Localized Electrical Heating System for Various Types of Buildings

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Abstract. The article presents an overview of the factors determining the establishment of zones with high temperature in industrial, public and administrative buildings. The authors state the task on the improvement of the electric energy use efficiency and cost savings associated with the heating of these buildings by infrared electric heater devices.

Materials and methods: The experiments were conducted in a room with the sizes of 3x6 m² with a ceiling height of 3 m, the concrete floor was covered with laminate, in which increments of 250 mm were drilled and installed the thermocouple. In the process, had used the patented heating element with distributed heating layer. Signals from the thermocouples were recorded by instruments of the firm "ARIOES" brand ТРМ 138 with the standard software delivered together with devices (Owen Process Manager). The obtained distributions of the temperature fields were imported into MS Excel. Control voltage, current consumption, power was carried out by the device of firm "ARIOES" brand of IMS.

The results of the study: the article defines the purpose of the study and carried out the characterization of infrared heaters with various types of heating elements. The authors detail the main parameters of different types of infrared heaters, evaluated its possibility for application in other areas where the need to create areas of increased temperature.

Discussion and conclusion: the result of this work it was determined that heating appliances that use patented heating element with distributed heating layer, improve thermal performance and bring you maximum comfort at a much greater distance compared to existing similar devices.

1. Introduction
In winter, there is a need to create additional zones with increased temperature. This is mainly practiced in industrial premises. Even heating of large production areas is energy intensive and not always expedient. A rational and efficient heating system in production facilities plays an important role in providing comfortable conditions for workers [1].

According to many experts, rational energy use can save more than 40% of total energy consumption [2].

The main methods that are used for the rational use of thermal energy are presented in the work of Vatuzov DN, Puringa S.M. And Filatov EB [3] And Cheng Y., Nin J., Gao N. [4], the authors indicate that further complex work in this direction is necessary.

In production, it is not uncommon for cases in which different technological processes are performed in the same room, which are associated with certain comfort conditions that are created taking into account the category of work and the corresponding energy expenditure of the organism.
At the same time, the workers' warmth depends on the complex action of microclimatic factors, on the intensity of the work performed, on the degree of fatigue, on clothing, and on other factors [5,6].

There is a great experience of both Russian and foreign designers to create localized heating zones with the help of a ventilation system, an air heating system, and a radiation system in industrial premises [7].

The need for creating zones with different temperatures does not only appear in industrial premises. It is difficult to find people who would not feel discomfort in shopping centers in winter, where climatic conditions are created for people staying in these premises for a long time and doing light work and where buyers come in winter clothes. Despite the fact that the zones of long-term finding of buyers and sellers are separated, there are practically no activities to create different climatic zones in such premises.

Similar problems, for example, arise in the buildings of airports and railway stations, where workers are simultaneously present, departing or arriving passengers and passengers awaiting departure. Moreover, the zones of people in different clothes, people doing work, people in a state of rest or movement are also divided.

The creation of different temperature zones by means of air-heat flow control is a very complex and expensive process [8]. The best option, according to many scientists, is the radiation (radiant) method of heating. In the world practice, for the creation of localized zones with a higher temperature, heating systems based on electric radiation (infrared) heaters have been widely used [9]. Radiation (infrared) heating systems radiantly heat surfaces rather than air volumes, which allows them to be used to heat individual zones, plots or workplaces in production facilities without the need to heat them entirely, which can not be achieved with traditional water or air heating.

In the work of V.Yu. Karnitsky and V.S. Ushnikova [10] considers the solution of this problem with the help of infrared heating. The paper shows that using infrared heaters can significantly reduce heating costs and help save more than 45% of electricity compared to other heating systems. As a result, the cost of equipment, installation and operation of infrared heating is almost 2.5 times cheaper than that of water heating. It should be noted that the opinions of other authors differ on the optimal fraction of radiant heat transfer, arguing that maximum heat emission of heating devices by radiation should be ensured [11,12]. They are opposed by the opinion of scientists who prefer the use of panels with a fraction of radiant heat transfer of the order of 60-70% [13,14].

