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Assessment of labor conditions class by the intensity of heat treatment by the method of diagrams when changing the layout of technological equipment

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Introduction. Failure to comply with the requirements for the technological microclimate can lead to the development of occupational diseases and accidents. Therefore, in the general system of measures that ensure normal working conditions, one of the most important tasks is to reduce heat emissions.
Problem Statement. The paper studies the thermoradiation mode of workplaces. For this purpose, a scientific method based on the construction of radiation diagrams is used. The irradiation field of an object is based on the radiation diagrams of various sources that affect the working space.
Theoretical Part. Diagrams are used to express the quantitative parameters and boundaries of the distribution of radiant flows in the total field of irradiation of the workplace. Diagrams are built for different operating modes and operations based on theoretical calculations or real measurements. The method of diagrams is considered on the example of the cementation section of the foundry. The result of replanning, i.e. changing the location of the furnaces installed in the room, is shown.
Conclusion. The study of the intensity of thermal irradiation of the workplace by the method of diagrams showed that changing the layout of production equipment, as well as protection by distance, helps to reduce heat radiation and thus ensure compliance with sanitary and hygienic standards adopted for production facilities.

Keywords: thermal irradiation, thermal shop, modeling, thermal irradiation diagrams.

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Introduction. The worker's body is significantly affected by the conditions of the production room, which affect the heat exchange of the person and the environment. In metallurgy, the microclimate in the workplace is determined by the speed of air movement, the intensity of thermal radiation from equipment and surfaces, and relative humidity.

Failure to comply with the requirements of the technological microclimate can lead to the development of occupational diseases and accidents. Therefore, in the general system of measures ensuring normal working conditions, one of the most important tasks is the reduction of heat emissions.

The greatest impact on the human body has the intensity of the radiation flow. It depends on a number of factors, including:

— location of the equipment,
— size of the radiating surface,
— duration of exposure,
— distance to the radiation source,
— angle of incidence of the rays.

Problem statement. The authors investigate the heat radiation mode of workplaces. For this purpose, a scientific method based on the construction of radiation distribution diagrams is used. The radiation field of an object is based on the radiation fields of various sources that affect the workplace.

Theoretical part

Method of distribution diagram of exposure. Distribution diagram — a flat vector diagram of the location of irradiation in the space surrounding the source (radiation distribution diagram), or on the surface of the object (exposure distribution diagram). Distribution diagrams are built in a vertical or horizontal plane. For a technically sound solution for thermal protection of the workplace, it is necessary to know the type, amount of irradiation, spectral composition, as well as the direction of the prevailing radiant flow, in order to correctly determine the installation location and the size of the screen or the curtain. A visual picture of the irradiation field is shown by the exposure distribution diagram, which represents the distribution of irradiations that occur on the surface of an object when exposed to various heat sources. So, using distribution diagrams, you can express the quantitative parameters and boundaries of the distribution of radiant fluxes in the total irradiation field of the workplace. When constructing distribution diagrams of an open space, the worker's chest is taken as the center. Distribution diagrams are constructed for different operating modes and operations based on theoretical calculations or natural measurements of irradiance values [1].

Let us consider this method on the example of a foundry cementation site (Fig. 1).

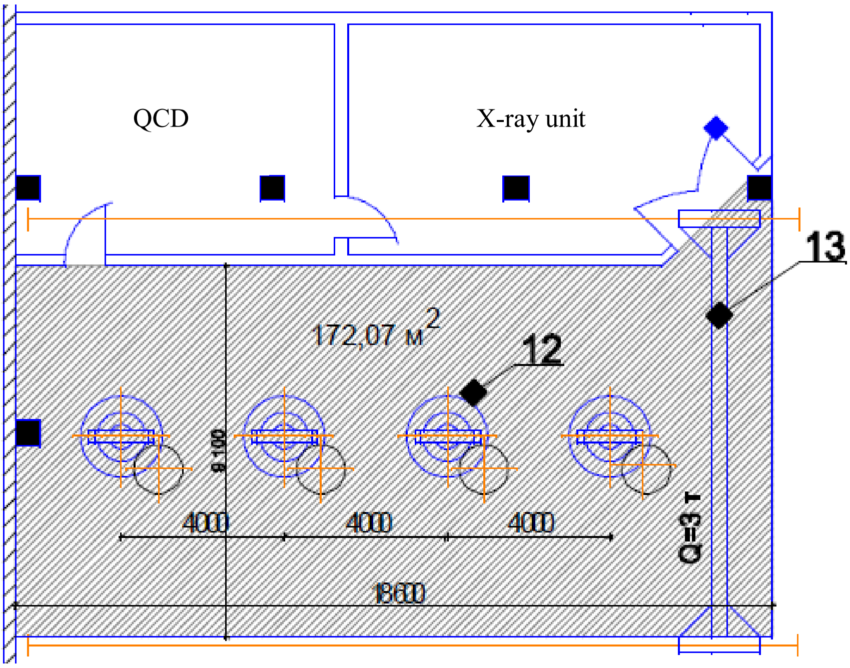

Fig. 1. Plan of the foundry

On this territory there are unfavorable conditions due to the large number of electric furnaces of the type Ts-105A, epy workers are exposed to infrared radiation from almost all sides.

