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ME 131303

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2017

B.Tech. 3rd Semester End-Term Examination

Mechanical

BASIC THERMODYNAMICS

Full Marks – 100 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer Question No 1. and any *six* questions from the rest. (10 × 1 = 10)

1. Answer the following.

   (a) If barometer reads 760 mm of Hg, then 5 cm Hg vacuum = ———— kPa absolute pressure.

   (b) A ———— is a device which increases the velocity of a fluid at the expense of its pressure drop whereas a ———— is a device which increases the pressure of a fluid at the expense of its kinetic energy.

   (c) The property introduced by the first law of thermodynamics is ————.

   (d) When a process remains infinitesimally close to an equilibrium state at all times, it is called ————.

   (e) In a reversible adiabatic process, ———— remains constant.

[Turn over

(f) Work done for a polytropic process 1-2 is given by:

(i) $W_{1-2} = \frac{p_1 v_1}{n-1}\left[1-\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}\right]$

(ii) $W_{1-2} = \frac{p_1 v_1}{1-n}\left[1-\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}\right]$

(iii) $W_{1-2} = \frac{p_1 v_1}{n-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}-1\right]$

(iv) $W_{1-2} = \frac{p_1 v_1}{1+n}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}-1\right]$

(g) Properties of substances like pressure, temperature and density, in thermodynamic coordinates, are

(i) Path functions

(ii) Point functions

(iii) Cyclic functions

(iv) Thermodynamic functions

(h) The value of index, $n=1$, in polytropic process $pv^n = C$, indicates

(i) A reversible process

(ii) An isothermal process

(iii) An adiabatic process

(iv) An irreversible process

(i) Amount of oxygen required for complete combustion of 5 kg of carbon is

(i) 2.6 kg (ii) 13.33 kg

(iii) 7.33 kg (iv) 5.33 kg

(j) According clausius' inequality, a cycle is reversible when

(i) $\oint \frac{dQ}{T} = 0$ (ii) $\oint \frac{dQ}{T} < 0$

(iii) $\oint \frac{dQ}{T} > 0$ (iv) $\oint \frac{dQ}{T} \leq 0$

2. Write notes on:

(a) Bomb calorimeter

(b) Carnot cycle

(c) Formation of 1 kg steam for ice at 0°C at 1 bar pressure. (5+5+5)

3. (a) State both the statements of 2nd law of thermodynamics.

(b) Differentiate between

(i) Extensive and intensive properties

(ii) Absolute pressure and gauge pressure

(iii) SI and CI engines

(iv) Point and path functions

(v) Reversible and irreversible processes. (5+10)

4. (a) Show that no heat engine working between two fixed temperatures can have efficiency greater than that of a reversible engine working between the same temperatures.

(b) What is the principle of thermometry? Name any three thermometers along with their thermometric properties

(c) Prove that energy is a property of a thermodynamic system. (5+5+5)

5. (a) Explain in details the rankine cycle with a p-v diagram and derive its efficiency.

(b) In an air standard diesal cycle, the compression ratio is 16 and at the beginning of isentropic compression, the temperature is 15°C and the pressure is 0.1 MPa. Heat is added until the temperature at the end of constant pressure process is 1480°C.

Calculate:

(i) Cut off ratio

(ii) Heat supplied per kg of air

(iii) Cycle efficiency

(iv) m.e.p. (5+10)

6. (a) What are proximate analysis and ultimate analysis of fuel?

(b) Dry exhaust gas from an oil engine had the following composition by volume:

$CO_2 = 8.85\%$, $CO = 1.5\%$, $O_2 = 6.8\%$,
$N_2 = 80.15\%$

The fuel oil had a percentage composition by mass as:

$C = 85\%$, $H_2 = 14\%$, $O_2 = 2\%$

(i) Convert this volumetric analysis to percentage analysis by weight

(ii) Determine the A/F ratio. (5+10)

7. (a) Define the following terms: Degree of superheat, calorific value, stoichiometric air, HCV and LCV.

(b) A reversible heat engine which drives a reversible refrigerator operates between a source and a sink at temperatures 450°C and 38°C respectively. The refrigerator has its source at –25°C and rejects heat to the sink at 38°C as the heat engine. The heat energy transfer to the heat engine is 2100 kJ and the network output of the combined engine-refrigerator plant is 350 kJ. Determine.

(i) The heat transfer to the refrigerant and the net heat transfer to the sink.

(ii) Recondiser (i) Given that the efficiency of the heat engine and COP of the refrigerator are each 50% of their maximum possible value. (5+10)

8. (a) What are steady flow devices? Explain with examples. What assumptions are made during the analysis of a system undergoing steady flow process?

(b) In a steam power plant operating on ideal Rankine cycle, steam enters the turbine at 20 bar, 350°C and expands to condenser pressure of 0.1 bar. It then condenses to saturated liquid water and is pumped back into the boiler by a pump. Determine the cycle efficiency.

(c) In a steam power station, steam flows steadily through a 0.25 m diameter pipeline from the boiler to the turbine. At the boiler end, the steam conditions are found to be: $p = 4$ Mpa, $t = 400^{\circ}C$, $h = 3213.6 kJ/kg$ and $v = 0.073 m^3/kg$. At the turbine end, the conditions are found to be $p = 3.5$ MPa, $t = 390^{\circ}C$, $h = 3202.6$ kJ/kg and $v = 0.084 m^3/kg$. There is heat loss of 8.5 kJ/kg from the pipeline. Calculate the steam flow rate. (5+5+5)

9. (a) Establish the inequality of claussius.

(b) An engine working on Otto cycle is supplied with air at 0.2 MPa, 36°C. The compression ratio is 8. Heat supplied is 2200kJ/kg. Calculate the cycle efficiency, maximum pressure and temperature of the cycle.

(c) Calculate the entropy change of the universe as a result of a copper block of 600g mass and with Cp of 150 J/k at 100°C is placed in a lake at 8° C. (5+5+5)