TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering & Technology

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY EXAMINATIONS FOR
THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING
(Y3 S1)
INSTITUTIONAL BASED

EMG 2302 ENGINEERING THERMODYNAMICS II

END OF SEMESTER EXAMINATIONS

SERIES: APRIL 2017

TIME: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

This paper contains **FIVE** questions. Answer **ANY THREE** questions

Supplied: *Thermophysical and Transport Properties of Fluids (SI Edition)*, by Moran, J. M., and Shapiro, H. N.

Question 1

An ideal Rankine cycle with reheat uses water as the working fluid. Superheated steam vapour enters the turbine at 8 MPa, 480^{o}C. Steam expands through the first-stage turbine at 0.7 MPa and reheated to 480^{o}C. The condenser pressure is 8 kPa. The net power output of the cycle is 100 MW.

(a) Draw a schematic of the entire process and sketch the process on a *T-s* diagram.

Calculate;

(b) The rate of heat transfer to the working fluid passing through the steam generator, in MW.

(c) The thermal efficiency.

(d) The rate of heat transfer to cooling water passing through the condenser, in MW.

(20 marks)

Question 2

A power plant operates on a regenerative vapour power cycle with one open feedwater heater. Steam enters the first turbine stage at 12 MPa, 520^{o}C and expands to 1 MPa, where some of the steam is extracted and diverted to the open feedwater heater operating at 1 MPa. The remaining steam expands through the second turbine stage to the condenser pressure of 6 kPa. Saturated liquid exits the open feedwater heater at 1 MPa. Assume each turbine stage and the pump has an isentropic efficiency of 100%.

(a) Draw a schematic diagram for the cycle and sketch the process on a *T*-*s* diagram.

Calculate for the cycle;

(b) The thermal efficiency and

(c) The mass flow rate into the first turbine stage, in kg/h, for a net power output of 330 MW.

(20 marks)

<u>Question 3</u>

(a) A Carnot refrigeration cycle uses Refrigerant 134a as the working fluid. The refrigerant enters the condenser as saturated vapour at 28^{o}C and leaves as saturated liquid. The evaporator operates at a temperature of –10^{o}C. Determine in kJ per kg of refrigerant flow,

(i) The work input to the compressor.

(ii) The work developed by the turbine.

(iii) The heat transfer to the refrigerant passing through the evaporator.

(iv) What is the coefficient of performance of the cycle? **(8 marks)**

(b) A vapour-compression refrigeration cycle circulates Refrigerant 134a at the rate of 6 kg/min. The refrigerant enters the compressor at –10^{o}C, 1.4 bar and exits at 7 bar. The isentropic compressor efficiency is 67%. There are no appreciable pressure drops as the refrigerant flows through the condenser and the evaporator. The refrigerant leaves the condenser at 7 bar, 24^{o}C. Ignore heat transfer between the compressor and the surroundings. Let T_o = 21^{o}C, p_o = 1 bar. Calculate,

(i) The coefficient of performance.

(ii) The refrigeration effect, in tons

(iii) The rates of exergy destruction in the compressor and expansion valve, each in kW.

(iv) The changes in specific flow exergy of the refrigerant passing through the evaporator and condenser, respectively, in kJ/kg. **(12 marks)**

<u>Question 4</u>

(a) A counter-flow heat exchanger operating at steady state has water entering as saturated vapour at 1 bar with a mass flow rate of 2 kg/s and exiting as saturated liquid at 1 bar. Air enters in a separate stream as 300 K with a negligible change in pressure. Heat transfer between the heat exchanger and its surrounding is negligible as are changes in kinetic and potential energy. Let T_o = 300 K, p_o = 1 bar. Calculate:

(i) The change in the flow of exergy rate of each stream, in kW.

(ii) The rate of exergy destruction in the heat exchanger, in kW. **(12 marks)**

(b) A pump operating at steady state takes in saturated liquid water at 0.1 bar and discharges water at 10 MPa. The isentropic pump efficiency is 70%. Heat transfer with surroundings and kinetic and potential energy effects can be neglected. If T_o = 25°C, calculate for the pump,

(i) Exergy destruction, in kJ per kg of water flowing.

(ii) The exergetic efficiency. **(8 marks)**

<u>Question 5</u>

(a) Using the Psychrometric chart, determine

(i) The relative humidity, the humidity ratio, and the specific enthalpy of the mixture, in kJ per kg of dry air corresponding to dry-bulb and wet-bulb temperatures of 30 and 25°C, respectively.

(ii) The humidity ratio, mixture specific enthalpy, and wet-bulb temperature corresponding to dry-bulb temperature of 30°C and 60% relative humidity.

(iii) The dew-point temperature corresponding to dry-bulb and wet-bulb temperatures of 30 and 20°C, respectively. **(7 marks)**

(b) In a condenser of a power plant, energy is discharged by heat transfer at a rate of 836 MW to a cooling water that exits the condenser at 40°C into the cooling tower. Cooled water at 20°C is returned to the condenser. Atmospheric air enters the tower at 25°C, 1 atm, 35% relative humidity. Make-up water is supplied at 25°C. For operation at steady state, determine the mass flow rate, in kg/s of

(i) The entering atmospheric air,

(ii) The make-up water.

Ignore kinetic and potential energy effects. **(13 marks)**