To determine the thermal irradiation of a person using the distribution diagram method, it is necessary to know the exact dimensions of the shop, equipment, and the distance from the radiation source to the workplace [2]. Fig. 2 shows a diagram of the construction of the exposure distribution diagram for operators who are constantly engaged in hot work at the furnaces.

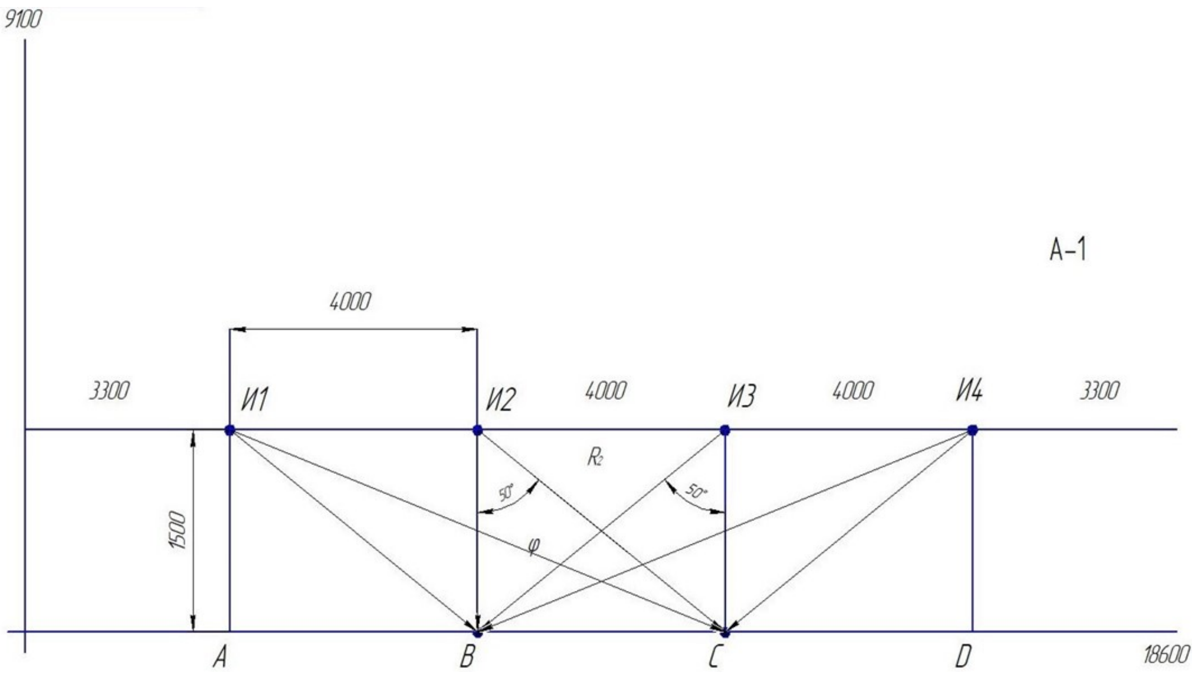

Fig. 2. Diagram for calculating the exposure distribution diagram of the furnace operator

Points A, B, C, D — four positions of the casters serving the furnace and realizing the technological process of carburizing the shanks. I1, I2, I3, I4— electric furnaces located at a close distance relative to each other. The temperature of each varies from 700 °C to 910 °C. Heat treatment mode: heating of the shanks and exposure to the carburizing medium.

Radiation intensity of the source that affects the employee:

$$E_0 = \varepsilon C_0 \left(\frac{T}{100}\right)^4, \quad (1)$$

whereε — the emissivity factor; C_0— the radiation coefficient of a black body radiator, W/(m^2·K) (C_o= 5,67); T— the temperature of the radiation source, K.

The radiation intensity when the cover of all four sources is open is equal to $E_0 = 69710{,}2$ W/m^2, when the cover is closed $E_0 = 1097{,}5$ W/m^2.

Thermal calculation of radiation acting on employees in four positions, W/m^2:

$$E_1 = \frac{E_0}{\pi r_1^2 cos\varphi_1}. \quad (2)$$

According to formula (2), we will combine all the data obtained in the calculation in table 1 and determine the class of working conditions for the operator of thermal equipment.

