The change in the orientation of the evaporation head (horizontal and vertical positions) and also the increase in the temperature of the cooling water to 60°C had an insignificant effect on the amount of the removed power and the temperature within the heater.

NOTATION

d, l, diameter and length of the porous sample, respectively; \( T_1 - T_{10} \), temperatures, measured by the thermocouples 1-10 (Fig. 1); \( \Delta T = T_5 - T_3 \), radial temperature drop along the wick; \( Q \), supplied power; \( Q_{300}^o \), \( q_{300}^o \), supplied power, supplied heat-flux density, heat-transfer coefficient at the temperature \( T_8 = 300°C \), respectively.

LITERATURE CITED


THREE-DIMENSIONAL RADIATIVE HEAT-TRANSFER PROBLEM WITH SHADING

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The problem of radiative heat transfer between diffuse gray surfaces bounding a closed volume of arbitrary configuration is discussed.

Often in calculations of the heating of airframe structures it is necessary to solve problems of radiative heat transfer between the surfaces of various structural elements forming the interior compartments of an aircraft. In many cases the entire bounding surface is nonconvex and has such a complex configuration as to present serious difficulties in applying the zonal method.

For situations in which one of the dimensions of such a bounded volume is much greater than all the rest, we have proposed [1] a method for solving the planar radiative heat-transfer problem with allowance for shading and have demonstrated the substantial influence of this factor on the distribution of \( q_{inc} \) over the surface of compartments of real structures. In the present study we elaborate the method of analysis of radiative heat transfer with allowance for shading in the three-dimensional case.

We consider the problem of radiative heat transfer between diffuse gray surfaces bounding a closed volume of arbitrary configuration. An open volume can be closed by the addition of a fictitious surface with \( e = 1 \) and \( T = (q_{inc}/\sigma)^{1/4} \), where \( q_{inc} \) is the dissipated heat flux from the surrounding medium.

We assume that the bounding surface comprises \( N \) plane faces having the shape of a convex rectangle. These are actually the kind of surfaces that occur in the majority of real problems, and any continuous surface can always be approximated with sufficient accuracy by a system of plane faces. The temperature and emissivity distributions over each face are variable.

The radiative heat transfer in such a region is described by a system of Fredholm integral equations of the second kind in the incident flux density:

\[
q_{inc}(p_i) = \sum_{j=1}^{N} \int_{F_j} \left\{ \sigma(p_j) T^4(p_j) \right\} \left[ 1 - \epsilon(p_j) \right] q_{inc}(p_j) K(p_i, p_j) dF_j, \quad (1)
\]

where \( K(p_i, p_j) \) is a function of the angular coefficients.

\[
K(p_i, p_j) = K(p_i, p_r) = \begin{cases} 
\cos \varphi_i(p_i, p_j) \cos \varphi_j(p_i, p_r) & \text{if } \kappa = 0, \\
0 & \text{if } \kappa = 1,
\end{cases}
\]

(2)

\(\varphi_i\) and \(\varphi_j\) are the angles between the normals to the \(i\)-th and \(j\)-th faces and the line segment of length \(R(p_i, p_j)\) joining points \(p_i\) and \(p_j\), and \(\kappa\) is the visibility parameter: The point \(p_i\) "sees" the point \(p_j\) for \(\kappa = 0\) and does not see it for \(\kappa = 1\).

Points \(p_i\) and \(p_j\) are mutually visible if the angles between the normals to the surfaces on which the points are situated and the segment \([p_i, p_j]\) have absolute values less than \(\pi/2\), i.e., if

\[
\cos \varphi_i(p_i, p_j) > 0, \quad \cos \varphi_j(p_i, p_r) > 0
\]

(3)

and the segment \([p_i, p_j]\) does not intersect any faces of the surface other than the \(i\)-th and \(j\)-th faces. The latter conditions holds if either the segment does not intersect the planes through these faces, i.e.,

\[
|2t_k - 1| > 1, \quad k = 1, 2, \ldots, N, \quad k \neq i, j
\]

(4)

where

\[
t_k = \frac{A_kx_k + B_ky_k + C_kz_k + D_k}{A_k(x_j - x_i) + B_k(y_j - y_i) + C_k(z_j - z_i)},
\]

and \(A_k, B_k, C_k, D_k\) are the coefficients of the equation for the plane passing through the \(k\)-th face, which are expressed in terms of the coordinates of three corners of the face:

\[
x \quad y \quad z \quad 1
\]

\[
x_{1,k} \quad y_{1,k} \quad z_{1,k} \quad 1
\]

\[
x_{2,k} \quad y_{2,k} \quad z_{2,k} \quad 1
\]

\[
x_{3,k} \quad y_{3,k} \quad z_{3,k} \quad 1
\]

or the point of intersection \(p_k\) does not belong to the \(k\)-th face, as is indicated by failure of at least one of the conditions

\[
t_{h+s} > 1, \quad s = 1, 2, 3, 4
\]

(5)

where

\[
t_{h+s} = \frac{(x'_{s+1} - x'_s)(y'_{s+1} - y'_s) - (x'_{s+1} - x'_s)(y'_{s+1} - y'_s)}{(x'_s - x'_{s+1})(y'_s - y'_{s+1}) - (x'_s - x'_{s+1})(y'_{s+1} - y'_s)}, \quad s = 1, 2, 3, 4
\]

\[
x'_{s+1} = x'_s, \quad y'_{s+1} = y'_s
\]

\[
x'_s = \frac{1}{4} \sum_{s=1}^{4} x'_s, \quad y'_s = \frac{1}{4} \sum_{s=1}^{4} y'_s
\]

(6)

\(x'_s, y'_s (s=1, 2, 3, 4)\), \(x'_{h+s}, y'_{h+s}\) are the coordinates of the corners of the \(k\)-th face and the point of intersection in the local coordinate system \(0x'y'\).

We now proceed with the solution of the system of equations (1). On each face we overlay a variable-step computing grid with boundary points situated at the faces (see Fig. 1). We denote the number of grid nodes on the \(j\)-th face by \(M_j = SR\), and the number of mesh cell by \(L_j = (S - 1)(R - 1)\), where \(S\) and \(R\) are the numbers of nodes in the direction of the axes \(0x'\) and \(0y'\), respectively. We enumerate the cells in such a way that

\[
l = s + (r - 1)(S - 1), \quad s = 1, 2, \ldots, S, \quad r = 1, 2, \ldots, R
\]

and the order numbers of the nodes comprising the corners of these cells are, respectively,

\[
m_{1,s} = s + (r - 1)S,
\]

\[
m_{2,s} = s + rS, \quad s = 1, 2, \ldots, S
\]

\[
m_{1,r} = s + 1 + rS, \quad r = 1, 2, \ldots, R
\]

\[
m_{2,r} = s + 1 + (r - 1)S
\]

(7)

From the system of equations (1) we obtain the following expression for the incident flux density at the nodes: