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Analysis of the use of heating film in the heat supply of industrial premises

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Abstract: The situation in the country and around the world needs new, better energy resources and ways to use them to save energy, and with it, the economic, ecological and social position of any state. Energy saving is a necessary issue for improving economic performance by reducing energy consumption while maintaining comfortable conditions. Large industrial buildings are a significant consumer of thermal energy. An effective approach is needed for the design of heating systems, taking into account the possible modes of their operation to ensure the rational use of energy resources.

Keywords: film infrared heater, heating supply, energy savings, energy-efficient systems, heating, infrared heaters, radiant energy, working place, temperature regime

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Introduction

Hygienic characteristics are one of the most important to consider in the general assessment of a heating system, especially when deciding on the use of a particular heating system in a room. It is the main goal to create favorable working conditions in the workplace, which would ensure high efficiency and health. Optimal and admissible microclimatic conditions are established for the working zone of production premises, taking into account the difficulty of the work and the period of the year (EN 15316-2-1:2007; State Building Standards of Ukraine B.2.5-67:2013). When different work is conducted in the workplace at the same time, microclimate indicators should be set, taking into account the majority of workers, or, if neces-

sary, organizing workplaces that have separate microclimates. Air temperature in the workplace related to height and horizontally, as well as during the work shift should not exceed the normalized values of the allowable temperature for a given category of work. The temperature of the inner surfaces of the working area (walls, floor, ceiling), process equipment, outer surfaces of process equipment, and enclosing structures should not exceed 2°C outside the normative values of air temperature for this category of work.

Failure to observe this requirement, due to technological processes or the nature of work, that occurs when working outdoors, obliges the employer to introduce additional breaks during work, select appropriate work clothes and shoes for employees adapted to the type of work performed, as well as provide restorative nutrition. All this, in general, leads to additional costs and reduced efficiency. Therefore, it is important to ensure the appropriate temperature in the workplace.

Analysis

Heat supply of industrial buildings is usually carried out by traditional methods with the use of air and water convective heating systems (Fig. 1).



a) convective heating system



b) air heating system

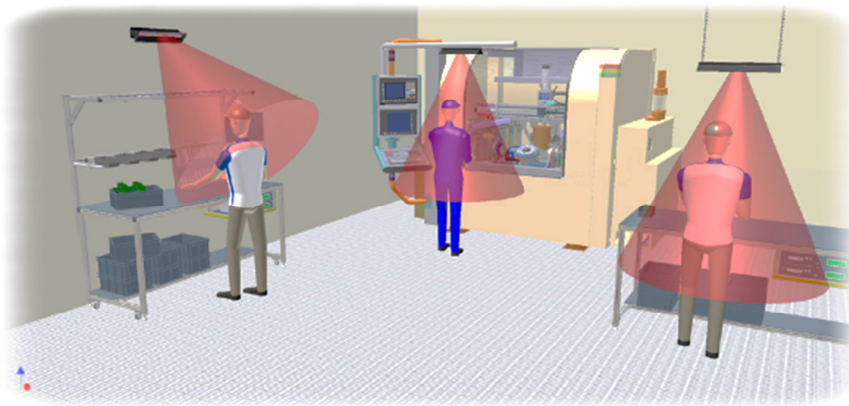
Fig. 1. Varieties of traditional heating systems for industrial buildings
(<https://stroydizain.pp.ua>)

Heating of this type is quite inefficient for such buildings, as inertia, the presence of a significant temperature gradient over the height of the room and the accumulation of large amounts of warm air above the work area lead to excessive energy consumption.

The most efficient and economical way to provide heat for employees in individual workplaces in high ceilinged rooms is systems with infrared heaters (Ango, 1957; Burakovsky, et al., 1978; Zhelikh, et al., 2012) (Fig. 2).



a) infrared film electric heater (<http://budivnik.in.ua>)



b) infrared heating system (<http://termoeng.com.ua>)

Fig. 2. Varieties of infrared heating systems for industrial buildings

Film infrared electric heaters have been successfully used for several years to create heating systems such as “warm floor”, “warm wall” and “warm ceiling”. Infrared heating is used both as an additional and main heat source. Its use is unlimited: residential, public, cultural and industrial buildings, including storage and ancillary. The use of an infrared heating system with infrared films can compete with any type of electrical heater. This heating system has relatively high

efficiency, requires minimal equipment and installation costs, is fast, environmentally friendly and has many additional benefits. For effective work it is enough to adhere to two conditions: safe distance to an infrared source and enclosing designs of the building are warmed according to regulatory requirements to a heating surface.

The principle of operation of infrared heating is to pass through a film electric heater an electric current. The heaters then begins to emit intense heat. This energy is just like natural solar radiation, and affects the objects and enclosing structures of the room, heating them quickly.

The design of the film infrared heating system is simple (Fig. 3).

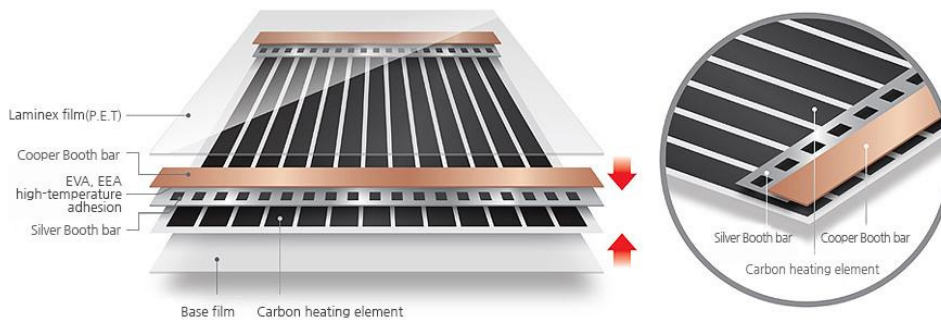


Fig. 3. Structure of far-infrared ray heating film (<http://www.buykorea.org>)

The film heating element consists of three main layers: a heating element, the purpose of which is to convert electrical energy into heat; foil, which promotes uniform distribution of thermal energy over the entire surface of the heater; double-sided lamination with polyester film (PET), which performs an insulating and protective functions.

