EB – Exercises

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Conteúdo

Questão 1

A $150\,\mathrm{m^3}$ reactor is operated at $35\,^\circ\mathrm{C}$ to produce biomass from glucose. The O_2 consumption rate is $1.5\,\mathrm{kg\,m^{-3}\,h^{-1}}$. The stirrer dissipates heat at the speed of $1\,\mathrm{kW\,m^{-3}}$. The cooling water flows at a temperature of $10\,^\circ\mathrm{C}$ and at a flow rate of $60\,\mathrm{m^3/h}$, it passes inside a coil placed inside the reactor. If the system operates in steady state, determine the temperature of the cooling water leaving the reactor.

Data:

- $Q = 460\,\mathrm{kJ\,mol\,(O2)^{-1}}$
- $Cp_{\mathrm{H_2O}} = 75.4\,\mathrm{J\,mol^{-1}\,{}^\circ C^{-1}}$

Resposta

$T_1 = T_0 + \Delta T;$

$\Delta H = \Delta H_{rxn} + W_s;$

$$\Delta H_{rxn} = Q * C_{\mathrm{O_2}} * V = \begin{pmatrix} 460\,\mathrm{kJ\,mol^{-1}} & * \\ 1.5\,\mathrm{kg\,m^{-3}\,h^{-1}} & * \\ 3600^{-1}\,\mathrm{h\,s^{-1}} & * \\ 32^{-1}\,\mathrm{mol\,g^{-1}} & * \\ 150\,\mathrm{m^3} & \end{pmatrix} \cong 898.438\,\mathrm{kJ\,s^{-1}};$$

$W_s = 1\,\mathrm{kW\,m^{-3}}\,150\,\mathrm{m^3} = 150\,\mathrm{kW};$

$\Delta H \cong 898.438\,\mathrm{kJ\,s^{-1}} + 150\,\mathrm{kJ\,s^{-1}} \cong 1048.438\,\mathrm{kJ\,s^{-1}} =$

$$= M\,Cp\,\Delta T =$$
$$= (v * \rho_{\mathrm{H_2O}}) \left(75.4\,\mathrm{J\,mol^{-1}\,{}^\circ C^{-1}}\,\frac{M_{w\,\mathrm{H_2O}}\,\mathrm{g}}{\mathrm{mol}}\right) \Delta T =$$
$$= (60 * 1000\,\mathrm{kg/h}) \left(\frac{75.4}{18}\,\mathrm{kJ\,kg^{-1}\,{}^\circ C^{-1}}\right) \Delta T \implies$$

$$\implies T_1/^\circ\mathrm{C} = T_0 + \Delta T \cong 10 + \left(\frac{1048.438\,\mathrm{kJ\,s^{-1}}}{\frac{75.4*60000}{18}\,\mathrm{kJ\,{}^\circ C^{-1}\,h^{-1}}\,\frac{\mathrm{h}}{3600\,\mathrm{s}}}\right) \cong 25.017$$

Questão 2

A fermenter used to produce an antibiotic should have a temperature of $27\,^{\circ}\mathrm{C}$. After considering the oxygen requirements of the microorganisms and the heat dissipated by the stirrer, the maximum amount of heat to be transferred was estimated at $550\,\mathrm{kW}$. The cooling water enters at a temperature of $10\,^{\circ}\mathrm{C}$ and leaves at $25\,^{\circ}\mathrm{C}$. The heat transfer coefficient in the fermentation fluid was estimated at $2150\,\mathrm{W\,m^{-2}\,^{\circ}C}{-}1$ and the heat transfer coefficient of the cooling water has the value of $14000\,\mathrm{W\,m^{-2}\,^{\circ}C^{-1}}$. The steel cooling coil has an outer diameter of $8\,\mathrm{cm}$ and a thickness of $5\,\mathrm{mm}$, the thermal conductivity of steel is $60\,\mathrm{W\,m^{-1}\,^{\circ}C^{-1}}$. Calculate the length of coil needed under these conditions.

Resposta

$$\Delta T = \frac{2\,T_{fluido} - (T_1 + T_2)}{2} = \frac{2 * 28 - (T_1 + T_2)}{2} = 9.5\,^{\circ}\mathrm{C};$$

$$Q = h\,A\,\Delta T;$$

$$h^{-1} = h_i^{-1} + h_e^{-1} + h_w^{-1}\,B = 2150^{-1} + 14000^{-1} + 60^{-1} * 5\,\mathrm{E}^{-3} \cong 1614\,\mathrm{m^{-2}}$$

$$A = \frac{Q}{h\,\Delta T} \cong \frac{550}{1614 * 9.5} \cong 35.870 \implies$$

$$\implies A = 2\,\pi\,r\,l \implies l = \frac{A}{2\,\pi\,r} \cong \frac{35.870}{2\,\pi\,(8/2)} \cong 142.8\,\mathrm{m}$$