Practice shows that the use of infrared systems for zone heating at production facilities has no alternative.

The flow of radiant energy of the infrared spectrum is directed directly to the necessary space and, without heating the ambient air, it falls on the floor, equipment installed in this zone and people in this zone. At the same time, the floor and the equipment, heated by convection, give this heat to the air around them. The comfortable condition of people in this zone, in accordance with the intensity of labor, is maintained not only by the ambient temperature, as in air heating, but also by heaters, heated floors and equipment with radiant energy. If necessary, it is possible to heat only the area where heat is directly needed, and not the whole room. Creating the necessary heat flow, you can directly heat the workplace [15].

Conditionally, according to the manufacturing principle, infrared heaters can be divided into four classes, depending on the heating element used: with a halogen heating element, a carbon heating element, a ceramic-sheathed heating element, and a tubular heating element with an aluminum shell.

All these devices from the positive side have proved themselves in the field of creating favorable heating zones in not large spaces. To create favorable working conditions for the worker standing at the machine tool, to the dispatcher, to the controller, in a relatively small space they can. But, not one of these heaters can create a uniform heat flow over a large area. If several heaters are installed, zones with high and low temperatures will inevitably form. This feature of this equipment reduces their range of applications, so they do not find wide application in other types of premises.

The purpose of our study was to determine the heating spectrum of infrared heating devices available on the market that could be used in civil buildings such as a shopping center, a market, an
airport building and a railway station. Develop an alternative solution and conduct its comparative analysis.

2. Materials and methods
For the experiments, the room was equipped with a size of 3x6 m² with a ceiling height of 3 m. The concrete floor of the room was covered with a laminate, in which holes and thermocouples were drilled in steps of 250 mm. Current-carrying wires were laid under the laminate and connect to the devices of the firm "OWEN" brand TRM138. Using the proprietary software (OWEN PROCESS MANAGER (OPM)) that comes with the instruments, the data from the thermocouples are recorded, analyzed, processed and displayed as graphs that are imported into the Excel program.

The microclimate parameters were calculated taking into account the use of combined heating, where the air temperature was maintained in the range of +15 °C by means of electric convector, infrared heaters with different types of heating elements were alternately installed in the upper of room. The parameters were determined in accordance with the existing norms and methods, which are described in detail in the textbook on construction thermophysics VN Bogoslovsky [16].

For the experiments, a thick-film heater with a distributed heating layer was made under patent for utility model No. 109628 [17] on a metal substrate, according to the technology described in patent No. 2463748 [18], which was installed in a housing similar in design to analogs.

Control voltage, current consumption, power was carried out with the device of the firm "OWEN" brand IMS-F1.Sh1.

In the processing of data, it was also taken into account that the targeted use of radiant heat exchange makes it possible to reduce the temperature of the ambient air without disturbing the conditions of thermal comfort [19-21] and the fact that the action of radiant heat within certain limits may have a beneficial effect on the body [22].

Results of Research
For the experiment, infrared heaters with identical capacity of 1 kW and a similar heat transfer area were chosen.

The graph of the distribution of the temperature field at the floor level showed that the heating device with a halogen heating element (Figure 1.) has a pronounced region with an elevated temperature at the center with a smooth decrease. It can be seen that with the installation of several heating devices, it is practically impossible to create a uniform temperature field.

![Figure 1. Graph of the distribution of the temperature field with a halogen heating element.](image-url)
Figure 2 shows the distribution of the temperature field at the floor level when using a heating device with a carbon heating element. Unlike a device with a halogen heating element, the pronounced region of elevated temperature has a spiral shape, and is also close to the center with a drop in temperature to the edge. It is also clear that with the installation of several heating devices it is practically impossible to create a uniform temperature field.

Figure 2. Graph of the distribution of the temperature field with a carbon heating element.

