

**Fluid Mechanics and Rate Processes: Tutorial 12**

**P1.** Stainless steel ball bearings ( $\rho=8085 \text{ kg/m}^3$ ,  $k=15.1 \text{ W/m} \cdot ^\circ\text{C}$ ,  $C_p=0.480 \text{ kJ/kg} \cdot ^\circ\text{C}$ , and  $\alpha=3.91 \times 10^{-6} \text{ m}^2/\text{s}$ ) having a diameter of 1.2 cm are to be quenched in water. The balls leave the oven at a uniform temperature of  $900^\circ\text{C}$  and are exposed to air at  $30^\circ\text{C}$  for a while before they are dropped into the water. If the temperature of the balls is not to fall below  $850^\circ\text{C}$  prior to quenching and the heat transfer coefficient in the air is  $125 \text{ W/m}^2 \cdot ^\circ\text{C}$ , determine how long they can stand in the air before being dropped into the water.

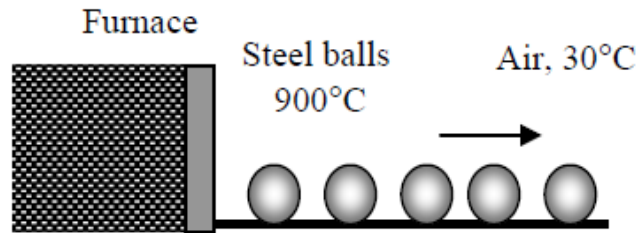


Fig.P1