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NUMERICAL SIMULATION OF THE THERMAL PROCESS IN THE PERFORATED GRAPHITE SHEET BY MESHLESS METHOD

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This paper presents the numerical simulation results of the thermal process in a perforated graphite sheet obtained by meshless method for solving three-dimensional non-stationary heat conduction problems in anisotropic solids [1, 2].

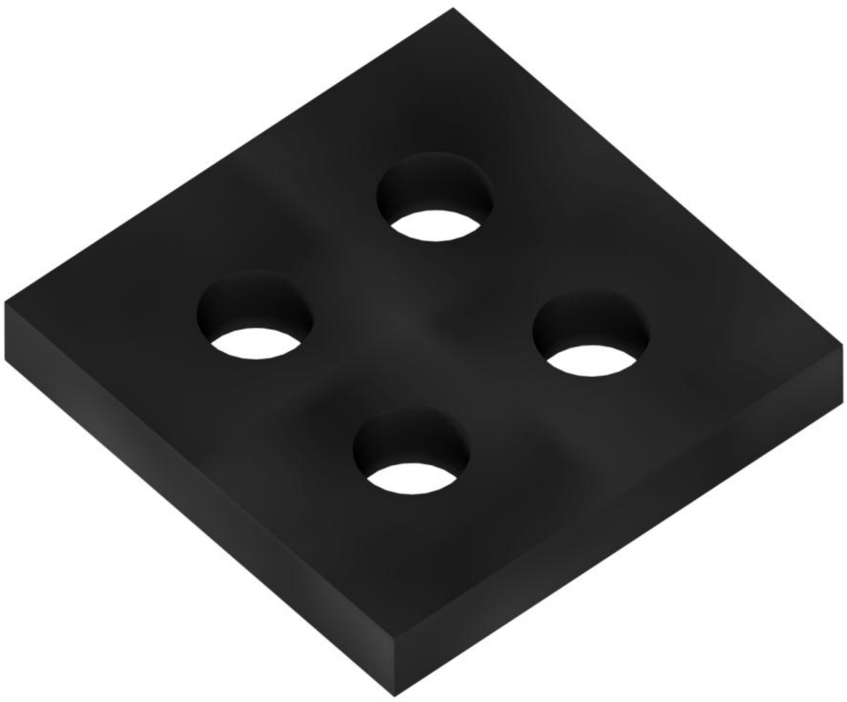


Fig. 1. **Visualization of the domain of the boundary-value problem**

Consider the perforated graphite sheet in the form of a rectangular parallelepiped, which has dimensions of 20×20×3 mm with holes 4 mm in diameter, shown in Fig. 1.

Physical properties of the perforated graphite sheet: density is $\rho = 1650$ kg/m^3; the thermal conductivity along the [001] direction is $k_{\parallel} = 151.2$ W/(m×K); the thermal conductivity in the (001) plane is $k_{\perp} = 98.9$ W/(m×K); the specific heat at constant pressure is $c_p = 720$ J/(kg×K). The optic axis is directed along the z-axis.

The non-stationary heat conduction equation for an anisotropic solid in a closed domain can be written as follows:

$$\rho c_p \frac{\partial u}{\partial t} = \text{div}\big(K \, \text{grad}(u)\big)$$

where:
ρ – density, c_p – specific heat at constant pressure, u – temperature, K – symmetric positive definite thermal conductivity tensor.

