COLLEGE OF ENGINEERING & TECHNOLOGY

MECHATRONICS DEPARTMENT

Course: Thermodynamics II Course Code: ME333 Lecturer: Dr Sameh Shaaban

Sheet No. 4

1- A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.12 and 0.7 MPa. The mass flow rate of the refrigerant is 0.05 kg/s. Show the cycle on a T-s diagram with respect to saturation lines. Determine (a) the rate of heat removal from the refrigerated space and the power input to the compressor, (b) the rate of heat rejection to the environment, and (c) the coefficient of performance.

2- Consider a 300 kJ/min refrigeration system that operates on an ideal vapor-compression refrigeration cycle with refrigerant-134a as the working fluid. The refrigerant enters the compressor as saturated vapor at 140 kPa and is compressed to 800 kPa. Show the cycle on a T-s diagram with respect to saturation lines, and determine (a) the quality of the refrigerant at the end of the throttling process, (b) the coefficient of performance, and (c) the power input to the compressor.

3- Refrigerant-134a enters the compressor of a refrigerator as superheated vapor at 0.14 MPa and -10°C at a rate of 0.12 kg/s, and it leaves at 0.7 MPa and 50°C. The refrigerant is cooled in the condenser to 24°C and 0.65 MPa, and it is throttled to 0.15 MPa. Disregarding any heat transfer and pressure drops in the connecting lines between the components, show the cycle on a T-s diagram with respect to saturation lines, and determine (a) the rate of heat removal from the refrigerated space and the power input to the compressor, (b) the isentropic efficiency of the compressor, and (c) the COP of the refrigerator.

4- Refrigerant-134a enters the compressor of a refrigerator at 140 kPa and -10°C at a rate of 0.3 m^3/min and leaves at 1 MPa. The isentropic efficiency of the compressor is 78 percent. The refrigerant enters the throttling valve at 0.95 MPa and 30°C and leaves the evaporator as saturated vapor at -18.5°C. Show the cycle on a T-s diagram with respect to saturation lines, and determine (a) the power input to the compressor, (b) the rate of heat removal from the refrigerated space, and (c) the pressure drop and rate of heat gain in the line between the evaporator and the compressor.

5- A plant using R22 has an evaporator saturation temperature of 1°C and condenser saturation temperature of 45°C. The vapour is dry saturated at entry to the compressor and is at a temperature of 75°C after compression to the condenser pressure. The compressor is a two-stage compressor each stage having the same pressure ratio and enthalpy rise. Assuming no under-cooling in the condenser. Sketch the cycle and represent the cycle on a pressure-enthalpy diagram and calculate (i) the coefficient of performance; and (ii) the power input required for a refrigeration capacity of 2 MW.

6- A vapour compression plant uses R134a has a suction saturation temperature of 5°C and a condenser saturation temperature of 45°C. The vapour is dry saturated on entering the compressor and there is no under-cooling of the condensate. The compression is carried out isentropically in two stages and a flash chamber is employed at an inter-stage saturation temperature of 15°C. Sketch the cycle and represent the cycle on a pressure-enthalpy diagram. Calculate: (i) the amount of vapour bled off at the flash chamber; (ii) the state of the vapour at the inlet to the second stage of compression; (iv) the work done per unit mass of refrigerant in the condenser; and (v) the coefficient of performance.

7- Consider a two-stage cascade refrigeration system operating between the pressure limits of 1.2 MPa and 200 kPa with refrigerant-134a as the working fluid. The refrigerant leaves the condenser as a saturated liquid and is throttled to a flash chamber operating at 0.45 MPa. Part of the refrigerant evaporates during this flashing process, and this vapor is mixed with the refrigerant leaving the low-pressure compressor. The mixture is then compressed to the condenser pressure by the high-pressure compressor. The liquid in the flash chamber is throttled to the evaporator pressure and cools the refrigerated space as it vaporizes in the evaporator. The mass flow rate of the refrigerant through the low-pressure compressor is 0.15 kg/s. Assuming the refrigerant leaves the evaporator as a saturated vapor and the isentropic efficiency is 80 percent for both compressors, determine (a) the mass flow rate of the refrigerant through the high-pressure compressor, (b) the rate of heat removal from the refrigerated space, and (c) the COP of this refrigerator. Also, determine (d) the rate of heat removal and the COP if this refrigerator operated on a single-stage cycle between the same pressure limits with the same compressor efficiency and the same flow rate as in part (a). The cooling water from the condenser of a power plant enters a wet cooling tower at 40°C at a rate of 90 kg/s. The water is cooled to 25°C in the cooling tower by air that enters the tower at 1 atm, 23°C, and 60 percent relative humidity and leaves saturated at 32°C. Neglecting the power input to the fan, determine (a) the volume flow rate of air into the cooling tower and (b) the mass flow rate of the required makeup water.