University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours Degree
Level 4 (Semester 2) Examination, December 2023
Academic year 2021/2022

Course Unit: ENT 4252 - ENT4252 Refrigeration and Air Conditioning

Duration: 2 hours

- Answer all **Four (04)** questions. Each question carries fifteen marks.
- Non-Programmable calculators are allowed
- P-h diagram of the R134a refrigerant and Psychometric chart is provided.
- Provide neat sketches and state any reasonable assumptions made.
- Symbols have their usual meaning.

Q1. The ideal vapour compression cycle is widely adopted for domestic and industrial applications because of its practical aspects.

a) Draw a T-S diagram of the reverse Carnot cycle and state thermodynamic processes associated with the cycle.

(1.8 Marks)

b) Draw a P-h diagram of the ideal vapour compression cycle and state thermodynamic processes associated with the cycle.

(1.8 Marks)

c) State **three** main practical difficulties associated with the reverse Carnot cycle when practically implementing it.

(1.8 Marks)

d) Briefly describe how the identified practical difficulties in the reverse Carnot cycle are mitigated in the ideal vapour compression cycle.

(1.8 Marks)

e) An Ideal vapour refrigeration cycle operates with the condenser pressure of 10 bar and evaporator pressure of 0.8 bar.

I. Construct the P-h diagram of the cycle in the provided P-h chart.

(1.6 Marks)

II. Find the following parameters using the constructed P-h diagram.

- Evaporator and condenser temperature
- Enthalpy values at the inlet to the compressor
- Enthalpy values at the condenser outlet
- Enthalpy values at the compressor outlet

(2.0 Marks)

III. Calculate the amount of energy absorbed from the refrigerated space in kJ/kg.

(1.0 Mark)

IV. Calculate the amount of energy released to the environment in kJ/kg.

(1.0 Mark)

V. Calculate the work input to the compressor in kJ/kg.

(1.0 Mark)

VI. Calculate the Coefficient of Performance (COP) of the cycle.

(1.2 Marks)

Q2.

a) Gas refrigeration cycles are commonly used for aircraft cooling systems due to their desirable characteristics.

I. Draw the simple gas refrigeration cycle on a T-S diagram and mention each thermodynamic process associated with the cycle.

(2.0 Marks)

II. State two main desirable characteristics of the gas refrigeration cycle.

(1.0 Mark)

b) Write **four** advantages of using gas refrigeration systems in aircraft cooling.

(3.0 Marks)

c) An ideal gas refrigeration cycle uses air as the working fluid. A refrigerator working on this cycle has to maintain a refrigerated space at -10 °C while rejecting heat to the surroundings at 300 K. If the pressure ratio of the compressor is 2.7. The ratio of the main specific heat capacities (γ) of the gas is 1.4.

I. Determine the maximum temperature of the cycle.

(3.0 Marks)

II. Determine the minimum temperature of the cycle.

(3.0 Marks)

III. Calculate the coefficient of the performance (COP) of the cycle.

(3.0 Marks)

Q3.

a) Absorption refrigeration system involves the absorption of refrigerant by a transport medium.

I. How does an absorption refrigeration system differ from a vapor-compression refrigeration system?

(1.0 Mark)

II. In absorption refrigeration cycles, why is the fluid is cooled in the absorber?

(3.0 Marks)

III. Briefly describe the importance of the rectifier.

(3.0 Marks)

b) An absorption refrigeration system receives heat from a source at 120 °C and maintains the refrigerated space at 0 °C. Suppose the temperature of the environment is 25 °C. Calculate the coefficient of performance (COP) of the system.

(4.0 Marks)

c) Two or more refrigerant cycles that operate in series are called cascade refrigeration systems. How does the coefficient of the performance (COP) of a two-stage cascade refrigeration system vary compared to the COP of the simple vapour-compression cycle operating under the same pressure limits? Briefly describe with the aid of a T-S diagram.

(4.0 Marks)

Q4.

a) The study of the air-water vapour mixture is called psychrometrics. Define the terms specific humidity and relative humidity.

(2.0 Marks)

b) Saturated air at 20 °C at a rate of 70 m^3/min (stream 01) is mixed adiabatically with the outside air at 35 °C and 50% relative humidity at a rate of 30 m^3/min (stream 02). Assume that the mixing process occurs at a pressure of 1 atm.

I. Mark the corresponding points on the given psychrometric chart. Find the enthalpy, specific humidity, and specific volume of each inlet stream.

(4.0 Marks)

II. Calculate the mass flow rates of dry air of streams 01 and 02.

(2.0 Marks)

III. Calculate the enthalpy of the mixture.

(3.0 Marks)

IV. Mark the corresponding point of the mixture on the psychrometric chart. Find the specific humidity, temperature and relative humidity of the mixture using the marked point on the chart.

(4.0 Marks)