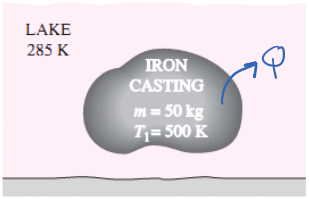
Meeting_015

Monday, May 10, 2021 10:03 AM

EXAMPLE 7–19 Entropy Generated when a Hot Block Is Dropped in a Lake

A 50-kg block of iron casting at 500 K is thrown into a large lake that is at a temperature of 285 K. The iron block eventually reaches thermal equilibrium with the lake water. Assuming an average specific heat of 0.45 kJ/kg · K for the iron, determine (*a*) the entropy change of the iron block, (*b*) the entropy change of the lake water, and (*c*) the entropy generated during this process.



$T_1 = 500\ K \longrightarrow T_2 = 285\ K$

$C_{آهن} = 0.45\ kJ/kg.K$

الف) تغییرات آنتروپی قطعه آهنی

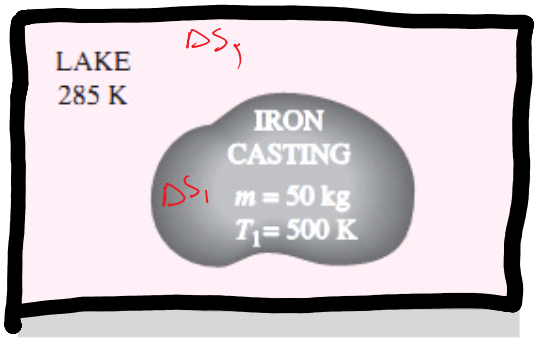
قطعه آهنی جامد $\Rightarrow$ $S_2 - S_1 = C_{av} \ln \frac{T_2}{T_1} = 0.45 \ln \frac{285}{500} = -0.125\ kJ/kg.K$

رابطه موازنه انرژی برای قطعه آهنی $\Rightarrow$ $Q - W = m(u_2 - u_1) = m C_{av}(T_2 - T_1)$

$Q = m C_{av}(T_2 - T_1) = 80 \times 0.45 (285 - 500) = -4807.5\ kJ$

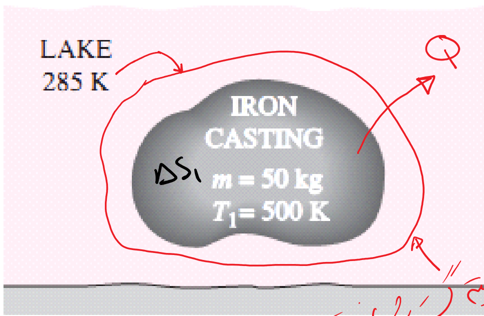
$q = \frac{Q}{m} = \frac{-4807.5}{50} = -96.15\ kJ/kg$

$\Delta S = \frac{+Q}{T} = \frac{96.15}{285} = +0.34\ kJ/kg.K$ (آب دریاچه)



$S_{gen} = \Delta S_{آهن} + \Delta S_{دریاچه} = -0.25 + 0.34 = +0.09 > 0$

$S_{in} - S_{out} + S_{gen} = \Delta S_1$



$$\cancel{S_{in}} - S_{out} + S_{gen} = \Delta S_1$$

$$-\frac{Q}{T} + S_{gen} = \Delta S_1$$

مرز سیستم کنترل

$$S_{gen} = \Delta S_1 + \frac{Q}{T} = -۰/۲۵ + \frac{۹۴/۷۵}{۲۸۵}$$

$$= ۰/۰۹ \ kJ/kg.K$$

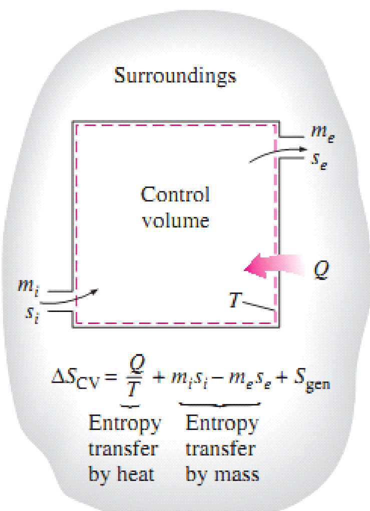
موازنه آنتروپی برای سیستم‌های باز

* دمای مرز حجم کنترل برابر با T و ثابت است.

