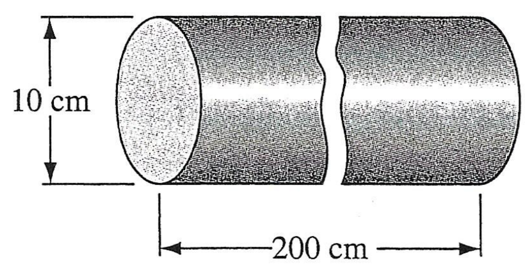
ASSIGNMENT #6

Distributed System Analysis Problems

6–1 A stainless steel cylindrical billet ($k = 14.4$ W/m K, $\alpha = 3.9 \times 10^{-6}$ m^2/s) is heated to 593°C preparatory to a forming process. If the minimum temperature permissible for forming is 482°C, how long can the billet be exposed to air at 38°C if the average heat transfer coefficient is 85 W/m^2 K? The shape of the billet is shown in the sketch.



6–2 A long copper cylinder 0.6 m in diameter and initially at a uniform temperature of 38°C is placed in a water bath at 93°C. Assuming that the heat transfer coefficient between the copper and the water is 1248 W/m^2 K, calculate the time required to heat the center of the cylinder to 66°C. As a first approximation, neglect the temperature gradient within the cylinder; then repeat your calculation without this simplifying assumption and compare your results.

6–3 A steel sphere with a diameter of 7.6 cm is to be hardened by first heating it to a uniform temperature of 870°C and then quenching it in a large bath of water at a temperature of 38°C. The following data apply:

surface heat transfer coefficient $\bar{h}_c = 590$ W/m^2 K

thermal conductivity of steel = 43 W/m K

specific heat of steel = 628 J/kg K

density of steel = 7840 kg/m^3

Calculate (a) the time elapsed in cooling the surface of the sphere to 204°C and (b) the time elapsed in cooling the center of the sphere to 204°C.

6–4 In the experimental determination of the heat transfer coefficient between a heated steel ball and crushed mineral solids, a series of 1.5% carbon steel balls were heated to a temperature of 700°C and the center temperature-time history of each was measured with a thermocouple as it cooled in a bed of crushed iron ore that was placed in a steel drum rotating horizontally at about 30 rpm. For a 5-cm-diameter ball, the time required for the temperature difference between the ball center and the surrounding ore to decrease from an initial 500°C to 250°C was found to be 64, 67, and 72 s, respectively, in three different test runs. Determine the average heat transfer coefficient between the ball and the ore. Compare the results obtained by assuming the thermal conductivity to be infinite with those obtained by taking the internal thermal resistance of the ball into the account.

6–5 A mild-steel cylindrical billet 25 cm in diameter is to be raised to a minimum temperature of 760°C by passing it through a 6-m long strip-type furnace. If the furnace gases are at 1538°C and the overall heat transfer coefficient on the outside of the billet is 68 W/m^2 K, determine the maximum speed at which a continuous billet entering at 204°C can travel through the furnace.