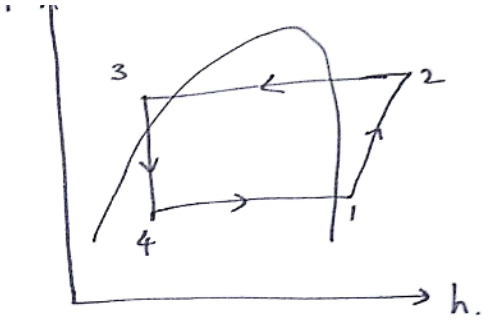
Question: A refrigerant 12 refrigeration system requires a load of 54 kW ...

A refrigerant 12 refrigeration system requires a load of 54 kW at an evaporator pressure of 270 kPa and a condenser pressure of 1009 kPa. The refrigerant is subcooled 10 degrees before entering the expansion valve and vapor is superheated 14 degrees before entering the compressor. A twin-cylinder compressor with stroke equal to 1.25 times the bore is to be used at a speed of 27 r/s. The volumetric efficiency is 84%. Determine (a) the quantity of cooling water in the condenser for an 11-degree increase in temperature, (b) the bore and stroke, and (c) the compressor power. *Answer: (a) 1.40 kg/s, (b) 8.58 x 10.73 cm, (c) 10.5 kW*

Expert Answer



Enthalpy at 1

$h_1 = h_{g1} + C_{pg}(\Delta T)_{superheat}$ @ 270kPa

$= 350.89 + 0.624 \times 14$

$= 359.626$ KJ/kg

$S_1 = S_{g1} + C_{pg} \ln \frac{T_{sup}}{T_{sat}}$ @ 270kPa

$= 1.5608 + 0.624 \ln\left(\frac{283}{269}\right)$

$= 1.5925$ KJ/kgK

$S_1 = S_2$

$S_2 = S_{g2} + C_{pg} \ln \left(\frac{T_{sup}}{T_{sat}}\right)$ @ 1009 KPa

$1.5925 = 1.5454 + 0.771 \ln\left(\frac{T_{sup}}{315}\right)$

$T_{sup} = 335$ K.

$h_2 = h_{g2} + C_{ps}(T_{sup} - T_{sat})$ @ 1009kPa

$= 369.49 + 0.771\,(335 - 315)$

$= 384.78$ KJ/kg

$h_3 = h_{f3} - C_{pl}(\Delta T)_{subcool}$ @ 1009kPa

$= 241.10 - 1.038 \times 10$

$= 230.72$ KJ/kg

$h_3 = h_4 = 230.72$ KJ/kg

$Q_L = \dot{m}_R (h_1 - h_4)$

$54 = \dot{m}_R (359.626 - 230.72)$

$\dot{m}_R = 0.4189$ kg/sec.

(a) Quantity of cooling water required

Heat rejected in condenser = Heat gain of cooling water

$\dot{m}_R (h_2 - h_3) = \dot{m}_c C_{pw} \Delta T$

(b) Bore and stroke

$$v_1 = v_{g1} \frac{T_{sup}}{T_{sat}}$$

$$= 0.06348 \left(\frac{335}{315}\right) = 0.0675 \ m^3/kg.$$

$$v_1 = \frac{\pi}{4} d^2 L \times \eta_v \times \text{no of cylin} \times \text{speed}$$

$$0.0675 = \frac{\pi}{4} \times d^2 \times 1.25d \times 0.84 \times 2 \times 27$$

$$d = 0.114 \ m = 11.4 \ cm$$

$$L = 1.25d = 14.35 \ cm.$$

n = ... assumed

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