EN727005

THERMODYNAMICS FOR CHEMICAL ENGINEERS

อุณหพลศาสตร์สำหรับวิศวกรเคมี

ตอน 3 กฎข้อที่ 2 ของ Thermodynamic

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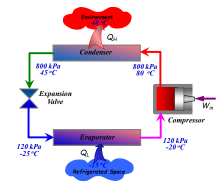
Refrigerator and Heat Pump

Vapor-Compression Refrigeration

is commonly used now a day.

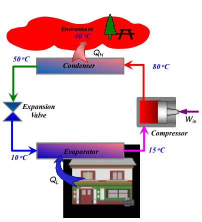
4 devices/processes:

1. Compressor: compress vapor to high Press.(HP)
2. Condenser: condense HP vapor to HP liq.
3. Expansion Valve: reduces pressure of HP liq. to LP
4. Evaporator: receive heat from low temp body ➔ LP liq. vaporizes to LP vap.

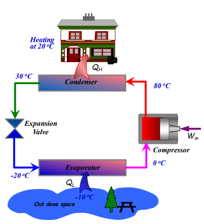


What happen to Pressure and Temperature of the Refrigerant

House-cooling using an **air-conditioner**



House-heating using a **heat pump**



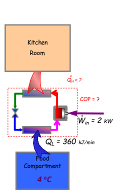
Coefficient of Performance

$$COP = \frac{\text{desired output}}{\text{required input}} = \frac{Q_{useful}}{W_{in}}$$

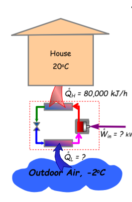
$$COP_R = \frac{Q_L}{W_{in}} = \frac{Q_L}{Q_H - Q_L} = \frac{1}{Q_H/Q_L - 1} \quad (5.5)$$

$$COP_{HP} = \frac{Q_H}{W_{in}} = \frac{Q_H}{Q_H - Q_L} = \frac{1}{1 - Q_L/Q_H} \quad (5.6)$$

Example 5.3 The compartment of a refrigerator is maintaind at 4°C by moving heat from it at a rate of 360 kJ/min. If the required power in put to the refrigerator is 2 kW, determine (a) the coefficient of the refrigerator and (b) the rate of heat discharge to the room that houses this refrigerator.



Example 5.4 A heat pump is used to meet the heating requirement of a house and maintain it at 20°C. On a day when the outdoor air temperature drops to -2°C, the house is estimated to lose heat at a rate of 80,000 kJ/h. If the heat pump under this conditions has a COP of 2.5, determine (a) the power consumed by the heat pump and (b) the rate at which the heat es extracted from the cold outdoor air



Solution (a) the power consumed by the heat pump

$$COP_{HP} = \frac{\dot{Q}_H}{\dot{W}_{in}}$$

Q_H = (-80,000 kJ/h)/(3600sec/h) = -22.22 kW

W_{in} = Q_H/COP = -22.22 kW/2.5 = -8.9 kW *answer*

(b) the rate at which the heat es extracted from the cold outdoor air

cv. refrigeration components: 1st law for a cycle

$$\Sigma Q_{net} = \Sigma W_{net}$$

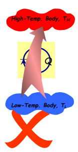
$$Q_L + Q_H = W_{in}$$

$$Q_L = W_{in} - Q_H = (-8.9\ kW) - (-22.22\ kW)$$

$$= 13.32\ kW$$ *answer*

The Second Law of Thermodynamics:
Clausuis Statement

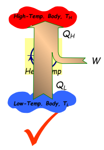
It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature body to a higher-temperature body.



meaning: $W > 0$

from $COP = \frac{Q}{W}$

No heat pump can have a COP of ∞



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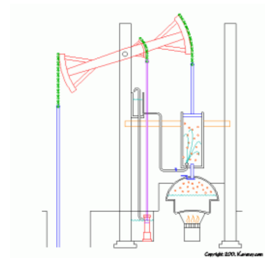

End of Part 3

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