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RESEARCH ARTICLE OPEN ACCESS

HEAT TRANSFER IN THE AREA

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ABSTRACT

O objetivo dessa Temperature control in computers, mobile devices and other devices is important for their stability. The finite differences method is used to calculate the temperatures in fixed nodes of devices, in the absence of internal heat dissipation and certain boundary conditions of the inner walls.

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INTRODUCTION

We will use the finite difference method to solve the stationary thermal conductivity in three-dimensional case.We will divide a solid body (device) into elementary parallelepipeds.

II. FINITE DIFFERENCES METHOD

For node 0 (Fig. 1), surrounded by6 nodes (1,2,3,4,5,6), the energy balance is:

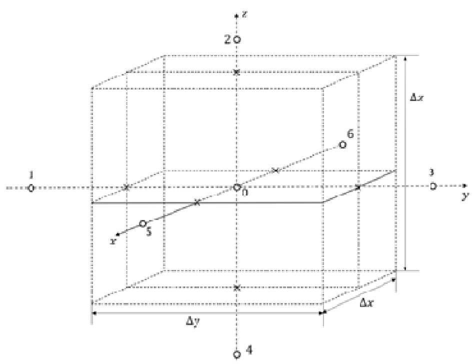


Fig. 1

$q_{1\to 0} + q_{2\to 0} + q_{3\to 0} + q_{4\to 0} + q_{5\to 0} + q_{6\to 0} = 0$

From Fourier's law we get:

$$k\Delta x\Delta z = \frac{T_1 - T_0}{\Delta y} + k\Delta x\Delta y\frac{T_2 - T_0}{\Delta z} + k\Delta x\Delta z\frac{T_3 - T_0}{\Delta y} + k\Delta x\Delta y\frac{T_4 - T_0}{\Delta z} + k\Delta y\Delta z\frac{T_5 - T_0}{\Delta x} + k\Delta y\Delta z\frac{T_6 - T_0}{\Delta x} = 0$$

If$\Delta x = \Delta y = \Delta z$(i.e., cubic nodes) the equation will be:

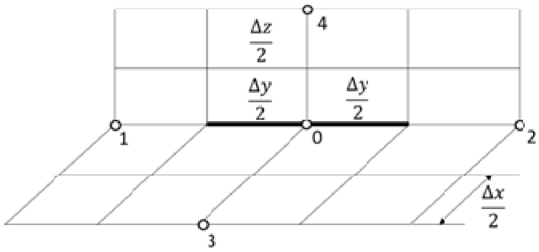
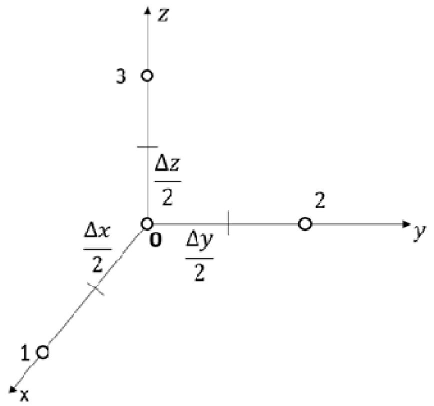


Fig. 2.

$$T_1 + T_2 + T_3 + T_4 + T_5 + T_6 - 6T_0 = 0$$

For node 0(Fig. 2) at the edge (the rear wall is thermally insulated and the main one is connected to the external environment) the equation is:

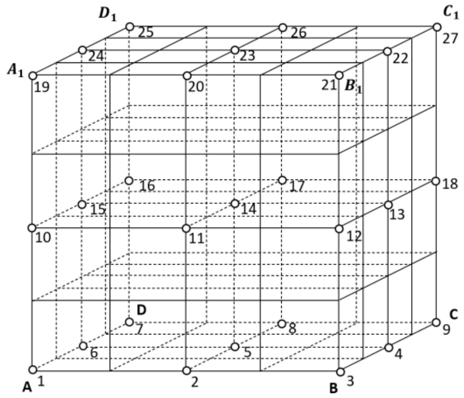
$$k\Delta y\frac{\Delta z}{2}\frac{T_3 - T_0}{\Delta x} + k\frac{\Delta x}{2}\Delta y\frac{T_4 - T_0}{\Delta z} + k\frac{\Delta x}{2}\frac{\Delta z}{2}\frac{T_1 - T_0}{\Delta y} + k\frac{\Delta x}{2}\frac{\Delta z}{2}\frac{T_2 - T_0}{\Delta y} + hc\Delta y\frac{\Delta x}{2}(T_\infty - T_0) = 0$$



For node0of the device (Fig. 3) with walls $x0y$and$y0z$– thermally insulated and the base is in contact with the external environment, the equation for the nodes1,2 and 3 is:

$$k\frac{\Delta y}{2}\frac{\Delta z}{2}\frac{T_1 - T_0}{\Delta x} + k\frac{\Delta x}{2}\frac{\Delta z}{2}\frac{T_2 - T_0}{\Delta y} + k\frac{\Delta x}{2}\frac{T_3 - T_0}{\Delta z} + hc\frac{\Delta x}{2}\frac{\Delta y}{2}(T_\infty - T_0) = 0$$

