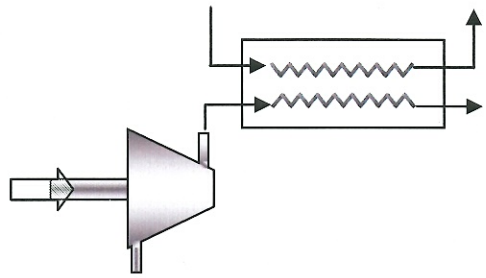
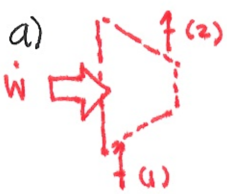
Example



0.016 kg/s of R-134a is compressed from 140 kPa and -10°C (h = 260 kJ/kg) to 1 MPa in a steady state compressor. The refrigerant is then passed through a heat exchanger in which it is cooled at constant pressure to 50°C. Water enters the other side of the heat exchanger at 20°C and 100 kPa and leaves at 30°C and 100 kPa. If the required compressor power is 1.2 kW,

a) find the specific enthalpy of the refrigerant leaving the compressor. (Hint, make just the compressor your system.)
b) Now making the *entire* heat exchanger your system, find the mass flow rate of water required. (For R-134a at 50°C and 1 MPa, h = 280.19 kJ/kg.)
c) Could you have found the mass flow rate of water in just one step? How might you do it? Do you think I'm going to ask you to do it? Are we playing that game for *Whose Line is it Anyway*?
d) Why did I give you the specific enthalpies of the R-134a?

a)



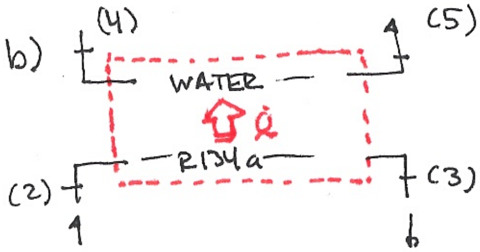
C.O.E.

$$\frac{d}{dt}(E_{sys}) = \dot{Q} + \dot{W} + \dot{m}\left(h_1 + \frac{V_1^2}{2} + gz_1\right) - \dot{m}\left(h_2 + \frac{V_2^2}{2} + gz_2\right)$$

($\frac{d}{dt}(E_{sys}) \to 0$: SS; $\dot{Q} \to 0$: ADIABATIC; IGNORE KE; IGNORE PE)

$$h_2 = \frac{\dot{W}_{IN}}{\dot{m}} + h_1 = \frac{1.2\ kW}{0.016\ \frac{kg}{s}}\left\langle\frac{kJ}{s \cdot kW}\right\rangle + 260\ \frac{kJ}{kg} = \boxed{335\ \frac{kJ}{kg}}$$

b)



C.O.E.

$$\frac{d}{dt}(E_{sys}) = \dot{Q} + \dot{W} + \sum_{IN} \dot{m}(h + \dots) - \sum_{OUT} \dot{m}(h + \dots)$$

($\frac{d}{dt}(E_{sys}) \to 0$: SS; $\dot{Q} \to 0$, $\dot{W} \to 0$: INTERNAL TO SYS.)

$$0 = \dot{m}(h_2) + \dot{m}_{WAT} h_4 - \dot{m}(h_3) - \dot{m}_{WAT} h_5$$

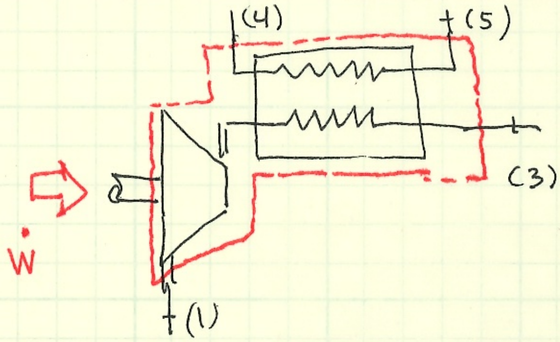
$$\dot{m}_{WAT} = \frac{\dot{m}(h_2 - h_3)}{(h_5 - h_4)} = \frac{\dot{m}(h_2 - h_3)}{c(T_5 - T_4) + v(P_5 - P_4)}$$

(MODEL AS INCOMPRESSIBLE)

$$= \frac{\left(0.016\ \frac{kg}{s}\right)\left(335\ \frac{kJ}{kg} - 280.19\ \frac{kJ}{kg}\right)}{\left(4.183\ \frac{kJ}{kg \cdot °C}\right)(30°C - 20°C) + 0.001\ \frac{m^3}{kg}(100\ kPa - 100\ kPa)}$$

$$= \boxed{0.0211\ kg/s}$$

c) YES WE CAN! MAKE COMPRESSOR & HXR SYSTEM:



d) R134a IS NIETHER AN IDEAL GAS NOR AN INCOMPRESSIBLE SUBSTANCE, & WE DON'T KNOW HOW TO FIND THE PROPERTIES of SUCH THINGS. (YET...)