Table 1

Classes of working conditions depending on the thermal radiation of furnaces, W/m^2

	A	B	C	D
Oven windows I1,I2,I3,I4 are open	13478,2	14846,5	14846,5	13478,2
Classofworkingconditions	4	4	4	4
Oven windows I1,I2,I3,I4 are closed	212,2	233,7	233,7	212,2
Classofworkingconditions	3,1	3,1	3,1	3,1
Oven window I1 is open,I2,I3,I4 are closed	9923,9	2197,4	1207,4	829,1
Classofworkingconditions	4	3,3	3,1	3,1
Oven window I2 is open,I1,I3,I4 are closed	2175,9	9945,4	2197,4	1185,9
Classofworkingconditions	3,3	4	3,3	3,1
Oven window I3 is open,I1,I2,I4 are closed	1185,9	2197,4	9945,4	2175,9
Classofworkingconditions	3,1	3,3	4	3,3
Oven window I4 is open,I1,I2,I3 are closed	829,1	1207,4	2197,4	9923,9
Classofworkingconditions	3,1	3,1	3,3	4

As follows from the results of calculations, the sanitary and hygienic standard for the level of irradiation of open workplaces of the caster 140 W/m^2 is significantly exceeded (by 6-71 times)[1].

Improper placement of furnaces can create adverse situations in which workers are exposed to infrared radiation from almost all sides. So-called heat pockets are formed and there are conditions under which the norms of thermal insulation of the body of workers are violated.

According to the distribution diagrams method described above, we will check how effective the redevelopment of the production premises is, whether it helps to reduce heat dissipation and thereby improve the class of working conditions [3].

Using the principle of "protection by distance", we have calculated mathematically according to the scheme of the shop, at what maximum possible distance from each other the electric furnaces I1, I2, I3, I4 and the foundry workers should be. The diagram of irradiation of workers during the re-planning of equipment in the shop is shown in Fig. 3.

[1]Gigienicheskietrebovaniya k mikroklimatuproizvodstvennykhpomeshchenii.SanitarnyepravilainormySanPiN 2.2.4.548-96 [Hygienic requirements for the microclimate of industrial premises.Sanitary rules and regulations SanPiN 2.2.4.548-96].Goskomsanepidnadzor of Russia.Rossiiskayagazetaot 1stOctober 1996. Available from: https://rg.ru/2010/07/15/sanpin548-dok.html.

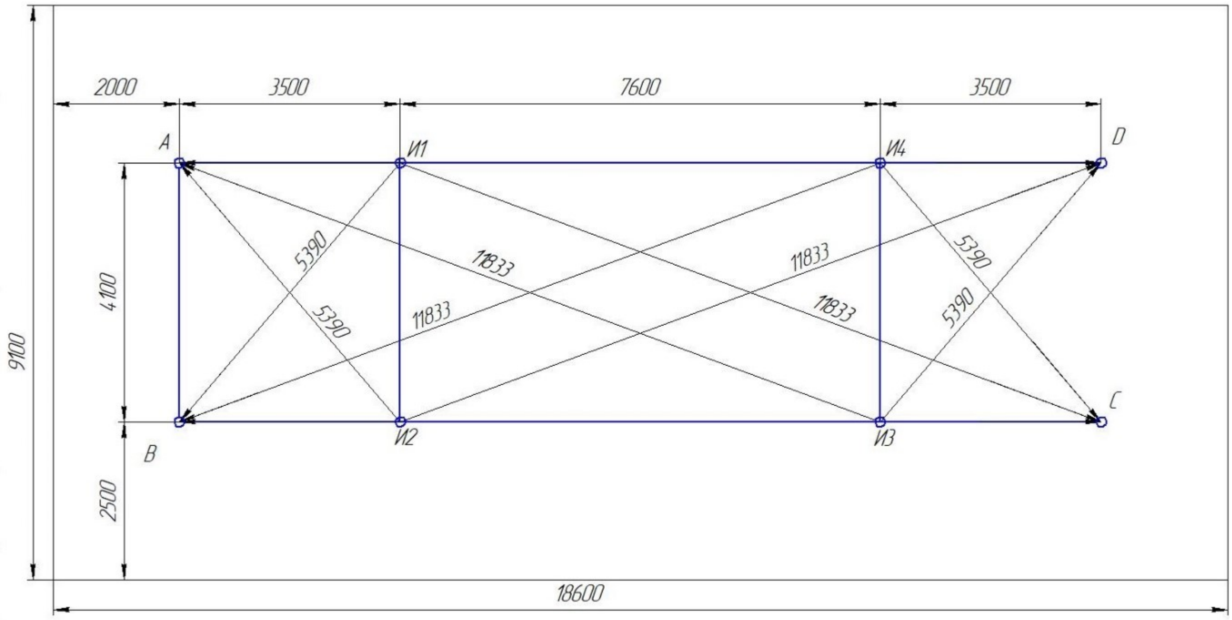

Fig. 3. Scheme for calculating the exposure distribution diagrams of workers when moving equipment in the foundry

Having made similar calculations for the shop with a new layout of equipment and working places change, in table 2 we will summarize the results of calculations of heat radiance of electric furnace operators.

