HW Ch # 2: Air refrigeration cycles

1- A Carnot cycle machine operates between the temperature limits of 47°C and –30°C. Determine the C.O.P. when it operates as 1. a refrigerating machine ; 2. a heat pump ; and 3. a heat engine.

2- A refrigerating plant is required to produce 2.5 tonnes of ice per day at – 4°C from water at 20°C. If the temperature range in the compressor is between 25°C and – 6°C, calculate power required to drive the compressor. Latent heat of ice = 335 kJ/kg and specific heat of ice = 2.1 kJ/kg K.

3- Ten tonnes of fish is frozen to –30°C per day. The fish enters the freezing chamber at 30°C and freezing occurs at –3°C. The frozen fish is cooled to –30°C. The specific heats of fresh and frozen fish are 3.77 kJ/kg K and 1.67 kJ/kg K respectively while latent heat of freezing is 251.2 kJ/kg K. Find the tonnage of the plant which runs for 18 hours per day. The evaporator and condensor temperatures are –40°C and 45°C respectively. If the C.O.P. of the plant is 1.8, determine the power consumption of the plant in kW. Also find the refrigerating efficiency of the plant.

4- A refrigerator storage is supplied with 30 tonnes of fish at a temperature of 27°C. The fish has to be cooled to – 9°C for preserving it for long period without deterioration. The cooling takes place in 10 hours. The specific heat of fish is 2.93 kJ/kg K above freezing point of fish and 1.26 kJ/kg K below freezing point of fish which is – 3°C. The latent heat of freezing is 232 kJ/kg. What is the capacity of the plant in tonnes of refrigeration for cooling the fish ? What would be the ideal C.O.P. between this temperature range ? If the actual C.O.P. is 40% of the ideal, find the power required to run the cooling plant.

5- A Bell-Coleman refrigerator works between 4 bar and 1 bar pressure limits. After compression, the cooling water reduces the air temperature to 17°C. What is the lowest temperature produced by the ideal machine ? Compare the coefficient of performance of this machine with that of the ideal Carnot cycle machine working between the same pressure limits, the temperature at the beginning of compression being –13°C.

6- An air refrigeration system having pressure ratio of 5 takes air at 0°C. It is compressed and then cooled to 19°C at constant pressure. If the efficiency of the compressor is 95% and that of expander is 75%, determine: 1. the refrigeration capacity of the system, if the flow of air is 75 kg/min ; 2. the power of the compressor ; and 3. C.O.P. of the system. Assume compression and expansion processes to be isentropic. Take $\gamma = 1.4$; $c_p = 1$ kJ/kg K ; and $c_v = 0.72$ kJ/kg K.

7- An air refrigerator used for food storage, provides 50 TR. The temperature of air entering the compressor is 7°C and the temperature before entering into the expander is 27°C. Assuming a 70% mechanical efficiency, find : 1. actual C.O.P; and 2. the power required to run the compressor.

The quantity of air circulated in the system is 100 kg/min. The compression and expansion follow the law $pv^{1.3}$ = constant.

Take $\gamma = 1.4$; $c_p = 1$ kJ/kg K for air.