Birzeit University
Mechanical & Mechatronics Engineering Department
ENMC 4411 Thermal Fluid Engineering
Home work # 7 Convection heat transfer

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17.14 Steel plates of length $L = 1$ m on a side are conveyed from a heat treatment process and are concurrently cooled by atmospheric air of velocity $u_\infty = 10$ m/s and $T_\infty = 20^oC$ in parallel flow over the plates (Fig. P17.4). For a plate temperature 300^oC, what is the rate of heat transfer from the plate? The velocity of the air is much larger than that of the plate.

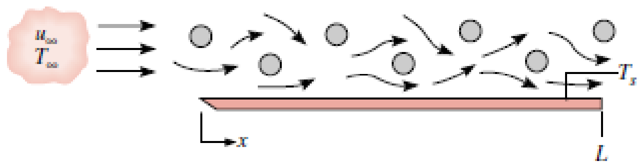

Figure P17.4

17.18 An array of power-dissipating electrical components is mounted on the bottom side of a 1.2 m by 1.2 m horizontal aluminum plate, while the top side is cooled by an air stream for which $u_\infty = 15$ m/s and $T_\infty = 300$ K. The plate is attached to a well-insulated enclosure such that all the dissipated power must be transferred to the air. Also, the aluminum is sufficiently thick to ensure a nearly uniform plate temperature.

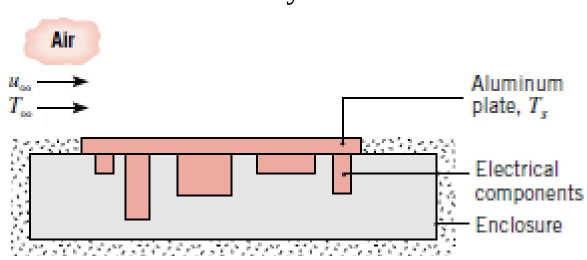

Figure P17.18

If the temperature of the plate is not to exceed 350 K, what is the maximum allowable power dissipation?

17.28 Consider the wing of an aircraft as a flat plate of 2.5-m length in the flow direction. The plane is moving at 100 m/s in air that is at a pressure of 0.7 bar and a temperature of -10^oC. The top surface of the wing absorbs solar radiation at a rate of 800 W/m^2. Assume the wing to be of solid construction and to have a single, uniform temperature. Estimate the steady-state temperature of the wing.

17.32 Consider the following fluids, each with a velocity of $u_\infty = 5$ m/s and a temperature of $T_\infty = 20^oC$, in cross flow over a 10-mm-diameter cylinder maintained at 50^oC: atmospheric air, saturated water, and engine oil. Calculate the rate of heat transfer per unit length, q/l.

17.41 Water at 20^oC flows over a 20-mm-diameter sphere with a velocity of 5 m/s. The surface of the sphere is at 60^oC. What is the rate of heat transfer from the sphere?

17.52 Ethylene glycol flows at 0.01 kg/s through a 3-mmdiameter, thin-walled tube. The tube is coiled and submerged in a well-stirred water bath maintained at 25^oC. If the fluid enters the tube at 85^oC, what heat rate and tube length are required for the fluid to leave at 35^oC? Neglect heat transfer enhancement associated with the coiling.

17.62 Water flows at 2 kg/s through a 40-mm-diameter tube 4 m long. The water enters the tube at 25^oC, and the surface temperature is 90^oC. What is the outlet temperature of the water? What is the rate of heat transfer to the water?

17.89 An electrical heater in the form of a horizontal disk of 400-mm diameter is used to heat the bottom of a tank filled with engine oil at a temperature of 5^oC. Calculate the power required to maintain the heater surface temperature at 70^oC.

17.95 A horizontal electrical cable of 25-mm diameter has a power dissipation rate of 30 W/m. If the ambient air temperature is 27^oC, estimate the surface temperature of the cable. Assume negligible radiation exchange.

17.113 Water at 225 kg/h is to be heated from 35 to 95^oC by means of a concentric tube heat exchanger. Oil at 225 kg/h and 210^oC, with a specific heat of 2095 is to be used as the hot fluid. If the overall heat transfer coefficient based on the outer diameter of the inner tube is 550 determine the length of the exchanger if the outer diameter is 100 mm.

17.124 A single-pass, cross-flow heat exchanger uses hot exhaust gases to heat water from 30 to 80^oC at a rate of 3 kg/s. The exhaust gases, having thermophysical properties similar to air, enter and exit the exchanger at 225 and 100^oC, respectively. If the overall heat transfer coefficient is 200 estimate the required surface area.