EX/CE/ME/T/211/2017(S)

B. CIVIL ENGG. 2ND YEAR 1ST SEM SUPPLEMENTARY EXAMINATION, 2017

THERMODYNAMICS AND HEAT POWER

Time: Three hours | Full Marks: 100

Answer any **five** questions

Use of thermodynamic tables and charts is permitted

Assume any suitable data if necessary

All parts of the same question must be answered together

Symbols carry usual meaning

1. a) State and explain the zeroth law of thermodynamics in brief. 05

b) State the similarities and differences between heat and work. 05

c) A closed system of a gas of 5kg mass undergoes expansion process ($pv^{1.3}$=constant) from 1Mpa and $0.5m^3$ to 0.5Mpa. The specific internal energy of the gas is given by, u=1.8pv + 85 kJ/kg, where p in kPa, v in $m^3/kg$. Determine heat and work interactions and change in internal energy. 10

2. a) A gas undergoes a thermodynamic cycle consisting of the following processes:

Process 1-2: constant pressure, $p_1$=1.4 bar, $V_1=0.028m^3$, $W_{1-2}$=10.5kJ.

Process 2-3: compression with pv=constant, $U_3=U_2$.

Process 3-1: constant volume, $U_1-U_3$= -26.4kJ.

There are no changes in kinetic and potential energies. a) sketch the cycle on the p-v diagram. b) calculate the net work of the cycle in kJ. c) calculate the heat transfer for process 1-2 in kJ. 12

b) A compressor receives air at 100kPa, $25^0C$ and discharges that at $185^0C$, 400kPa. The velocity of air at the inlet and exit are 150m/s and 50m/s respectively. The power input to the compressor is 3000kW. Neglecting heat transfer from the compressor and change in potential energy, find out the mass flow rate through the compressor. Assume $c_p$=1.005kJ/kgK. 08

3. a) Draw the p-v-T surface for pure water. Show on the surface an isobaric process line. Show the critical point and the triple line on this surface. 08

b) Define and explain dryness fraction of steam. 04

c) A vessel having a volume of $0.05m^3$ contains a mixture of saturated steam and water at a temperature of $300^0C$. The mass of liquid water is 10kg. Determine the pressure, mass, enthalpy, and entropy of total contents present in the vessel. 08

4. a) Show that no heat engine can have higher efficiency than a reversible heat engine operating between two given thermal reservoirs. 10

b) A reversible heat engine operates between three heat reservoirs A, B and C. The heat received by the engine from each of the reservoirs A and B is same and at temperatures $T_A$ and $T_B$ respectively; and the engine rejects heat to the reservoir C at temperature $T_C$. If the engine efficiency is K times the efficiency of a reversible heat engine operating between two reservoirs A and C only, show that:

$$\frac{T_A}{T_B} = 2(1-K)\frac{T_A}{T_C} + (2K-1)$$ 10

5. a) Show that entropy is a property of a system. 10

b) Deduce the expression for change of entropy of an ideal gas during a reversible process in terms of initial and final pressure and volume. 05

c) Show the expression of heat transfer for a reversible polytropic process and hence find the expression of polytropic specific heat. 05

6) a) Derive the expression of the air standard efficiency of an Otto cycle as a function of compression ratio. 08

b) An air standard diesel cycle has a compression ratio of 18 and the heat transferred to the working fluid per cycle is 1800kJ/kg. At the beginning of the compression process the pressure is 0.1 MPa and the temperature is $15^0$C. Determine: i) the pressure and temperature at each cardinal point in the cycle. ii) thermal efficiency and iii) the mean effective pressure. 12

7. Write short notes on the following: 05x4=20

a) Reversible process b) Assumptions of air standard cycles c) Rankine cycle d) throttling process

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