* مکانیزم‌های انتقال آنتروپی ← گرما
← جرم

* سیستم یک سیستم پایا است:

$\Delta m = 0$
$\Delta E = 0$
$\Delta S = 0$



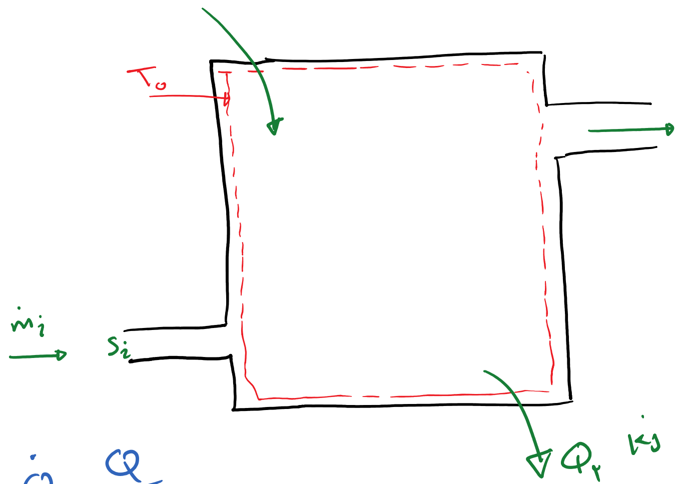
معادله موازنه آنتروپی ⇒ $S_{in} - S_{out} + S_{gen} = \Delta S_{c.v} = 0$

$$S_{in} - S_{out} + S_{gen} = 0 \Rightarrow \boxed{m_i s_i + \frac{Q}{T} - m_e s_e + S_{gen} = 0}$$

$$\boxed{S_{gen} = m_e s_e - m_i s_i - \frac{Q}{T}} \Rightarrow \boxed{S_{gen} = S_{out} - S_{in}}$$

Q.

kJ/kg.K



$$S_{gen} = S_{out} - S_{in}$$

$$S_{gen} = \left[s_e + \frac{q_2}{T_0}\right] - \left[s_i + \frac{q_1}{T_0}\right] \quad \frac{kJ}{kg.K}$$

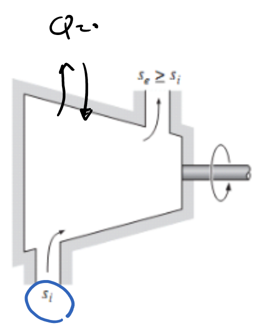
$$\dot{S}_{gen} = \left[\dot{m}_e s_e + \frac{\dot{Q}}{T_0}\right] - \left[\dot{m}_i s_i + \frac{Q_1}{T_0}\right] \quad \frac{kJ}{K.S}$$

$$\dot{Q}_2 = \frac{Q}{\Delta t}$$

$$\dot{m}_e s_e \left(\frac{kg}{s} \cdot \frac{kJ}{kg.K}\right) \quad \frac{kJ}{s.K}$$

اگر یک سیستم باز آدیاباتیک داشته باشیم رابطه موازنه آنتروپی آکه به صورت خواهد بود

$$S_{gen} = \left[s_e + \frac{q_2}{T}\right] - \left[s_i + \frac{q_1}{T}\right]$$



$$S_{gen} = s_e - s_i \qquad S_{gen} \geq 0$$

$$s_e \geq s_i$$

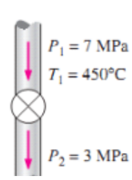
اگر فرایند برگشت پذیر - آدیاباتیک باشد

$$S_{gen} = 0 \longleftrightarrow s_e = s_i$$

مثال :

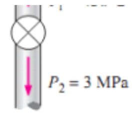
EXAMPLE 7–18 Entropy Generation during a Throttling Process

Steam at 7 MPa and 450°C is throttled in a valve to a pressure of 3 MPa during a steady-flow process. Determine the entropy generated during this



EXAMPLE 7–18 Entropy Generation during a Throttling Process

Steam at 7 MPa and 450°C is throttled in a valve to a pressure of 3 MPa during a steady-flow process. Determine the entropy generated during this process and check if the increase of entropy principle is satisfied.



$S_{gen} = ?$

① $\begin{cases} P_1 = ۷\ MPa \longrightarrow T_{sat} = ۲۸۵\ °C \\ T_1 = ۴۵۰\ °C \longrightarrow T_1 > T_{sat} \longrightarrow \end{cases}$ $\begin{cases} s_1 = ۶٫۶۳۵۳ \\ h_1 = ۳۲۸۸٫۳\ kJ/kg \end{cases}$

(بخار داغ)

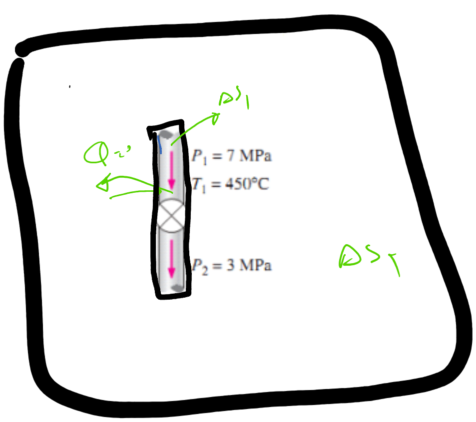
② $\begin{cases} P = ۳\ MPa \longrightarrow h_f = ۱۰۰۸ \quad h_g = ۲۸۰۳ \\ h_1 = h_2 = ۳۲۸۸ \longrightarrow h_2 > h_g \longrightarrow \end{cases}$ بخار داغ $\longrightarrow \{ s_2 = ۷\ kJ/kg\ K$

