Note Title 2/8/2021

2.34 Each line in the following table gives information about a process of a closed system. Every entry has the same energy units. Fill in the blank spaces in the table.

Process	Q	W	E_1	E_2	ΔE
a	+50	−20	−20	+50	70
b	+50	+20	+20	50	30
c	−40			+60	+20
d		−90		+50	0
e	+50		+20		−100

Process a

closed system

$Q - W = \Delta E$

$50 - (-20) = \Delta E$

$\Delta E = 70$

$\Delta E = E_2 - E_1$

$70 = 50 - E_1$

$E_1 = 50 - 70 = -20$

b)

$Q - W = \Delta E$

$50 - 20 = \Delta E$

$\Delta E = 30$

$E_2 - E_1 = 30$

$E_2 - 20 = 30$

$E_2 = 50$

2.48 A gas undergoes a thermodynamic cycle consisting of three processes:

Process 1–2: compression with $pV = constant$, from $p_1 = 1$ bar, $V_1 = 1.6\ m^3$ to $V_2 = 0.2\ m^3$, $U_2 - U_1 = 0$

Process 2–3: constant pressure to $V_3 = V_1$

Process 3–1: constant volume, $U_1 - U_3 = -3549$ kJ

There are no significant changes in kinetic or potential energy. Determine the heat transfer and work for Process 2–3, in kJ. Is this a power cycle or a refrigeration cycle?

Given Data

$P_1 = 1$ bar

$V_1 = 1.6\ m^3$

$V_2 = 0.2\ m^3$

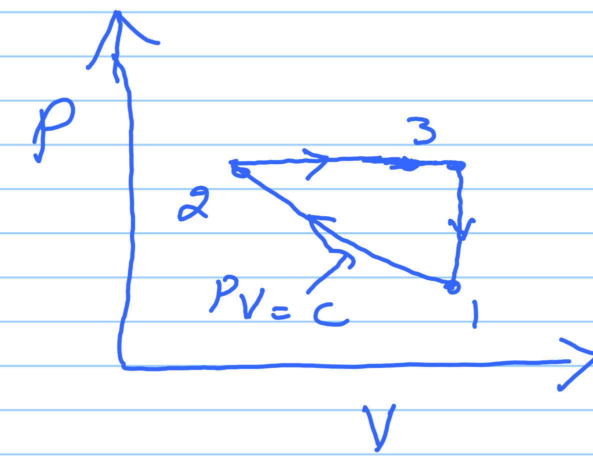
$U_2 - U_1 = 0$

$U_1 - U_3 = -3549$ kJ

To find

a) W_{23}, Q_{23} ?

b) Power cycle or Refrigeration cycle



$W_{cyc} = W_{12} + W_{23} + W_{31}$

$W_{31} = 0$ because $dV = 0$

$W_{31} = \int_{V_3}^{V_1} P\,dV$

$$W_{23} = \int_{V_2}^{V_3} P\,dV = P_2 (V_3 - V_2)$$

$$P_2 = P_3$$

$$W_{23} = 8 \times 10^5 (1.6 - 0.2) \times \frac{1}{10^3}$$

$$W_{23} = 1120 \text{ kJ}$$ → Ans

1–2 $PV = C$

$$P_1 V_1 = P_2 V_2$$

$$P_2 = P_1 (V_1 / V_2) = 1 \times \left(\frac{1.6}{0.2}\right) \times$$

$$P_2 = 8 \text{ bar}$$

By applying Energy for closed system

$$Q_{23} - W_{23} = U_3 - U_2$$

$\Rightarrow$ For a cycle $\Delta U = 0$

$$(U_2 - U_1) + (U_3 - U_2) + (U_1 - U_3) = 0$$

$$0 + U_3 - U_2 - 3549 = 0$$

$$\boxed{U_3 - U_2 = 3549 \text{ kJ}}$$

$$Q_{23} = U_3 - U_2 + W_{23} = 3549 + 1120$$

$$\boxed{Q_{23} = 4669 \text{ kJ}}$$

$$W_{12} = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} \frac{c\,dV}{V} \qquad (PV = c,\; P = c/V)$$

