HEAT TRANSFER OF MULTIPLE-VOID SLABS HEATED BY AIR

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It is experimentally shown that if the initial temperature of the air is taken as the determining temperature, then the heat transfer for three regimes of motion is satisfactorily described by a single generalized relationship.

Buildings in the Soviet Union have recently been constructed in which there is a system for radiant heating using air as the heat-transfer agent [1-3]; slabs containing voids in the ceilings and floors serve as heating devices. The operational regime of the system is characterized by a small flow rate of air in the voids of the slabs. The Reynolds numbers vary from 0.6 to $5.0 \cdot 10^3$, and within these limits there are no reliable data for determining the heat-transfer coefficient.

In the transitional region, as is indicated by Mikheev [4], the results of different experimental investigations noticeably differ. For the development of a reliable method of calculation we experimentally studied the heat transfer of multiple-void slabs of series II-04-4 with passage of air through all the voids, or with two or four of the voids closed off. Investigations were carried out on a test slab, cut in half. The width of this slab, in such calculations, is assumed to be such that the heat transfer in its outer surfaces is self-similar. For development and preparation of a test slab, special attention was paid to the method of measuring the void wall temperatures. The temperature of the heated air was measured at the beginning, middle, and end of a void in the slab.

Under natural conditions, on the upper surface of the ceiling and floors it is usual to have a certain thermal resistance. In order to imitate these conditions, investigations were also carried out with additional thermal resistance (R_{add}), equal, respectively, to 0.0, 0.16, 2.32, and 3.49 $m^2 \cdot °C/W$.

The general form of the test apparatus is shown in Fig. 1. For processing the results of the investigations the initial temperature of the heated air is assumed to be the determining temperature. Accordingly, the mean value of the heat-transfer coefficient was determined from the equation

$$\alpha = \frac{Gc\Theta}{\pi l L (t_{in} - t_W)} . \tag{1}$$

After the heat-transfer coefficients were calculated, the Nusselt and Reynolds numbers were determined. In calculations for radiant-heating systems with air and the heat-transfer agent, it is convenient to use the mass flow rate of air ($w\rho$). Taking this into account, the Reynolds number was determined from the equation

$$\mathrm{Re} = \frac{w\rho l}{\eta} . \tag{2}$$

Results of the tests are shown in Fig. 2. From the graph we see that if the initial air temperature is taken as the determining temperature, then heat transfer for all regimes of motion in the voids of the slabs is satisfactorily described by the single generalized relation $\mathrm{Nu} = 0.038\ \mathrm{Re}^{0.72}$, which confirms the theoretical considerations given in [5].

NOTATION

α, heat-transfer coefficient; G, flow rate of the air; c, specific heat of the air; Θ, change in temperature of the heated air; l, slab void diameter; L, operating length of the slab void; t_{in}, initial temperature of the heated air; t_W, wall void temperature; Re, Reynolds number; w, air velocity; ρ, density; η, dynamic viscosity; and Nu, Nusselt number.

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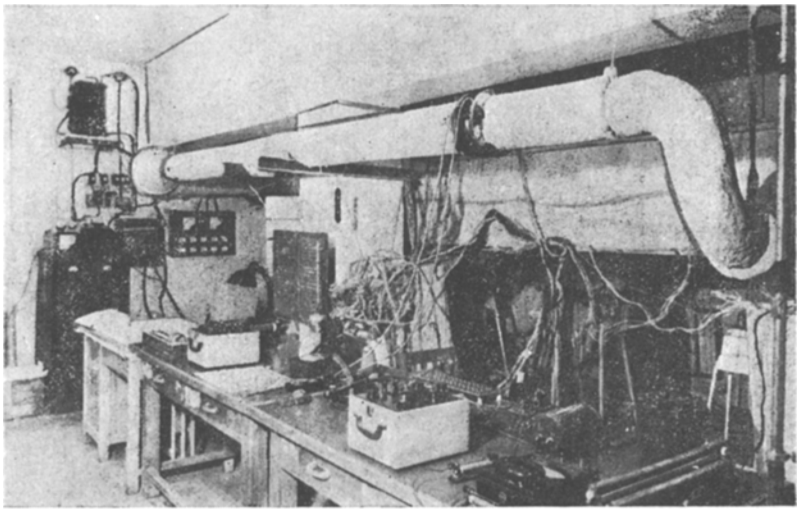

Fig. 1. General form of the test apparatus.

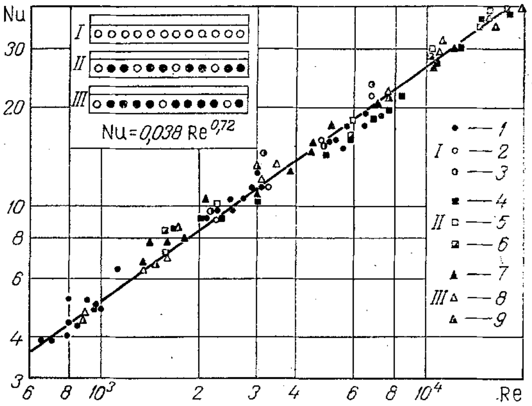

Fig. 2. Heat transfer of a multiple-void slab of length 5.6 m with passage of air through all the voids or with two and four of the voids closed off: 1) $R_{add} = 0$; 2) 1.16; 3) 3.49; 4) 0; 5) 1.16; 6) 3.49; 7) 0; 8) 1.16; and 9) 2.39.

LITERATURE CITED

1. V. F. Polikarpov, L. P. Ananikyan, and N. F. Bizyukin, "Results of investigations of the operation of a test system of radiant heating with air as a heat-transfer agent," in: Heating and Ventilation of Residential, Public, Industrial, and Manufacturing Agricultural Structures [in Russian], No. 23, Stroiizdat, Moscow (1967), pp. 135-144.
2. L. P. Ananikyan, A. F. Matveev, and I. A. Liberman, "Houses with radiant panel heating," Na Stroikakh Rossii, No. 7, 38-42 (1969).
3. V. Z. Pavlov, "Flow distribution in heated panels of radiant heating systems," Izv. Vyssh. Uchebn. Zaved., Stroit. Arkhit., No. 4, 136-141 (1972).
4. M. A. Mikheev, Foundations of Heat Transfer [in Russian], Gosénergoizdat, Moscow–Leningrad (1949), pp. 103-104.
5. S. N. Shorin, Heat Transfer [in Russian], Vysshaya Shkola, Moscow (1964), pp. 332-333.