Figure 3 shows the distribution of the temperature field at the floor level when using a heating device with a ceramic-sheathed heating element. The graph shows that the temperature distribution is more evenly compared to the halogen heating element and the carbon heating element with a non-significant spiral region of elevated temperature that is located throughout the region of increased heating. It can be seen that with the installation of several heaters, it is possible to expand the zone of increased heating with slight deviations from the uniform temperature.

Figure 3. Graph of the distribution of the temperature field with a ceramic-sheathed heating element.

Figure 4 shows the distribution of the temperature field at the floor level when using a heating device with a tubular heating element with an aluminum sheath. Despite the fact that the three
previous models are positioned on the market as advanced modern achievements, their result is significantly worse compared to the classical model, when an aluminum radiator is put on on a tubular heating element. The distribution of the temperature field with insignificant deviations, which are due to the fact that despite a good coefficient of thermal conductivity of aluminum, a uniform temperature on the heat transfer surface can not be obtained.

It can be seen that when installing several heaters, it is possible to expand the zone of elevated temperature.

Figure 4. Graph of the distribution of the temperature field with a tubular heating element with an aluminum shell.

A research of four types of infrared heaters has shown that a uniform temperature field can be obtained only if the heat transfer surface is evenly heated. Despite the fact that the heat flow can be controlled using the classical laws of optics, manufacturers of heaters with a halogen heating element and a carbon heating element could not obtain an uniform temperature field. This is confirmed in Figure 5, when a heating element with a distributed heating layer was used as the heating element. The temperature field was evenly distributed throughout the high temperature zone, there are no temperature deviations and local overheating.

Figure 5. Graph of the distribution of the temperature field with a thick-film heating element with a distributed heating layer.
3. Discussion and conclusions

In connection with the further expansion of the field of application of infra-red zonal heating systems in production, administrative and public buildings, the task of further improving their energy efficiency becomes very urgent.

After carrying out a small comparative analysis of the various infrared heaters that are currently in use and comparing their characteristics, it is evident that research is needed in this field with a view to ubiquitous application of this type of heating.

When selecting equipment, it is necessary to assess how much it is suitable for a particular room. On this depends the comfort of people who are in these rooms. It is also worth noting that low cost often hides low quality or limited functionality. Having solved the task of efficient and comfortable heating, it is possible to reduce the cost of life support for these premises, gaining economic benefits when creating more favorable conditions.

References

[1] Goshka L L 2009 To the question on necessity of introduction of effective systems of cooling of buildings magazine of civil Engineering 7 pp 33–37 Retrieved from http://engstroy.spbstu.ru/index_2009_07/gosh-ka_chapter7.PDF

[2] Alekseenko C 2004 Energy saving is the key to the growth of the national economy Science in Siberia, corresponding member Q. RAS 48(2484) pp 1–13 Retrieved from http://unistoryst.pbstu.ru/index_2013_11/1_.PDF

[3] Matusow D N, Pouring C M and Filatova E B 2013 Ways to improve the rational consumption and distribution of heat energy in residential buildings Construction Engineering Bulletin of the Caspian is 2 3(6) pp 33–35 Retrieved from http://journal.samgasu.ru/vestnik_sgasu/2014_04_13.PDF

[4] Jun Chen and Chi-sun Poon 2009 Photocatalytic construction and building materials: from fundamentals to applications Building and environment vol 44 pp 1899–06 Retrieved from http://www.brimee.eu/documents/28616/28897/Photocatalytic+construction+and+building+materials++From+fundamentals+to+applications.pdf?8f626406-e272-40aa-bd6e-c0ea2abf4b55?version=1.0

[5] Orr H, Wang John, Fetsch D and Dumont R 2013 Technical note: the tightness of older-generation energy-efficient houses in Saskatoon Journal of building physics vol 36 pp 294–307 Retrieved from http://journals.sagepub.com/DOI/PDF/10.1177/1744259112460748

