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BME-019

B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING) / BTMEVI

Term-End Examination

December, 2015

BME-019 : ENGINEERING THERMODYNAMICS

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt any* ***seven*** *questions. All questions carry equal marks. Use of scientific calculator is permitted. Use of steam table is also allowed.*

1. (a) Write the general expression for First Law of Thermodynamics. Hence prove that total energy of the system is a property. *5*

(b) A frictionsless piston-cylinder device contains 0·4 m^3 of air at 100 kPa and 80°C. The air is now compressed to 0·1 m^3 in such a way that the temperature inside the cylinder remains constant. Determine the work done during the process. *5*

2. (a) Explain the Kelvin-Planck and Clausius statements of Second law of Thermodynamics. 5

(b) Heat is transferred to a heat engine from a furnace at a rate of 80 MW. If the rate of waste heat rejection to a nearby river is 50 MW, determine the net power output and the thermal efficiency for this heat engine. 5

3. (a) What are the causes of irreversibilities ? With the help of suitable examples, explain the internally and externally reversible processes. 5

(b) A reversible heat engine is operating between – 13°C and 37°C. Find its COP as (i) heat pump (ii) refrigerator. 5

4. (a) A refrigerator with a COP of 4·0 transfers heat at a rate of 0·5 kJ/s at the condenser. Find the rate of heat transfer at the evaporator and the power input to the compressor. Also calculate the COP, if the refrigerator were to operate as a heat pump with same heat and work interactions. 6

(b) Prove that

$$(COP)_{hp} = (1 + COP)_{ref.}$$ 4

5. What do you understand by reversible and irreversible processes ? With the help of suitable examples, discuss the various factors responsible for irreversibility in a process. *10*

6. (a) Show that the entropy change in a process when a perfect gas changes from State 1 to State 2 is given by :

$$s_2 - s_1 = C_v \, ln \frac{T_2}{T_1} + R \, ln \frac{V_2}{V_1}.$$ *5*

(b) A heat source at 800 K loses 2000 kJ of heat to a sink at (i) 500 K and (ii) 750 K. Determine which heat transfer process is more irreversible. *5*

7. A steam power plant has steam at a pressure of 40 bar and temperature 400°C and exhausted into a condenser where a pressure of 0·05 bar is maintained. The mass flow rate of steam is 160 kg/s. Determine :

(i) Rankine cycle efficiency

(ii) Rankine engine efficiency

(iii) Power developed

(iv) Specific steam consumption

(v) Heat rejection in the condenser *10*

8. (a) Derive an expression for minimum work in two-stage compression with intercooling. *5*

(b) A gas is to be compressed from 30 kPa to 500 kPa. It is known that cooling corresponding to a polytropic exponent of 1·25 is practical and the clearance of the available compressor is 3%. Compare the volumetric efficiencies to be anticipated for

(i) single-stage compressor

(ii) two-stage compression with equal pressure ratios in the stages. *5*

9. (a) Show on T-s and P-h diagrams the effect of irreversibilities on compressor work. Express adiabatic efficiency of the compressor in terms of enthalpies. *5*

(b) Explain the working of a Reverse Brayton cycle. Derive the expression of COP for Reverse Brayton cycle. *5*

10. Write short notes on the following : *2×5=10*

(a) WHF

(b) Principles of Energy Conservation