperature $\bar{t}_{air}$ of the heater thermal capacity Q [W] and height of installing the heater H [m]

As a result of conducted experimental research for an empirical dependence of the relative air temperature $\bar{t}_{air}$ was obtained. The limits of variation of the input factors have changed as follows. For thermal capacity of infrared heater: 500 W ≤ Q ≤ 1500 W; for height of installing the heater: 1.13 ≤ H ≤ 1.73:

$$\bar{t}_{air} = 1.14 + 0.077\frac{Q-1000}{500} - 0.06\frac{H-1.43}{0.3} - 0.023\frac{Q-1000}{500}\cdot\frac{H-1.43}{0.3} \qquad (3)$$

CONCLUSIONS

This article presents the results of parametric studies of the temperature regime in the service area when applying infrared heaters. Graphical and empirical dependences of air temperature in the service area in production premises from thermal capacity of infrared heater and height of installing the heater were received.

It is proved that the application the axial fan above an infrared heater can increase the air temperature in the service area an average of 2.8%.

The results of the investigations can be used in the engineering design of heat supply systems for production premises, based on the infrared heaters, as well as designing the radiant heating systems in buildings and facilities used for industrial and agricultural purposes.

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ENERGOOSZCZĘDNE OGRZEWANIE NA PODCZERWIEŃ W OBIEKTACH PRZEMYSŁOWYCH

Najwyższą wydajność energetyczną systemu ogrzewania w zakładach produkcyjnych osiąga się poprzez utrzymywanie wymaganej temperatury w obszarze roboczym. Najbardziej skutecznymi systemami służącymi do tego celu są systemy grzewcze na podczerwień. Celem badań jest uzyskanie wymaganych parametrów temperatury w obszarze roboczym w zakładach przemysłowych za pomocą grzejników na podczerwień.

Słowa kluczowe: obszar roboczy, grzejnik na podczerwień, moc grzewcza, parametry mikroklimatu