Infrared radiation begins when a current passes through the film heater. When an electric current is passed through the heating elements, it is converted directly into thermal energy. Heat is transferred by contact from the heating element to the two surfaces of the heater (PET film). These surfaces emit infrared waves with a length of 9.7-10 μm .

It is erroneously believed that the radiation source is the heating elements or foil placed inside the film heater. The radiating surface of any low-temperature heater is its surface, or rather the PET film.

Operating temperatures at maximum load do not exceed 50°C, and the average specific power of heaters is 150-220 W/m^2 . This infrared heating system is controlled by thermostats, which are installed in all rooms heated by the system and are sensitive to temperature changes within one degree, turning off or supplying power to the heater as required.

The principle of operation of infrared heating is the conversion and radiation of energy (Zhelyh, 2016). If a low-temperature film electric radiator is installed on

a fencing surface (wall, ceiling, floor), which is decorated with decorative material, then the film infrared electric heater converts electrical energy into heat and radiates infrared waves on the surface of the heater. In this case, it will be the primary radiation. Spreading through the air gap from the heater to the outer layer of the facing surface of the room, the primary radiation heats this layer. It heats up quickly enough to a temperature of 38-40°C and in turn, begins to emit infrared waves that are directed into the space of the room. This process is secondary radiation. All objects in the area of the heater absorb secondary radiation and heat (Fig. 4).

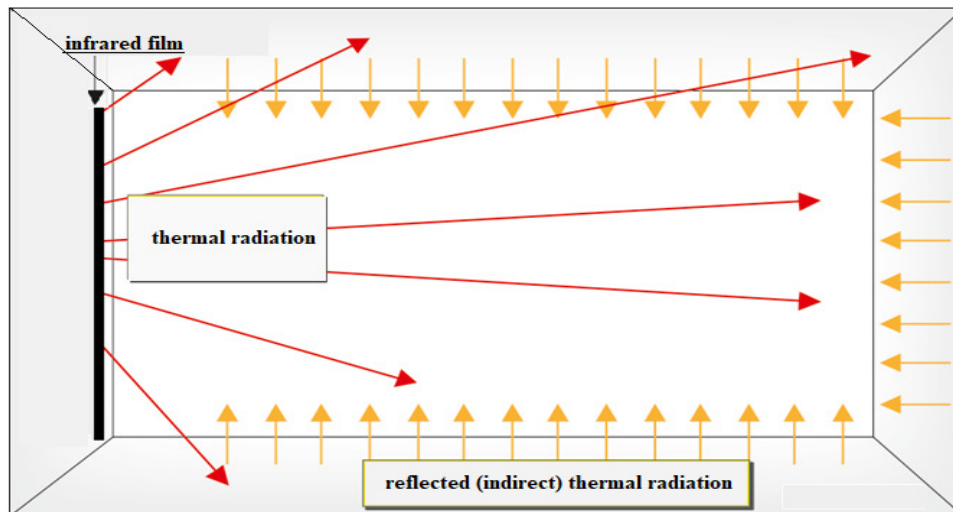


Fig. 4. Heat distribution of infrared film heating (<http://ua.trotec.com>)

Thus, the mechanism of space heating by a system using low-temperature film radiant electric heaters is as follows: conversion of electrical energy into heat – primary radiation – primary absorption – secondary radiation – secondary absorption (space heating).

The heating surface is safe and does not require control, but this is not the biggest advantage. They are:

- it is easy to establish individual microclimates with individual parameters in separate rooms, creating several temperature zones in one room;
- lack of additional equipment that requires periodic maintenance;
- uniform temperature distribution;
- a significant reduction in the intensity of convective heat fluxes that move dust in the room, which is detrimental to human health;
- low electromagnetic field strength, which meets Euro standards and does not cause adverse effects on the environment and humans;
- absolute quietness of work and the minimum volume of the occupied space;
- convenience of installation, the possibility of dismantling with preservation of consumer properties;

- possibility of full automation with programmed modes. Regardless of the external weather, climatic zone and season, the microclimate is maintained at a given level due to thermoregulation systems;
- use in explosive and fire-hazardous buildings;
- significant service life exceeding 25 years.

The main disadvantages of film electric heaters include:

- relatively low power of infrared film electric heaters requires good thermal insulation of premises and buildings;
- the need to supply sufficient electrical power to power heating elements;
- operating costs of film heating are on average 1.5 times higher than gas heaters, which is explained by the higher price of electricity compared to natural gas.

Conclusions

Recently, infrared heating systems have become increasingly popular, but still there is not an existing database on their effective installation and integration with other heating systems, in particular when an additional heating system is used. The use of film infrared heaters can save energy and allows delivery of the optimal temperature in the workplace. Infrared heating is not yet a competitor to gas heating, but in the absence of connection to the main gas pipeline, it has no equal, as the cost is lower by 1.5-2.5 than when using an electric convective heating system.

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