

The University of Zambia  
School of Engineering  
Department of Mechanical Engineering  
ME 341 Thermodynamics

ASSIGNMENT: REFRIGERATION and HEAT PUMP CYCLES

Q1. The capacity of a refrigerator is 210 T.R when working between  $-7^{\circ}\text{C}$  and  $26^{\circ}\text{C}$ . Assuming that the cycle is a reversed Carnot cycle and that the latent heat of ice is  $335\text{kJ/kg}$ . Determine the:

- Amount of ice produced per day from water at  $22^{\circ}\text{C}$ .
- Power required to drive the unit.

Q2. A cold storage plant is required to store 25 tonnes of meat. The meat is supplied at a temperature of  $25^{\circ}\text{C}$ . The freezing point of the meat is  $-4^{\circ}\text{C}$  and the meat is stored in a cold storage which is maintained at  $-9^{\circ}\text{C}$ . The specific heat of the meat above freezing point is  $2.96\text{kJ/kgK}$  while the specific heat of the meat below the freezing point is  $1.25\text{kJ/kgK}$ . The latent heat of the meat is  $237\text{kJ/kg}$ . If the plant requires  $78\text{kW}$  to drive it, and the C.O.P. of the plant is 0.35 of the Carnot C.O.P. determine:

- The plant capacity.
- The time taken to achieve the cooling.

Q3. A vapour compression refrigerator uses R-12 as refrigerant and liquid evaporates in the evaporator at  $-20^{\circ}\text{C}$ . The temperature of the refrigerant at the delivery from the compressor is  $15^{\circ}\text{C}$  when the vapour is condensed at  $10^{\circ}\text{C}$ . Find the C.O.P. if:

- there is no under-cooling
- the liquid is cooled by  $7^{\circ}\text{C}$  before expansion by throttling.

Take: Specific heats:  $c_{pv} = 0.64\text{kJ/kgK}$ ;  $c_{pl} = 0.94\text{kJ/kgK}$  for superheated vapour at constant pressure.

Q4. A vapour compression refrigerator uses methyl chloride and operates between the pressure limits of  $146\text{kN/m}^2$  and  $967\text{kN/m}^2$ . At the entry to the compressor, the methyl chloride is dry saturated and after compression has a temperature of  $103^{\circ}\text{C}$ . The compressor has a bore and stroke of  $78\text{mm}$  and runs at  $8\text{ rev/s}$  with a volumetric efficiency of  $80\%$ . The temperature of the liquid refrigerant as it leaves the condenser is  $33^{\circ}\text{C}$  and its specific heat capacity is  $1.62\text{kJ/kgK}$ . The specific heat capacity of superheated vapours may be assumed constant. Determine:

- C.O.P. of the refrigerator
- Mass flow of refrigerant in  $\text{kg/hr}$
- Cooling water required by the condenser in  $\text{kg/hr}$  if cooling water temperature rise is limited to  $11^{\circ}\text{C}$

Take Specific Heat Capacity of water =  $4.187\text{kJ/kgK}$

Q5. A simple heat pump is used for space heating. It consists of an evaporator, compressor, condenser and a throttle regulator. The heat pump uses Freon-12 and works between pressure limits of  $0.423\text{ MN/m}^2$  and  $0.219\text{ MN/m}^2$ . The heat transfer required from the condenser unit is  $120\text{ MJ/h}$ .

At the beginning of compression, the Freon-12 is assumed dry saturated and after compression, it has a temperature of  $58^{\circ}\text{C}$ . At the end of the condensation process, the refrigerant is liquid but not under-cooled. Assuming the specific heat capacity of the superheated vapour to be constant, determine:

- The mass flow rate of the Freon-12 in  $\text{kg/h}$  assuming no energy loss.
- The dryness fraction of the Freon-12 at entry to the evaporator
- The power of the driving motor assuming that only  $74\%$  of the power of the driving motor is available in the Freon-12.
- The ratio of the heat transferred from the condenser to the power required to drive the motor in the same time.

Duration: 1 Week

Submit Q3 and Q5 as Assignment