آدیاباتیک ← بدون گرما

$$S_{gen} = s_2 - s_1 = ۷ - ۶٫۶۴ \geq ۰$$

$\Delta S_2 = ۰$

$S_{gen} = \Delta S_1 = S_2 - S_1$



7–127 Cold water (c_p = 4.18 kJ/kg · °C) leading to a shower enters a well-insulated, thin-walled, double-pipe, counter-flow heat exchanger at 15°C at a rate of 0.25 kg/s and is heated to 45°C by hot water (c_p = 4.19 kJ/kg · °C) that enters at 100°C at a rate of 3 kg/s. Determine (*a*) the rate of heat transfer and (*b*) the rate of entropy generation in the heat exchanger.

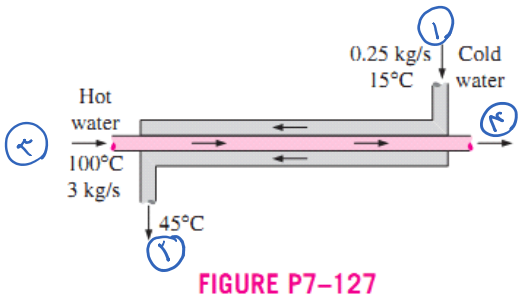


FIGURE P7–127

موازنه انرژی برای آب سرد

$q - \cancel{w}^{0} = h_2 - h_1 = C_{av}(T_2 - T_1)$

$q = 4.18(45 - 15) = 4.18 \times 30 = 125.4$ kJ/kg

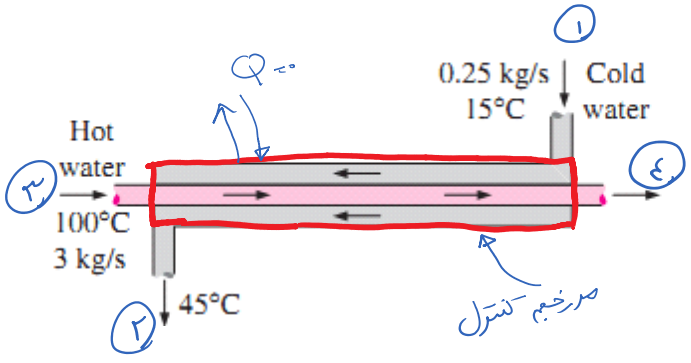
$\dot{Q} = \dot{m} q = 0.25 \times 125.4 = 31.35$ kJ/s (دریافت می‌کند)

موازنه انرژی آب گرم

$\dot{Q} - \dot{w}^{0} = \dot{m}(h_4 - h_3) = \dot{m} C_{av}(T_4 - T_3)$

$-31.35 = 3 \times 4.19 \times (T_4 - 100) \Rightarrow T_4 - 100 = -2.5$

$T_4 = -2.5 + 100 = 97.5°C$



$\dot{m}_1 = \dot{m}_2$ / $\dot{m}_3 = \dot{m}_4$

$\dot{S}_{gen} = \dot{S}_{out} - \dot{S}_{in} = [\dot{m}_4 s_4 + \dot{m}_2 s_2] - [\dot{m}_3 s_3 + \dot{m}_1 s_1]$

'gen out ' in

$$= [\dot{m}_2 s_2 - \dot{m}_3 s_3] + [\dot{m}_1 s_1 - \dot{m}_1 s_1]$$

$$= \dot{m}_3 [s_2 - s_3] + \dot{m}_1 [s_1 - s_1]$$

$$= \dot{m}_3 C \ln \frac{T_3}{T_2} + \dot{m}_1 C \ln \frac{T_1}{T_1}$$

$$= ٣ \times ٤{,}١٩ \ln \frac{٩٧{,}٥}{١٠٠} + ٠{,}٢٥ \times ٤{,}١٩ \ln \frac{٤٥}{١٥} =$$

EXAMPLE 7–21 **Entropy Generation Associated with Heat Transfer**

A frictionless piston–cylinder device contains a saturated liquid–vapor mixture of water at 100°C. During a constant-pressure process, 600 kJ of heat is transferred to the surrounding air at 25°C. As a result, part of the water vapor contained in the cylinder condenses. Determine (*a*) the entropy change of the water and (*b*) the total entropy generation during this heat transfer process.

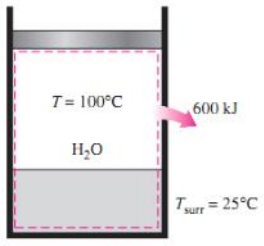


FIGURE 7–69
Schematic for Example 7–21.

$$\Delta S = \frac{Q}{T} = \frac{-٦٠٠}{١٠٠} = -٦ \text{ kJ/K}$$

$$\Delta S = +\frac{Q}{T} = \frac{٦٠٠}{٢٥} = +٢٤$$

$$S_{gen} = \Delta S_1 + \Delta S_2 = ٢٤ - ٦ = ١٨$$