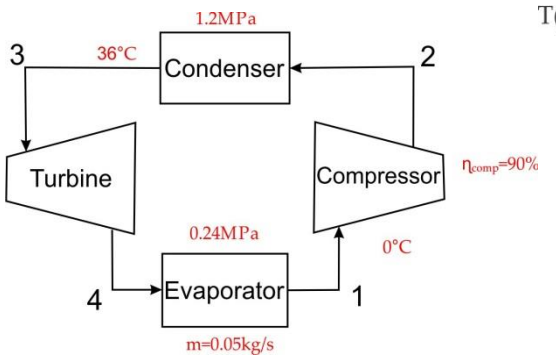
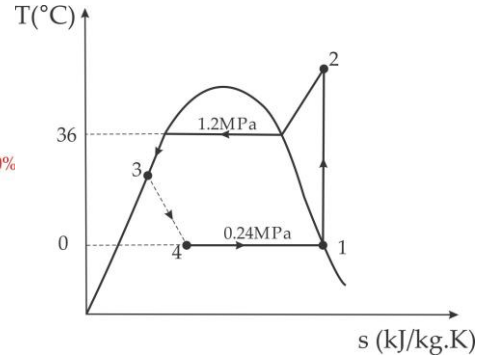
A refrigeration system equips with intercooling and throttling valve uses refrigerant-134a as the working fluid. It operates on a vapor compression cycle between 1.2 MPa and 0.24 MPa. The refrigerant enters the compressor at a temperature of 0 ^{o}C and leaves the condenser at a temperature of 36 ^{o}C. The mass flow rate of the refrigerant is 0.05 kg/s. Show the cycle on a T-s and P-h diagrams with respect to saturation lines. Changes in kinetic and potential energies can be neglected. If the isentropic efficiency of the compressor is 90 percent, determine,

i) the refrigerant temperature at the compressor outlet, ^{o}C
ii) the rate of heat removal from the refrigerated space, kW
iii) the rate of heat rejection to the environment, kW
iv) the power required by the compressor, kW, and
v) the coefficient of performance of the refrigeration system.





From table,

$P_1 = 0.24\text{MPa} @ \text{saturated vapour}$

$h_1 = h_{g@0.24\text{MPa}} = 247.28\text{kJ/kg}$

$s_1 = s_{g@0.24\text{MPa}} = 0.934584\text{kJ/kg} \cdot \text{K}$

$P_2 = 1.2\text{MPa}$

$s_{2s} = s_1 = 0.93458\text{kJ/kg} \cdot \text{K}$

$h_{2s} = h_{1.2\text{MPa}} = 280.852\text{kJ/kg}$

$T_{2s} = 52.27°\text{C}$

$$P_3 = 1.2\text{MPa}$$
$$h_3 = h_f = 117.77\text{kJ/kg}$$

$$h_4 \cong h_3 = 117.77\text{kJ/kg(throttling)}$$

$$\dot{Q}_L = \dot{m}(h_1 - h_4) = 0.05(247.28 - 117.77) = 6.4755\text{kW}$$

$$\eta_{comp} = \frac{h_{2s} - h_1}{h_2 - h_1} \Rightarrow h_2 = h_1 + \frac{h_{2s} - h_1}{\eta_{comp}} \Rightarrow h_2 = 247.28 + \frac{280.852 - 247.28}{0.9} = 284.58\text{kJ/kg}$$

$$\dot{Q}_H = \dot{m}(h_2 - h_3) = 0.05(284.58 - 117.77) = 8.34\text{kW}$$

$$\dot{W}_{in} = (h_{2s} - h_1)/\eta_{comp} = \dot{m}\left[(h_{2s} - h_1)/\eta_{comp}\right] = 0.05 \times [(280.852 - 247.28)/0.9] = 1.8651\text{kW}$$

$$COP = \frac{\dot{Q}_L}{\dot{W}_{in}} = \frac{6.4755\text{kW}}{1.8651\text{kW}} = 3.4719$$