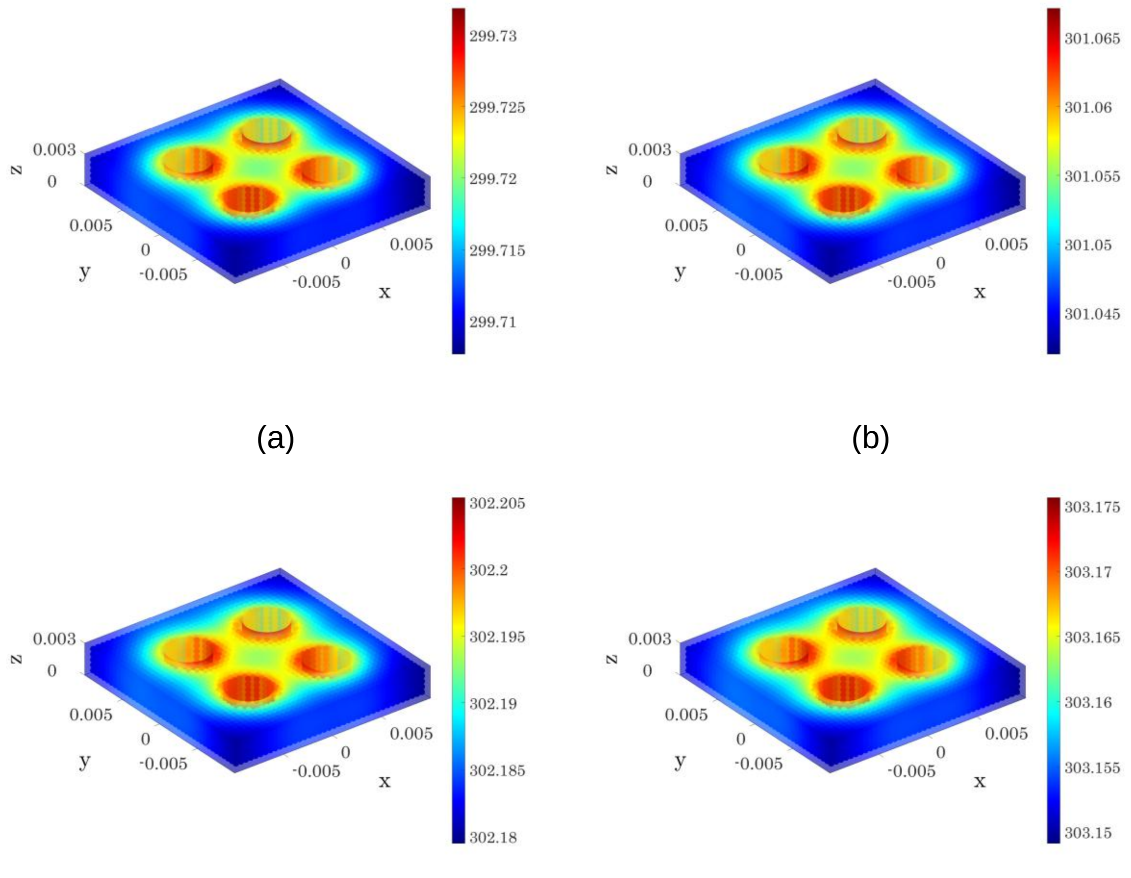
At the initial moment of time, the perforated graphite sheet is at a temperature of $u_0 = 298.15$ K. A constant heat flux of $q_0 = 1000$ W/m^2 is set on the surface of each of the holes in the perforated graphite sheet. Heat exchange with the environment occurs on other parts of the surface of the perforated graphite sheet. The boundary conditions for this boundary-value problem can be written as

heat flow: $q = -q_0$,

heat exchange: $q = -h(u_\infty - u)$

where:
$q = \frac{\partial u}{\partial \nu}$ *– heat flux in anisotropic medium,* $h \sim 15$ *W/(m^2×K) – heat transfer coefficient,* $u_\infty = 298.15$ *K – ambient temperature.*

The number of interpolation nodes inside and on the boundary of domain of the heat conduction problem for all calculations is $N_d = 6225$ and $N_b = 3536$, respectively. The time interval of the non-stationary boundary-value problem is 60 s with a time step 0.1 s.



(c) (d)

Fig. 2. **Visualization of the temperature field distribution inside the perforated graphite sheet at times *t* = 15 s (a), *t* = 30 s (b), *t* = 45 s (c), *t* = 60 s (d)**

Fig. 2 shows the simulation results of the temperature field distribution inside the perforated graphite sheet at different times.

References:

[1] Protektor, D. O., Kolodyazhny, V. M., Lisin, D. O. & Lisina, O. Yu. (2021). A Meshless Method of Solving Three-Dimensional Nonstationary Heat Conduction Problems in Anisotropic Materials. *Cybernetics and Systems Analysis*, (57), 470-480. DOI: https://doi.org/10.1007/s10559-021-00372-8

[2] Protektor, D. (2021). Family of the Atomic Radial Basis Functions of Three Independent Variables Generated by Helmholtz-Type Operator. *East European Journal of Physics*, (4), 49-58. DOI: https://doi.org/10.26565/2312-4334-2021-4-05