[6] Tenpieric M, V van der Spoel and Cauberg N 2008 Analytical model for calculating thermal bridge effects in high performance exterior building envelopes Journal of building physics vol 31 pp 361–87 Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/1744259107088008

[7] 1998 Dennis machine ventilation where it's needed Ashrae journal and Oct. pp 39–47 Retrieved from http://ashrae.org/Files/e-newsletters/press-Oct98

[8] Shelekhov I Y and Shishelova T I 2007 Development of the heating equipment and research of its efficiency in life support systems Bulletin of ISTU 1(29) 1.104 TS-109 Retrieved from http://journals.istu.edu/vestnik_irgtu/journals/2007/01a

[9] Goshka L L 2009 To the question on necessity of introduction of effective systems of cooling of buildings Magazine of civil Engineering 7 pp 33–37 Retrieved from http://engstroy.spbstu.ru/index_2009_07/index_2009_07.html

[10] Karnitsky Y V and Ear V S 2016 Specialist. Infrared heating and efficient form of heating Izvestiya of the Tula state University 12-3 pp 96–98 Retrieved from http://cyberleninka.ru/article/n/infrared-heating-how-cost-1-effective-form-of-heating

[11] Infrared heating Retrieved from http://www. otopimdom.ru/index.php?id=394

[12] Infrared radiation and its impact on man Retrieved from http://otravleniya.net/izluchenie/infrakrasnoe-izluchenie-vliyanie-na-cheloveka.html

[13] All about infrared heaters for the garden Retrieved from
http://oblagorod.ru/obogrev/infrakrasnye-obogrevateli-s-termoregulyatorom - for-giving.message: I-11
[14] The economic effect of the application of infrared heaters. Calculation of the cost Retrieved from http://www.teplo.ufakit.ru/?partid=56
[15] Dickman John 2008 Improving humidity control with energy recovery Journal of ashrae and August pp 38–45 Retrieved from http://www.airxchange.com/collateral/documents/English-US/Dieckmann_Ashrae_Article.PDF
[16] Bogoslovsky V N 1982 Building Thermophysics (thermo-physical fundamentals of heating, ventilation and air conditioning systems) (Moscow: Higher. School) p 415 Retrieved from http://www.twirpx.com/file/5619/
[17] Shelekhov I Y, Shelekhova I V, Ivanov N A, Kim Byoung-Chul and Golovnii I M 2011 Heating element (RU Patent 109628) Retrieved from http://www1.fips.ru/fips_servl/fips_servlet
[18] Shelekhov I Y, Shelekhova I V, Ivanov N A, Golovnii I M and Kim Byoung-Chul 2012 Method of manufacturing thick-film resistive heater (RU 2463748) Retrieved from http://www1.fips.ru/fips_servl/fips_servlet
[19] Kurylenko N I 2015 The dissertation on competition of a scientific degree of doctor of technical Sciences. Scientific and technical basis for the formation of a microclimate of industrial facilities with radiant heating systems (The Ministry of education and science of the Russian Federation FSBEI HPE Tyumen state University of architecture and construction) p 235 Retrieved from http://www.tgasu.ru/content/page/post-4931/dissertaciya_.docx.pdf
[20] Shelekhov I Y, Smirnov E I and Inozemtsev V P 2016 Design of the heating devices based on physical and mathematical modeling Scientific review 1 pp 42–48 Retrieved from http://engineering.science-review.ru/ru/issue/view?id=4
[21] Shelekhov I Y, Shishelova T I and Dukhovny L I 2012 peculiarities of the use of heating equipment in buildings with variable thermal regime Fundamental researches pt 2 3 Retrieved from https://fundamental-research.ru/ru/issue/view?id=436
[22] Shelekhov I Y and Shishelova T I 2012 Comparative analysis of the use of electric heaters in the premises Fundamental research 9-2 pp 421–424 Retrieved from https://fundamental-research.ru/ru/issue/view?id=457