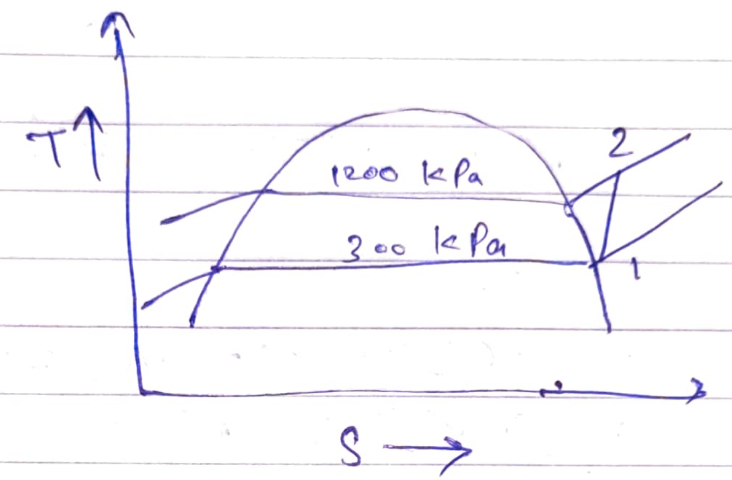
Thermo ~~A~~ Tut - 11

(1)

a. T-s diagram of compression process 1-2



b. from saturated ~~water~~ ~~table~~ R-134a table @ 320 kPa

$h_1 = h_g = 251.88$ kJ/kg

$S_1 = S_g = 0.93006$ kJ/kg.K

$V_1 = V_g = 0.063604$ m³/kg.

- during process (1)-(2) :-

$S_2 = S_1 = 0.93006$ kJ/kg.k

enthalpy at state (2) @ 1200 kPa

$S_2 = 0.93006$ kJ/kg.k

Date
Page

- from R-134a tables using interpolation

$$h_2 = 278.27 + (289.64 - 278.27) \times \left(\frac{0.93006 - 0.9267}{0.9614 - 0.9267}\right)$$

$$= 279.3706 \text{ KJ/kg}$$

- $-W_{in} = \dot{m} \times (h_2 - h_1)$

$$100 = \dot{m}\,(279.3706 - 251.88)$$

$$\dot{m} = 3.6376 \text{ kg/s}$$

- $Q = \dot{m} \times V$

$$= 3.6376 \times 0.063604$$

$$= 0.23137 \text{ m}^3/\text{s}$$

2

$$\eta_{rev} = 1 - \frac{T_0}{T_H}$$

$$= 1 - \frac{\cancel{1}20 + 273\ K}{1200 + 273\ K}$$

$$= 0.801$$

Second law efficiency

$$\eta_2 = \frac{\eta_{th}}{\eta_{th(rev)}} = \frac{0.40}{0.801} = \underline{49.93\%}$$

3 given:-

$\dot{Q}_{heat} = 50000\ kJ/h$

$T_{out} = 4°C = 277\ K$

$T_{house} = 25°C = 298\ K$

$$\dot{W}_{sum,in} = \dot{Q}_{heat} = \frac{50000\ kJ/h}{3600\ s} = 13.89\ kW$$

$$COP_{Pump,rev} = \frac{1}{1 - \frac{T_L}{T_H}} = \frac{1}{1 - \frac{277}{298}} = 14.198$$

Actual power: $\dot{W}_{sum,in} = \dot{W}_{rev,in} + \dot{I}$

$$\therefore \dot{W}_{rev,in} = \frac{\dot{Q}_{heat}}{COP} = \frac{50000}{14.198 \times 3600} = \underline{0.978\ kW}$$

$$\dot{I} = \dot{W}_{sum} - \dot{W}_{rev} = 13.89 - 0.978 = \underline{12.912\ kW}$$

A from saturated R-134a - temp. table @ -26°c

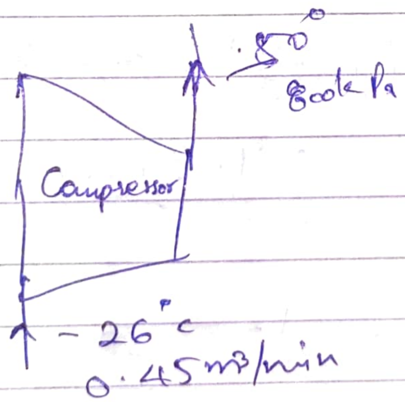
initial enthalpy, $h_1 = 234.68$ KJ/kg
" entropy $S_1 = 0.951$ KJ/kg.K

mass flow rate $\dot{m} = \frac{\dot{V}_1}{\alpha_1} = \frac{\frac{0.45}{60} \text{ kg/s}}{0.1894}$

$\dot{m} = 0.0395$ kg/s

final entropy, enthalpy @ 800kPa & 50°c and using interpolation.

$h_2 = 286.69$ KJ/kg
$S_2 = 0.9802$ KJ/kg.K



for isentropic process, $S_2 = S_1 = 0.951444$ KJ/kg.K

@ P_2 = 800kPa & $S_2 = 0.951$ KJ/kg.K, enthalpy using interpolation :-

$$\frac{h_{2s} - 276.45}{286.69 - 276.45} = \frac{0.95144 - 0.9480}{0.9802 - 0.9480}$$

$h_{2s} = 277.5436$ kJ/kg

a

$W_{actual} = \dot{m} \times (h_2 - h_1)$
$= 0.03959 \times (286.69 - 234.68)$
$= 2.059$ kW

b

$W_{in} = \dot{m}(h_{2s} - h_1)$
$= 0.03959 \times (277.5436 - 234.68)$
$= 1.697$ kW

isentropic efficiency :-

$$\eta = \frac{W_{in}}{W_{actual}}$$

$$= \frac{1.697}{2.059}$$

$= 82.42\%$

c

$X_{des} = T_0 \times S_{gen}$
$= 0.03959 \times 300 \times (0.9802 - 0.9514)$
$= 0.3416$ kW

reversible work input :-

$W_{rev} = 2.059 - 0.3416$
$= 1.7174$ kW

Second law efficiency :—

$$\eta_2 = \frac{W_{rev}}{W_{act}} = \frac{1.7414}{2.0519} = 83.41\%$$