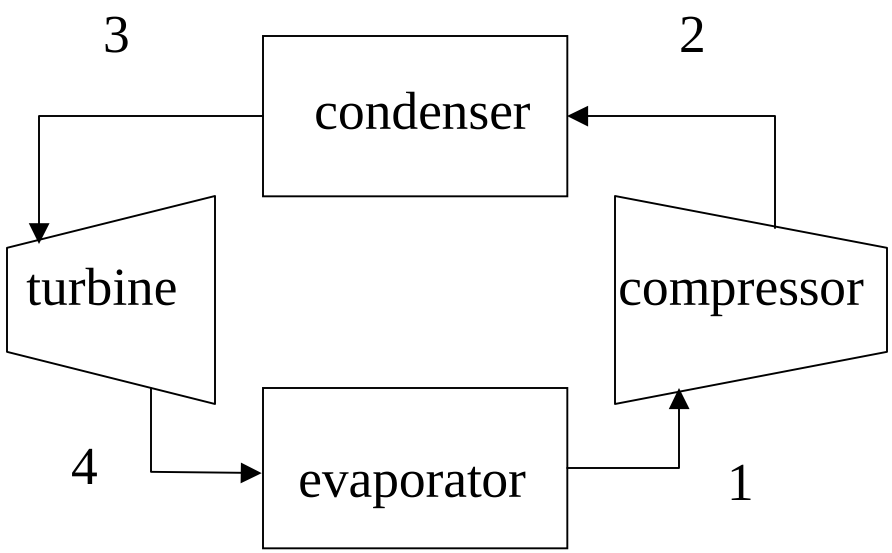
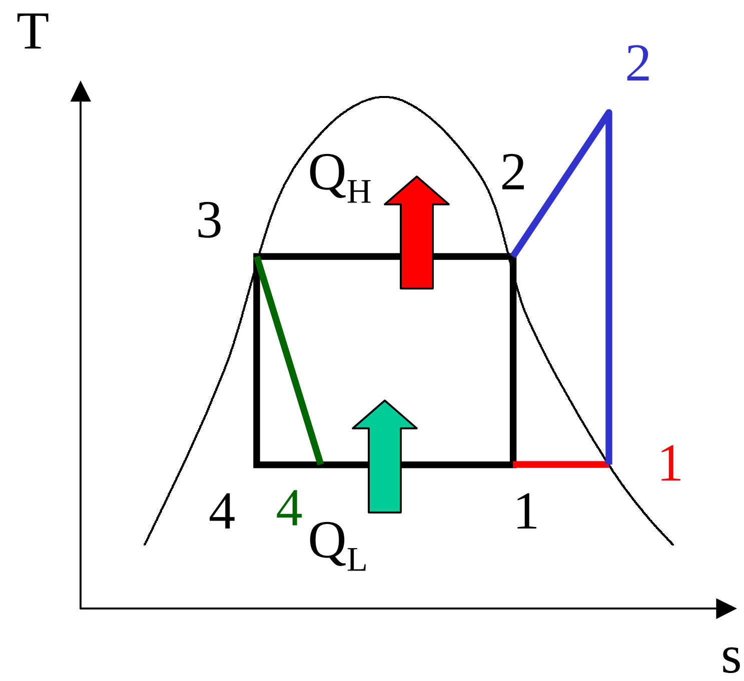
Refrigeration Cycles

- A Carnot cycle in reverse





- Evaporates liquid into 100% vapor
- Compress vapor instead of two phase mixture
- Replace turbine by an expansion valve (not an isentropic process)

Throttling Process

- A significant reduction in pressure can be achieved by introducing a restriction into the flow line. The restriction can be a partially-opened valve, or a porous plug, or a capillary tube.
- Enthalpy (internal energy + flow work) is a constant going through a throttling process: $h_1=h_2$.

Example: Saturated liquid refrigerant-134a enters the throttling device at 1 MPa and is exiting at a lower pressure of 0.1 MPa. Determine the temperature drop during this process.

At inlet: from table A-9, $T_1=T_{sat@1MPa}$ =39.39°C, $h_1=h_{f@1MPa}$=105.29 kJ/kg

At outlet: $h_1=h_2$, P_2=0.1 MPa, T_2=-26.43°C
h_f=16.29, h_{fg}=215.06, $x=(h_2-h_f)/h_{fg}$=0.414 (41.4% of the refrigerant-134a vaporizes during the throttling process). Question: where does the energy come from to vaporize the refrigerant?

ΔT = -26.43-39.39 = -65.82°C, temperature drops significantly during the throttling process.

Some Considerations

• The most common refrigerants, CCl_2F_2, Freon-12 (CFCs). Detrimental to the ozone (O_3) layer, thus leading to the penetration of more ultraviolet radiation into the earth atmosphere. Solution: replaced by Refrigerant 134a, CF_2FCF_3.

• In order to produce reasonable heat transfer, the temperature difference should be as high as possible (> 10°C). Therefore, in the evaporator the temperature should be as low as possible. It can be achieved by reducing the pressure. Problem: too low of a pressure (below atmospheric pressure) can cause air leakage into the system. Ex: at atmospheric pressure, refrigerant 134 has a saturation temp. of -26.43°C.

• Heat pumps and air conditioners have the same mechanical components. Therefore, a combined system to meet both heating and cooling requirements. Just reverse the cycle such that the evaporator becomes the condenser, and the condenser becomes evaporator. (Perfect in areas where large cooling load is needed during summer and relatively small heating load during winter)