UNIVERSITY HAMMA LAKHDAR OF EL-OUED
Faculty of Technology
Department of Mechanical Engineering
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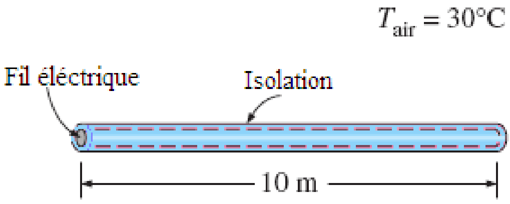
1st Y. Sc. Masters in Energetics
Intermediate Heat & Mass Transfer

Series N°2: Thermal Conduction (continued)

Ex.01: A tube is insulated so that the external insulation radius is less than the critical radius. Now the insulation is removed. Will the rate of tube heat transfer increase or decrease for the same tube surface temperature?

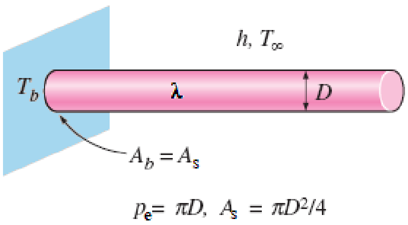
Ex.02: An electric wire of $2\,mm$ in diameter and $10\,m$ in length is firmly wrapped with a $1\,mm$ thick plastic cover whose thermal conductivity is $\lambda = 0.15 W/m.°C$. Electrical measurements indicate that a current of $10\,A$ flows through the wire and there is a voltage drop of $8\,V$ along the wire. If the insulated wire is exposed to a medium at $T_\infty = 30$ with a heat transfer coefficient, $h = 24\ W/m^2.°C$, determine the temperature at the interface of the wire and the plastic cover in steady state. Also determine, if by doubling the thickness of the plastic cover this interface temperature will increase or decrease?



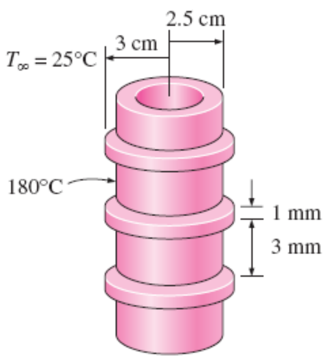
Ex.03: Two hot and cold water tubes $8\,m$ long extend in parallel in a thick layer of concrete. The diameters of the two tubes are $5\,cm$ and the distance between the axes of the tubes is $40\,cm$. The surface temperatures of the hot and cold tubes are $60°C$ and $15°C$, respectively. Taking the thermal conductivity of the concrete to be $\lambda = 0.75\ \mathrm{W/m.°C}$, determine the rate of heat transfer between the tubes. (Answer: 306 W)

Ex.04: Why do we use fins on surfaces?

Ex.05: Obtain a relationship for the efficiency of a fin of constant cross section A_s, perimeter p_e, length L and thermal conductivity λ exposed to convection with a medium at T_∞ with a heat transfer coefficient h. Assume that the fins are long enough so that the temperature at the tip is almost equal to T_∞. Take the temperature of the fin at the base to be T_b and neglect the heat transfer to the fin tips. Simplify the relationship for **(a)** a circular fin of diameter D, and **(b)** a rectangular fin of thickness e.



Ex.06: Steam in a heating system flows through tubes whose external diameter is $5\,cm$ and whose walls are maintained at a temperature of $180°C$. Circular fins made of $2024-T6$ aluminum alloy ($\lambda = 186\ \mathrm{W/m\cdot°C}$, $\eta_{ailette} = 0.97$) with an outer diameter of $6\,cm$ and a constant thickness of $1\,mm$ are attached to the tube. The space between the fins is $3\,mm$, and thus there are 250 fins per unit length of the tube. Heat is transferred to the ambient air at $T_\infty = 25°C$, with a heat transfer coefficient of $40\ \mathrm{W/m^2.°C}$. Determine the increase in heat transfer of the tube per unit of its length following the addition of the fins. (Answer: 2639 W)

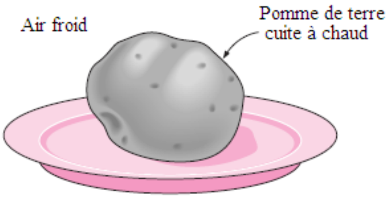


Ex.07: An electronic card of dimensions; 0.3 cm thick, 12 cm high, and 18 cm long encloses 80 logic elements closely located on one side, each dissipating 0.04 W. The board is impregnated with copper fillings and has an effective thermal conductivity of 20 $W/m.°C$. All heat produced in the chips (electronic components) is conducted through their board and is dissipated at the back side to an environment at $40°C$, with a heat transfer coefficient of $50\ W/m^2.°C$. **(a)** Determine the temperatures on both sides of the electronic board. **(b)** Now, a plate (0.2 cm thick × 12 cm high × 18 cm long) made of aluminum ($\lambda = 237$ W/m. °C) with 864 aluminum spine fins of 2 cm length and 0.25 cm diameter is attached to the backside of the circuit board with 0.02 cm thick epoxy adhesive ($\lambda = 1.8$ W/m. °C). Determine the new temperatures on both sides of the electronic board.

Ex.08: Solve the previous exercise (**Ex.07**) using a copper plate with copper fins ($\lambda = 386$ W/m. °C) instead of aluminum.

Ex.09: What is the *lamped capacitance* analysis? When is it applicable?

Ex.10: Consider a hot potato cooked on a dish. The temperature of the potato is observed to drop by $4°C$ during the first minute. Will the temperature continue over the second minute to drop less than, equal to, or more than $4°C$? Why?



Ex.11: Obtain relations for the characteristic lengths of a large plane wall of thickness $2L$, a very long cylinder of radius r_0 and a sphere of radius r_0?

Ex.12: The temperature of a gas flow must be measured by a thermocouple whose junction can be considered as a sphere of 1.2 mm diameter. The properties of the junction are $\lambda = 35$ W/m. °C, $\rho = 8500$ kg/m^3 and $C_p = 320$ J/kg. °C and the heat transfer coefficient between the junction and the gas is $h = 65$ W/m^2. °C. Determine how long it will take the thermocouple to read 99% of the initial temperature difference. (Answer: 38.5 s)

Ex.13: We consider a 1000 W power iron whose base is made of $2024 - T6$ aluminum alloy ($\rho = 2770$ kg/m^3, $C_p = 875$ J/kg. °C, $\alpha = 7.3 \times 10^{-5}$ m^2/s) with a thickness of 0.5 cm. The base has a surface area of 0.03 m^2. Initially, the iron is in thermal equilibrium with the ambient air at $22°C$. Taking the heat transfer coefficient at the surface of the base to be 12 $W/m^2.°C$ and assuming that 85% of the heat produced in the resistance wires is transferred to the base, determine how much time will take the base to reach the temperature of $140°C$. Is it realistic to assume that the base temperature is uniform at all times?