Table 2

Classes of working conditions depending on the thermal radiation of furnaces after the redevelopment of the shop, W/m^2

	A	B	C	D
Oven windows I1,I2,I3,I4 are open	3431,3	3431,3	3431,3	3431,3
Classofworkingconditions	4	4	4	4
Oven windows I1,I2,I3,I4 are closed	53,9	53,9	53,9	53,9
Classofworkingconditions	2	2	2	2
Oven window I1 is open,I2,I3,I4 are closed	1837,7	1032,2	491,8	231,3
Classofworkingconditions	3,2	3,1	3,1	3,1
Oven window I2 is open,I1,I3,I4 are closed	1032,2	1837,7	231,3	491,8
Classofworkingconditions	3,1	3,2	3,1	3,1
Oven window I3 is open,I1,I2,I4 are closed	491,8	231,3	1837,7	1032,2
Classofworkingconditions	3,1	3,1	3,2	3,1
Oven window I4 is open,I1,I2,I3 are closed	231,3	491,8	1032,2	1837,7
Classofworkingconditions	3,1	3,1	3,1	3,2

When changing the location of the equipment, the intensity of thermal irradiation of workers significantly decreased. The sanitary and hygienic standard for the level of irradiation of open workplaces of operators of electric stoves 140 W/m^2 was exceeded by 1,6-13 times.

Changes in the classes of working conditions of employees before and after the redevelopment are presented in the form of a diagram (Fig. 4). Four conditions were related to the 4th class. After the transformation, such dangerous conditions are not recorded at the enterprise. Six conditions were in class 3.2 and were also completely eliminated. Accordingly, these ten conditions have become less dangerous. Now they belong to class 3.1, as it can be clearly seen in the diagram.

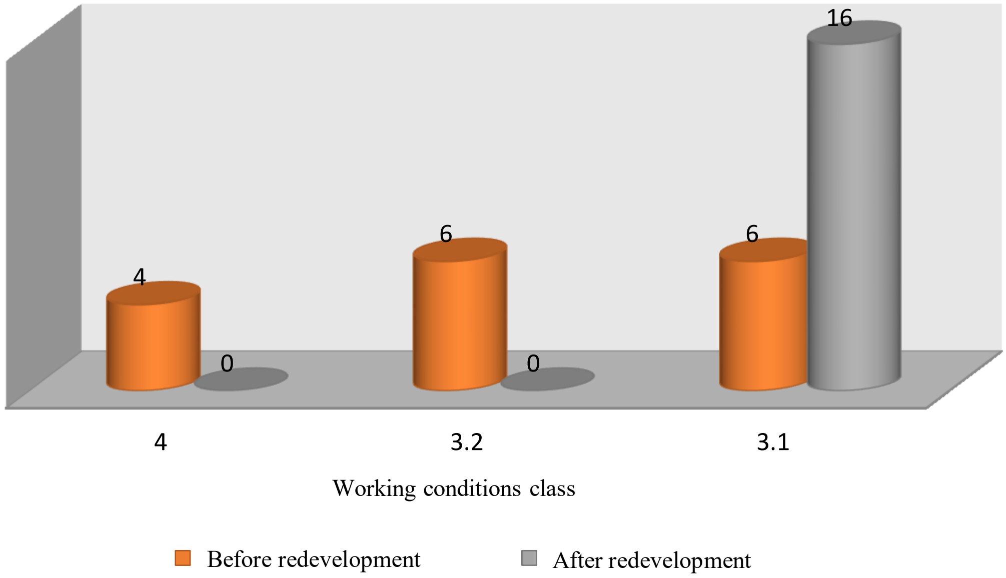

Fig. 4. Reduction of the hazard level of working conditions after the redevelopment of the shop

Thus, setting the optimal distance between the furnaces allowed us to reduce the class of working conditions to the 1st degree of harm (with the initial indicators of dangerous and harmful conditions of the 2nd degree [4]).

Conclusion. The operator of the electric furnace works in harmful conditions. One of the main factors that negatively affect the employee is the heating microclimate. Study of the intensity of thermal radiation of the workplace by distribution diagram method showed that alterations to industrial premises, as well as the protection distance will help reduce heat radiation and thus to ensure the compliance with sanitary and hygienic standards developed for industrial premises.

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Contribution of the authors:

N.A. Lyubetskaya — collection and analysis of literary data, participation in research, literary and patent analysis, text editing. I.V. Bogdanova — research methodology, problem statement, participation in research, critical analysis, editing. Yu.I. Bulygin — scientific supervision, formulation of the main research concept and structure of the article.