It has been shown that series (8) converges even when the number of terms is infinite. Taking some finite sum, we may estimate the error then obtained.

The figure gives curves of variation of the coefficients with Δq, $\Delta^2 q$ and $\Delta^3 q$ as a function of $x = r/b$.

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CHOICE OF NECESSARY THERMAL RESISTANCE OF EXTERIOR WALLS

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In actual buildings, heat transfer between the surrounding medium and the wall structure is unsteady. The method of technical thermal calculation recommended in the code [1] reduces the calculation of unsteady heat transfer to a steady calculation. Such a simplification is a first crude approximation, which may lead to large error under certain conditions.

To calculate unsteady heat transfer through the walls, the code [1] introduces the quantity thermal inertia (characteristic thermal inertia of the wall)

$$D = \sum_{i=1}^{n} R_i s_i = \sum_{i=1}^{n} \frac{\delta_i \omega^{1/2}}{a_i^{1/2}}, \tag{1}$$

where s_i is the assimilation factor $[s_i = (\lambda_i c_i \gamma_i \omega)^{1/2}]$; ω is the angular frequency of the temperature oscillation; $R_i = \delta_i/\lambda_i$ is the thermal resistance of the i-th layer.

As has been shown in [2,3], the quantity D is not a characteristic of the thermal inertia for multilayer and finite thickness structures. Therefore the calculation of an unsteady system and the correction of the calculated outside temperatures according to D in the expression for R_r is unjustified.

According to [1], the insulating value of outside walls must be not less than R_r, as determined from the formula

$$R_0^r = \frac{(t_{in} - t_{ex})\, nb}{\alpha_2 \Delta t^d}, \quad \text{or} \quad R_0^r = \frac{(t_{in} - t_{ex})\, nbR_h}{\Delta t^d}, \tag{2}$$

where t_{in}, t_{ex} are the internal and external temperatures, respectively; Δt^d is the temperature difference between the calculated temperature of the inside air and the temperature of the inside surface, and n, b are correction coefficients characterizing the location of the structure and the quality of the heat insulation (the advisability of introducing which gives rise to serious objections). Then the R value of the structure is corrected by a whole series of stipulations and recommendations, and it is noted, finally, that R should be increased by a factor of not more than 1.5 in comparison with R_0^r as determined from (2).

Thus, the code procedure for calculating an unsteady system makes use of a whole series of quantities and coefficients, the designation and meaning of which do not make physical sense, namely: D, the thermal inertia, s, Y, thermal assimilation factors, etc.

Solutions in general form were obtained in [4] for multilayer structures with boundary conditions of the first and third kinds and a harmonic temperature variation of the medium. The expression for the temperature on the inside surface has the form

$$t_s = t_{in} + (t_{ex} - t_{in})\frac{1}{\alpha_2 R} + \frac{2^{n-1} K_1 \ldots K_{n-1} \sqrt{2}\, t_m}{(K_1 + 1) \ldots (K_{n-1} + 1)\, \Delta_0^1}, \tag{3}$$

where t_{in} and t_{ex} are, respectively, the calculated internal and external temperatures; α_2 is the heat transfer coefficient on the inside; R is the thermal resistance of the structure; $\frac{2^{n-1} K_1 \ldots K_{n-1} \sqrt{2}}{(K_1 + 1) \ldots (K_{n-1} + 1)\, \Delta_n^1} = k$ is the damping of oscillations in the structure, which, as shown in [2], depends on Bi_1^*, Bi_2^*, K_i, h_i, D_i and D; $Bi_1^* = \alpha_1/(\lambda_1 c_1 \gamma_1 \omega)^{1/2}$, $Bi_2^* = \alpha_2/(\lambda_n c_n \gamma_n \omega)^{1/2}$ defines the heat transfer conditions at the boundary and the materials of the outside layers; $K_i = (\lambda_i c_i \gamma_i/\lambda_{i+1} c_{i+1} \gamma_{i+1})^{1/2}$, $h_i = (K_i - 1)/(K_i + 1)$ describes the nonuniformity of the structural material and the order of the layers; $D_i = R_i s_i$ characterizes the ratio of the geometric dimensions of the layers; and $D = \sum_{i=1}^{n} R_i s_i$ is the thermal inertia according to the code [1].

We will use (3) to choose the R_r of wall structures.

The limiting permissible temperature on the inside surface is the dew point temperature t_φ. Therefore,

$$t_\varphi > t_{in} + (t_{ex} - t_{in})\frac{1}{\alpha_2 R} + k t_m, \tag{4}$$

in which

$$R > \frac{t_{ex} - t_{in}}{\alpha_2 (t_\varphi - t_{in} + k t_m)}, \tag{5}$$

or for negative external temperatures

$$R \geq \frac{t_{in} - t_{ex}}{\alpha_2 (t_{in} - t_\varphi - k t_m)}. \tag{6}$$

Expression (6), of course, relates the choice of R_r to the calculated external and internal temperatures, the heat transfer conditions, the dew point temperature of the internal air, the amplitude of temperature oscillations of the external air, t_m, and the damping of the oscillations, k.

If we calculate the heat flux, using the expression given in [2] for the temperature field, it is divided into two terms, a constant component and a variable component. The ratio of the amount of heat transmitted through the wall due to the variable component (per half period) to the amount transmitted through the wall due to the constant component (per half period) will be termed the nonuniformity of heat loss; as calculations show [3], this quantity varies strongly for different walls.

Therefore, the second requirement to determine the suitability of structures must be the nonuniformity of heat loss (depending on the type and regime of operation of the heaters (or coolers)).

We consider that the choice of R_r should be determined by the following conditions:

a) the R of the structure must not be less than R_r, determined from (5) and (6);

b) for given conditions (amplitude of oscillations) the nonuniformity of heat loss must not exceed the assigned value A. The value of A is determined depending on the purpose and type of building, the inertia of the heat sources, and the ratio of the cost of cold-storing elements to cooling plant power.

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