Menoufiya University
Faculty of Engineering
Shebin El-Kom
Academic Year: 2012-2013

Year:third Year
Department: mechanical power Eng
Subject: Thermal energy systems
Time Allowed: 3 hours
Date: 04/06/2013

ILOs : A11,A14,A17,B2,C15,C17,D1,D2 and D3

Table and chart of steam are allowed.

Answer the following question:

Question (1):..(15 mark)

1) - what the meaning of the following: exergy – availability and unavailability energy.

2) - What do you understand by second law efficiency? How does it differ from first law Efficiency?

3) Discuss the following items: Internal - external irreversibility and work lost for any cycle.

4) - Compare between the exergy (availability) and energy based upon their characteristics.

5) - For simple Rankine cycle, with net diagrams explains the internal and external irreversibilities which associated with the boiler, turbine, condenser and pump.

Question (2):..(20 mark)

a) Two tanks A and B contain 1 kg of air at 1 bar, 50 °C and 3 bar , 50 °C when atmosphere is at 1 bar , 15 °C. Identify the tank in which stored energy is more; also find the availability of air in each tank.

b) A steel casting weighing 20 kg is removed from a furnace at a temperature of 800 °C and heat treated by quenching in a bath containing 500 kg water at 20°C . Calculate the change in availability of the universe due to this operation. The specific heat of the water is 4.18 kJ/kg.K, and that of steel is 0.42 kJ/kg.K. Assume that the bath of the water is rigid and perfectly insulated from the surroundings after the casting has been dropped in, and take the datum temperature and pressure as 20 °C and 1 bar respectively.

Question (3):..(15 mark)

Steam enters a turbine steadily at 3 MPa and 450°C at a rate of 8 kg/s and exits at 0.2 MPa and 150°C . The steam is losing heat to the surrounding air at 100 kPa and 25°C at a rate of 300 kW, and the kinetic and potential energy changes are negligible. Determine (*a*) the actual power output,

(*b*) the maximum possible power output,

(*c*) the second-law efficiency,

(*d*) the exergy destroyed, and

(*e*) the exergy of the steam at the inlet conditions.

Question #4 (20 points)

a) **Explain** how the second law of thermodynamics specifies the direction of processes. (1 point)

b) **What** is the irreversibility? **What** are the factors that cause irreversibility in the thermodynamics processes? (2 points)

c) Piston/cylinder arrangement contains 2.0 kg of air ($\gamma = 1.4$, R=287 J/kg.k) at 0.1 MPa and 300 K. The air undergoes an internally reversible process in which the air entropy varies linearly with air temperature. At the end of the process the air pressure and temperature become 0.15 MPa and 600 K respectively. (7 points)

- Sketch the process on P-v and T-s diagrams
- Calculate the entropy change of air during the process.
- Calculate the heat transfer during the process
- Calculate the work transfer during the process

d) Air flows steadily through 20 cm diameter well insulated pipe. The reading of pressure and temperature of the air at two stations in the pipe A and B are : $P_A = 1.0\ bar,\ T_A = 27\ ^oC$, $P_B = 1.3\ bar,\ T_B = 47\ ^oC$. **Deduce** the direction of air flow in the pipe. And **calculate** the f velocity at the two locations if the air mass flow rate is 1 kg/s. (5 points)

e) An evacuated tank is connected through a valve to an air supply at room temperature, T_o (K) and at pressure P_s. The valve is opened allowing air to flow into the tank until the pressure inside the tank becomes $P_2 = P_s / \gamma$. At this point the valve is closed. The filling process occurs rapidly and is essentially adiabatic and can be assumed as USUF process. **Show that** the final air temperature in the tank is $T_2 = \gamma T_o$ *and* **show that** the irreversibility (per unit mass enters the tank) during the process is equal to $T_o * C_V (2\gamma - 1) * \ln(\gamma)$ (5 points)

Make use of the following relations (if needed)

$$\dot{Q}_{cv} - \dot{W}_{cv} = \frac{dE_{cv}}{dt} + \sum \dot{m}_e h^*_e - \sum \dot{m}_i h^*_i \qquad (1)$$

$$\dot{m}_i - \dot{m}_e = \frac{dm_{cv}}{dt} \qquad (2)$$

$$\dot{S}_{gen,tot} = \frac{ds_{cv}}{dt} + \sum \dot{m}_e s_e - \sum \dot{m}_i s_i - \sum \frac{\dot{Q}_{cv}}{T_{surr}} \qquad (3)$$