INTERNAL NATURAL CONVECTION FOR A DEFLECTED HEAT SOURCE OF FINITE SIZE

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UDC 536.25

Experimental results obtained by studying internal natural convection in a model commensurable in height with the height of the deflected heat source are presented and discussed.

In the machine rooms of thermal power stations and in chemical and textile factories the heat evolution of the equipment is often accompanied by harmful impurities which create unpleasant working conditions. Despite the fact that the heat-emitting equipment is often localized and does not require constant attention by servicing personnel, ventilation has to be organized in order to normalize the conditions of work. In such cases it is convenient to use the method of partial ventilation [1] or deflection of the heat sources [2].

In order to confirm the efficiency of the latter we carried out some experiments in a shadow apparatus based on the OSK-3 optical bench, using a parallel beam with a rectilinear Ronka grating arranged in the second focal plane of the principal object in the receiving part of the apparatus [3]. The model was made of Plexiglas and constituted a cavity in the form of a rectangular parallelepiped $70 \times 70 \times 130$ mm^3 in size. The wall thickness was 30 mm. The model was filled with distilled water at 21°C and arranged with its long face parallel to the optic axis of the apparatus. The heater was 130 mm long and 43.5 mm high; it was fixed in the middle of the lower face of the model. Parallel to the optic axis of the apparatus and the plane of the heater and at a distance of 5 mm from the latter, plane Teflon deflectors 20 mm high and 2.5 mm thick were placed.

On connecting the current of the 32.5 W heater a temperature field was created in the model (which formed a thermally-insulated region); the Töpler patterns of these fields taken 105 and 210 sec from the initiation of the heat source are respectively shown in Fig. 1a and b. The alternating light and dark bands (sometimes lines) correspond to regions of equal gradient of the refractive index of the medium, and hence to equal temperature gradients. Using the theory of the shadow method [4] and the temperature dependence of the refractive index of water [5], we may calculate the temperature distribution over the height of the insulated space. An analysis of the shadow-pattern calculations shows that the temperature field created

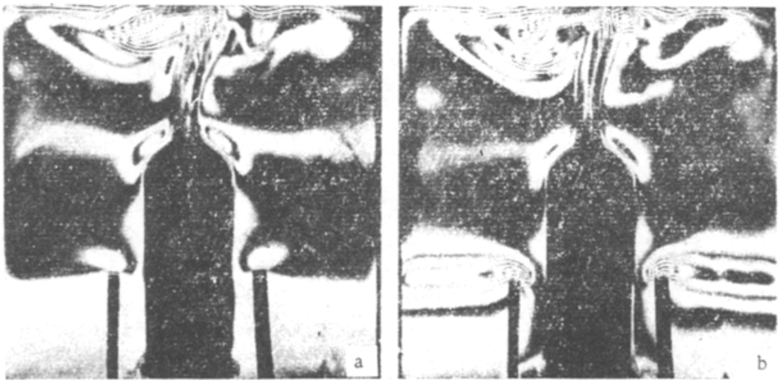

Fig. 1. Shadow photographs (Töpler patterns) of the model under test: a), b) 105 and 210 sec, respectively, after the initiation of the source.

Perm Polytechnic Institute. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 27, No. 3, pp. 457-459, September, 1974. Original article submitted December 30, 1973.

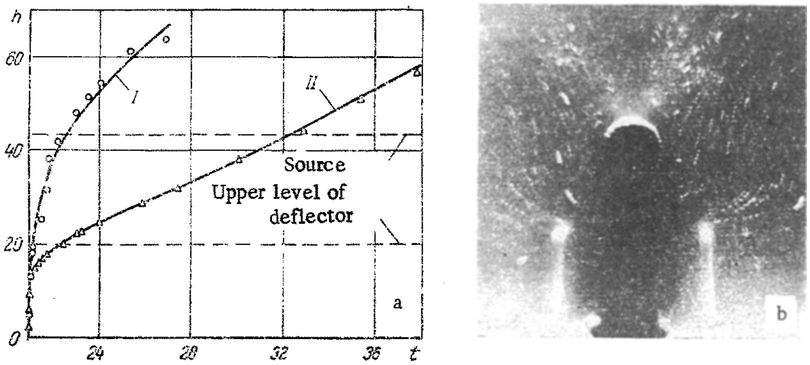

Fig. 2. Temperature distribution over the height of the test volume (a) (I, II represent conditions 105 and 210 sec after the initiation of the source), and photograph of the motion of light-scattering particles (b) (h, mm; t, °C).

in the model after 105 sec basically retains its form over the next 105 sec, but is distorted by the effects of conduction after about 330 sec. The photographs presented in Fig. 1a and b clearly show the sharp boundary of the zone unperturbed by convective mixing at the level of the deflector, and also the zones in which temperature gradients exist. The results of an analysis of the shadow pictures of Fig. 1a and b are presented in Fig. 2 as curves I and II respectively, and convincingly support the foregoing conclusion. Analysis of the Töpler patterns was carried out in a section equally distant from the deflector and the side wall of the model. The existence of different zones is also confirmed by photographs of the motion of light-scattering particles illuminated by a pulsed light source. Figure 2b shows a characteristic photograph (taken approximately 210 sec after the connection of the heater) of the central section of the model cut by a light "knife," using four lamp flashes following each other at intervals of 2.56 sec. Thus each moving particle marks the track in the form of a chain of four points, along which we may estimate the velocities at various points of the test volume. A study of Fig. 2b indicates that there is hardly any motion in the zone bounded by the deflectors and the side walls of the model, so that this region is not embraced by convection; the particle velocities are greatest at the level of the edges of the deflector, and there is strong horizontal flow of liquid due to advection; in the zone of equal gradients (above the edges of the deflector) the flow is vertical and ordered; in the zone of the convective jet above the heat source the motion of the liquid is turbulized — the velocity varies in direction and magnitude.

Thus the model experiment here described confirms the possibility of controlling the formation of a temperature field in such a volume by mechanical deflection of the heat source. If a workshop or factory contains heat-emitting equipment not requiring the constant access of servicing personnel, it is desirable to separate out a working zone for this equipment by means of deflectors, so creating any desired conditions without interrupting the technological process. We should note that in order to convert the results of the model experiment to the full-scale object we must use the distance between the upper edge of the deflector and the upper boundary of the model as defining dimension for the corresponding similarity criteria.

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