Example: A cube-shaped microelectronic device $ABCDA_1B_1C_1D_1$ c $AB = 0{,}2\ m$, divided into cubes with $\Delta x = \Delta y = \Delta z = 0{,}1\ m$and nodes from $1 \div 27$ (Fig. 4)



The equation for node 5is:

$$k\Delta x\frac{\Delta z}{2}\frac{T_2-T_5}{\Delta y}+k\Delta x\frac{\Delta z}{2}\frac{T_8-T_5}{\Delta y}+k\Delta y\frac{\Delta z}{2}\frac{T_6-T_5}{\Delta x}+k\Delta y\frac{\Delta z}{2}\frac{T_4-T_5}{\Delta x}+k\Delta x\Delta y\frac{T_{14}-T_5}{\Delta z}++hc\Delta x\Delta y(T_\infty-T_5)=0$$
$(\Delta x=\Delta y=\Delta z=0{,}1)$
$$T_2-T_5+T_8-T_5+T_6-T_5+T_4-T_5+2(T_{14}-T_5)+\frac{hc.2\Delta z}{k}(T_\infty-T_5)=0$$
$$T_2+T_8+T_6+T_4+2T_{14}-6T_5+\frac{40.0{,}1.2}{10}(20-T_5)=0$$
$$50+T_8+40^0+60^0+2T_{14}-6{,}8T_5=-16$$
$$-6{,}8T_5+T_8+2T_{14}=-166$$

The equation for node8is:

$$k\Delta x\frac{\Delta z}{2}\frac{T_5-T_8}{\Delta y}+k\frac{\Delta y}{2}\frac{\Delta z}{2}\frac{T_7-T_8}{\Delta x}+k\frac{\Delta y}{2}\frac{\Delta z}{2}\frac{T_9-T_8}{\Delta x}+k\Delta x\frac{\Delta y}{2}\frac{T_{17}-T_8}{\Delta z}+hc\Delta x\frac{\Delta y}{2}(T_\infty-T_8)=0$$
$$2(T_5-T_8)+T_7-T_8+T_9-T_8+2(T_{17}-T_8)+\frac{2.40.0{,}1}{10}(20-T_8)=0$$
$$2T_5+T_7+T_9+2T_{17}-6{,}8T_8=-16$$
$$2T_5+40+60+2T_{17}-6{,}8T_8=-16$$
$$2T_5+2T_{17}-6{,}8T_8=-116$$
$$T_5-3{,}4T_8+T_{17}=-58$$

The equation for node14is:

$$k\Delta x\Delta y\frac{T_5-T_{14}}{\Delta z}+k\Delta x\Delta y\frac{T_{23}-T_{14}}{\Delta z}+k\Delta y\Delta z\frac{T_{15}-T_{14}}{\Delta x}+k\Delta y\Delta z\frac{T_{13}-T_{14}}{\Delta x}++k\Delta x\Delta z\frac{T_{11}-T_{14}}{\Delta y}+k\Delta x\Delta y\frac{T_{17}-T_{14}}{\Delta z}=0$$
$$T_5-T_{14}+T_{23}-T_{14}+T_{15}-T_{14}+T_{13}-T_{14}+T_{11}-T_{14}+T_{17}-T_{14}=0$$
$$T_5+T_{23}+T_{15}+T_{13}+T_{11}+T_{17}-6T_{14}=0$$
$$T_5+30+40+60+50+T_{17}-6T_{14}=0$$
$$T_5-6T_{14}+T_{17}=-180$$

The equation for node17is:

$$k\Delta x\frac{\Delta y}{2}\frac{T_{26}-T_{17}}{\Delta z}+\Delta x\frac{\Delta y}{2}\frac{T_8-T_{17}}{\Delta z}+k\frac{\Delta y}{2}\Delta z\frac{T_{18}-T_{17}}{\Delta x}+k\frac{\Delta y}{2}\Delta z\frac{T_{16}-T_{17}}{\Delta x}+k\Delta x\Delta z\frac{T_{14}-T_{17}}{\Delta y}=0$$
$$T_{26}-T_{17}+T_8-T_{17}+T_{18}-T_{17}+T_{16}-T_{17}+2T_{14}-2T_{17}=0$$
$$T_{26}+T_8+T_{18}+T_{16}+2T_{14}-6T_{17}=0$$
$$30+T_8+60+40+2T_{14}-6T_{17}=0$$
$$T_8+2T_{14}-6T_{17}=-130$$

The system of equations for the four nodes is:

Node 5: $-6{,}8T_5+T_8+2T_{14}=-166$
Node 8: $T_5-3{,}4T_8+T_{17}=-58$
Node 14: $T_5-6T_{14}+T_{17}=-180$
Node 17: $T_8+2T_{14}-6T_{17}=-130$

The result is:

$T_5=43{,}815^0$
$T_8=42{,}786^0$
$T_{14}=44{,}579^0$
$T_{17}=43{,}657^0$

CONCLUSION

The temperature information in the fixed nodes of the device helps to turn off the device or move its components in different places inside the body.

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