NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

THERMODYNAMICS

TIE 2101

First Semester Main Examination Paper

December 2014

This examination paper consists of four (4) printed pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Steam tables

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INSTRUCTIONS AND INFORMATION TO CANDIDATE:

1. Answer any five (5) questions.
2. Each question carries 20 marks.
3. Use of calculators is permissible.

Question 1

a) Differentiate between an open, a closed and an isolated type of systemgiving examples of each. [6]

b) Define the following terms relating to a thermodynamic system;

   i) Enthalpy, [2]

   ii) Entropy, [2]

   iii) Exergy, [2]

   iv) Work. [2]

c) Explain the laws of thermodynamics and their implications. [6]

Question 2

A mass of air occupying 0.5 m^3 at 2 Bar and 200 °C is compressed reversibly and adiabatically to 5 Bar and then it undergoes isobaric expansion so that it gives out 45 kJ of work. If the system is to be brought back to its initial state,

a) Sketch the cycle on a p-V diagram, [4]

b) Calculate the polytropic index for bringing the system to its original state, [8]

c) Calculate the network done of this cycle, [5]

d) Compute the power developed if the number of cycles executed per minute is 300. [3]

Question 3

a) Compare and contrast the steam turbine and the gas turbine power cycles. [8]

b) In the turbine of a gas turbine unit the gases flow through the turbine at 17 kg/s and the power developed by the turbine is 14000kW. The specific enthalpies of the gases at inlet and outlet are 1200kJ/kg and 360kJ/kg respectively, and the velocities of the gases at inlet and outlet are 60m/s and 150m/s respectively.

   i) Calculate the rate at which heat is rejected from the turbine. [6]

   ii) Find also the area of the inlet pipe given that the specific volume of the gases at the inlet is $0.5m^3/kg$. [6]

Question 4

a) What is refrigeration? [2]

b) With the help of a block diagram, explain the working of the simple vapour compression refrigeration system. [3]

   i) Show the cycle onT-S and p-h diagrams, [3]

   ii) Derive the expression for C.O.P in terms of the enthalpy. [3]

c) In a refrigerating plant using R12 the vapour leaves the evaporator dry saturated at 2.191 Bars and is compressed to 8.477 Bars. The temperature of the vapour leaving the compressor is 50 ºC and the liquid leaves the condenser at 25ºC and is throttled to the evaporator pressure, calculate:

   i) The refrigerating effect. [3]

   ii) The specific work input. [3]

   iii) The COP_{ref}. [3]

Question 5

(a) Discuss the stages in the formation of steam and derive an expression for the dryness fraction. [6]

(b) A steam boiler generates steam at a pressure of 30 Bar, temperature of 300 °C at the rate of 2 kg/s. The steam is expanded isentropically in a turbine to a condenser pressure of 0.05bar, condensed at constant pressure and pumped back to the boiler.

   i) Draw the schematic arrangement of the above T-S diagram of Rankinecycle, [2]

   ii) Find the heat supplied in the boiler/hr, [3]

   iii) Determine the quality of steam after expansion, [3]

   iv) What is the power generated by the turbine? [3]

   v) Estimate the Rankine efficiency considering pump work. [3]

Question 6

An ideal dual combustion cycle has a volume ratio of the adiabatic compression of 15:1. At the beginning of the adiabatic compression the pressure, volume and temperature of the gas are 100 kN/m^2, 0.084 m^{3}and 25 °C, respectively. The maximum pressure and temperature of the cycle are 7.2 MN/m^2 and 1300 °C, respectively. For the cycle determine:

a) the pressure, volume and temperature at the cycle process change points. [3]
b) the net work done, [3]
c) the thermal efficiency, [3]
d) the heat received, [3]
e) the work ratio, [3]
f) the mean effective pressure, [3]
g) the Carnot efficiency within the cycle temperature limits. [2]

Take Cp =1.005kJ/kgK and Cv= 0.717 kJ/kgK, where

Cp is the specific heat at constant pressure and Cv is the specific heat at constant volume.

Question 7

a) With the aid of sketches describe the ways inwhich heat is transferred giving practical examples in each case. [6]
b) State the Newton's law of cooling [2]
c) In a small furnace, the heat loss to the surroundings is to be kept down to 1800 W/m^2. The internal temperature of 180 mm firebrick wall which lines the furnace is 700 °C, and the temperature of the air surrounding the furnace is 27 °C. Neglecting the temperature drop through the steel casing, Take the thermal conductivity of the firebrick to be 1.2 W/mK, the thermal conductivity of the lagging to be 1.4 W/mK and the convection heat transfer coefficient of the lagging surface as 20 W/m^{2}K**.** Radiation from the lagging surface may be ignored.

   i) Calculate the thickness of exterior lagging required, [8]
   ii) Estimate also the temperature of the outer surface of the lagging. [4]

End of examination