$$= c \ln(V_2/V_1) = P_1 V_1 \ln\left(\frac{V_2}{V_1}\right)$$

$$= 1\times10^5 \times 1.6 \ln\left(\frac{0.2}{1.6}\right) \times \frac{1}{10^3}$$

$$\boxed{W_{12} = 3327\text{ kJ}}$$

$$= -332710.64\text{ J}$$

$$= \boxed{-3327\text{ kJ}}$$

$$W_{cyc} = W_{12} + W_{23} + W_{31}$$

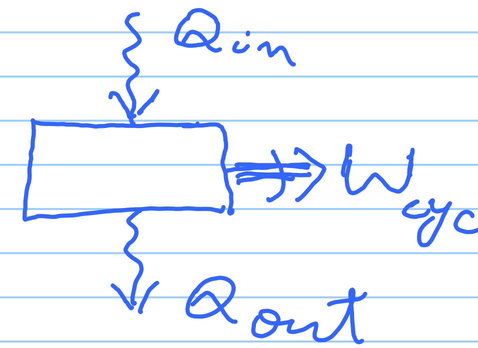
$$= -332.7 + 1120 + 0$$

$$= \boxed{1787.3\text{ kJ}} \Rightarrow W_{cy} > 0$$

So, it is a power cycle

Given Data

2.53 A power cycle has a thermal efficiency of 35% and generates electricity at a rate of 100 MW. The electricity is valued at \$0.08 per kW · h. Based on the cost of fuel, the cost to supply $\dot{Q}_{in}$ is \$4.50 per GJ. For 8000 hours of operation annually, determine, in \$,



$\eta = 35\%$

$\dot{W}_{cyc} = 100\ MW$

unit price/value for power = \$0.08 / kW·h

unit price for fuel / $\dot{Q}_{in}$ = \$4.50 GJ

operation time = 8000 hr

To find a) \$ value of electricity

\$ value of $\dot{Q}_{in}$ / fuel = ?

Total electricity produced

$W_{cycl} = 100\ MW \times 8000\ hr/yr \times \frac{10^3\ kW}{1\ MW}$

$= 8 \times 10^8 \text{ kW.h/yr}$

Total value of electricity

$= 8 \times 10^8 \text{ kW.h/yr} \times \$0.08/\text{kWh}$

$= \$64 \times 10^8 /\text{yr}$

money generated

\$ for $\dot{Q}_{in} = ?$

$\eta = \frac{\dot{W}_{cyc}}{\dot{Q}_{in}} \Rightarrow \dot{Q}_{in} = \frac{\dot{W}_{cyc}}{\eta} = 285.7 \text{ MW}$

$\$ \dot{Q}_{in} = \$4.50/\text{GJ} \times \frac{285.7}{10^3} (\text{GW}) \times 8000 \text{ hr} \times 3600$

$= \$ 37 \times 10^8 /\text{yr}$

A classroom that normally contains 40 people is to air conditioned with window air conditioning units of 5 kW capacity. A person at rest may be assumed to dissipate heat rate of about 360 kJ/hr. There are about 10 light bulbs in the classroom, each with a rating of about 100W. The rate of heat transfer to the class room through the walls and windows is estimated to be 15,000 kJ/hr. If the room is to maintained at a constant temperature of 21°C, determine the number of air conditioning units required?

One person = 360 kJ/hr = 360 kJ / 3600 s = 0.1 kW

For 40 person = 40 × 0.1 = 4 kW

For light bulbs = 100 × 10 = 1 kW

from windows = 15000 kJ/hr = 4.17 kW

$\Sigma Q = 4 + 1 + 4.17 = 9.17\ kW$

Total unit = $\frac{9.17}{5} \approx 2$