HAMMA LAKHDAR UNIVERSITY OF EL-OUED
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1st Y. Sc. Masters in Energetics
Intermediate Heat & Mass Transfer

Take Home Exercises. Generalities & Thermal conduction. Bundle N°1

Ex.01: A heating device containing an electrical resistance of 1.2 kW of power, whose thermal conductivity is $\lambda = 10.4\ Btu/h.ft \cdot °F$, has a radius $r_0 = 0.06$ in, and a length $L = 15\ in.$ and is used for heating a certain space. Assuming that the thermal conductivity is constant and the heat transfer is 1D, express the mathematical formulation (the *differential equation* and the *boundary conditions*) of this heat conduction problem during the steady state. (Do not resolve.)

Ex.02: Consider a double-paned window having a height of 1.2 m and a width of 2 m, and consisting of two layers of glass 3 mm thick ($\lambda = 0.78\ W/m \cdot °C$) separated by a layer of stagnant air, 12 mm thick ($\lambda = 0.026\ W/m \cdot °C$). Determine the stationary rate of heat transfer through this window and the temperature of its interior surface for a day during which the room is maintained at 24°C while the temperature outside is $-5°C$. Take the convection heat transfer coefficients of the interior and exterior surfaces of the window to be $h_1 = 10\ W/m^2 \cdot °C$ and $h_2 = 25\ W/m^2 \cdot °C$ and neglect the heat transfer by radiation. (Answers: 114 W, 19.2°C)

Ex.03: Consider a glass window 1.2 m high and 2 m wide, whose thickness is 6 mm and the thermal conductivity is $\lambda = 0.78\ W/m \cdot °C$. Determine the steady heat flux through this glass window, and the temperature of its interior surface, for a day during which the room is maintained at 24°C while the temperature outside is $-5°C$. Take the convection heat transfer coefficients of the interior and exterior surfaces of the window to be $h_1 = 10\ W/m^2 °C$ and $h_2 = 25\ W/m^2 \cdot °C$ and neglect the radiation heat transfer.

Ex.04: A wall 4 m high and 6 m wide consists of two horizontal surfaces (18 $cm \times 30\ cm$) made of bricks ($\lambda = 0.72\ W/m \cdot °C$) separated by layers of 3 cm thick adhesive tape ($\lambda = 0.22\ W/m \cdot °C$). There are also layers of 2 cm thick adhesive tape on each side of the wall and a layer of 2 cm thick rigid foam ($\lambda = 0.026\ W/m \cdot °C$) on the internal surface of the wall. The indoor and outdoor temperatures are 22°C and 4°C and the heat transfer coefficients by indoor and outdoor convection are $h_1 = 10\ W/m^2 \cdot °C$ and $h_2 = 20\ W/m^2 \cdot °C$, respectively. Assuming the conduction heat transfer is 1D and neglecting the thermal radiation, determine the heat flux through the wall.

Ex.05: Steam at 320°C flows into a stainless steel pipe ($\lambda = 15\ W/m \cdot °C$) whose internal and external diameters are 5 cm and 5.5 cm, respectively. The pipe is covered with a layer of glass wool insulation 3 cm thick ($\lambda = 0.038\ W/m \cdot °C$). Heat is transferred to the environment at 5°C by natural convection and radiation, with a combined natural convection and radiation heat transfer coefficient of 15 $W/m^2 \cdot °C$. Taking the heat transfer coefficient within the pipe to be 80 $W/m^2 \cdot °C$, determine the rate of heat loss from the steam per unit length of the pipe. Also, determine the temperature drops across the pipe shell and insulation.

Ex.06: We consider a short cylinder whose end surfaces are isolated. The cylinder is initially at a uniform temperature T_i and is subjected to convection by its lateral surface with a medium at temperature T_∞, with a heat transfer coefficient h. Is the heat transfer in this short cylinder is 1D or 2D? Explain.

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