ASSIGNMENT #4

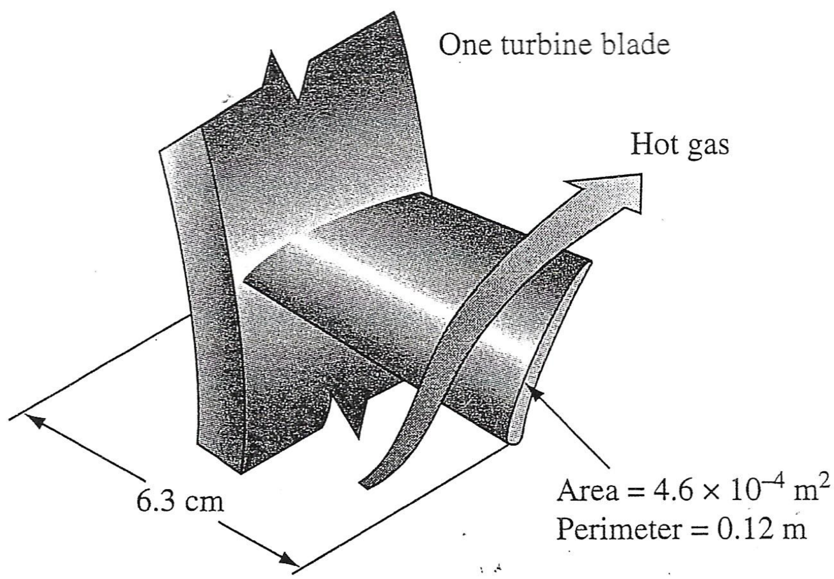
Energy Generation / Extended Surfaces

4–1 A small dam, which can be idealized by a large slab 1.2-m thick, is to be completely poured in a short period of time. The hydration of the concrete results in the equivalent of a distributed source of constant strength of 100 W/m^3. If both dam surfaces are at 16°C, determine the maximum temperature to which the concrete will be subjected, assuming steady-state conditions. The thermal conductivity of the wet concrete can be taken as 0.84 W/m K.

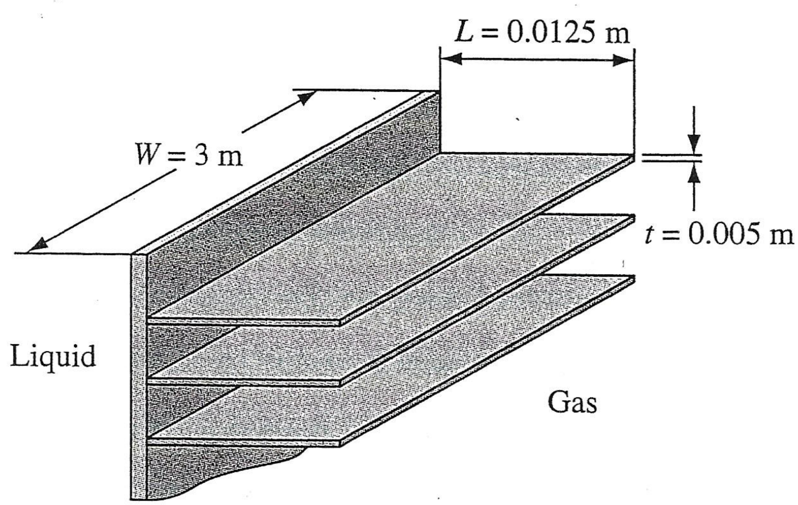
4–2 An electrical heater capable of generating 10,000 W is to be designed. The heating element is to be a stainless steel wire having an electrical resistivity of 80×10^{-6} ohm-centimeter. The operating temperature of the stainless steel is to be no more than 1260°C. The heat transfer coefficient at the outer surface is expected to be no less than 1720 W/m^2 K in a medium whose maximum temperature is 93°C. A transformer capable of delivering current at 9 and 12 V is available. Determine a suitable size for the wire, the current required, and discuss what effect a reduction in the heat transfer coefficient would have. (*Hint*: Demonstrate *first* that the temperature drop between the center and the surface of the wire is independent of the wire diameter, and determine its value.)

4–3 The tip of a soldering iron consists of a 0.6-cm-diameter copper rod, 7.6 cm long. If the tip must be 204°C, what are the required minimum temperature of the base and the heat flow, in Btu's per hour and in watts, into the base? Assume that $\bar{h} = 22.7$ W/m^2 K and $T_{air} = 21$°C.

4–4 A turbine blade 6.3 cm long, with cross-sectional area $A = 4.6 \times 10^{-4}$ m^2 and perimeter $P = 0.12$ m, is made of stainless steel ($k = 18$ W/m K). The temperature of the root, T_s, is 482°C. The blade is exposed to a hot gas at 871°C, and the heat transfer coefficient $\bar{h}$ is 454 W/m^2 K. Determine the temperature of the blade tip and the rate of heat flow at the root of the blade. Assume that the tip is insulated.



4–5 The wall of a liquid-to-gas heat exchanger has a surface area on the liquid side of 1.8 m^2 (0.6 m × 3.0 m) with a heat transfer coefficient of 255 W/m^2 K. On the other side of the heat exchanger wall flows a gas, and the wall has 96 thin rectangular steel fins 0.5 cm thick and 1.25 cm high ($k = 3$ W/m K) as shown in the accompanying sketch. The fins are 3 m long and the heat transfer coefficient on the gas side is 57 W/m^2 K. Assuming that the thermal resistance of the wall is negligible, determine the rate of heat transfer if the overall temperature difference is 38°C.



A section of the wall