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ME 181303

15/2/23

Roll No. of candidate

2023

B.Tech. 3rd Semester End-Term Examination

Mechanical Engineering

BASIC THERMODYNAMICS

(New Regulation and New Syllabus)

Full Marks – 70 Time – Three hours

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

Answer Question No. 1 and any *four* from the rest.

1. Answer the following MCQ : $(10 \times 1 = 10)$

(i) All perfect gases change in volume by 1/273 of its original volume at 0° C for every 1°C change in temperature, when the absolute pressure remains constant. This statement is according to

(a) Boyle's law (b) Charles' law

(c) Gay – Lussac law (d) Joule's law

(ii) A process, in which the temperature of the working substance remains constant during expansion or compression, is called

(a) Isothermal process (b) Hyperbolic process

(c) Adiabatic process (d) Polytropic process

(iii) The work done in a steady flow process is given by

(a) $\int_1^2 v\,dp$ (b) $-\int_1^2 v\,dp$

(c) $\int_1^2 p\,dv$ (d) $-\int_1^2 p\,dv$

(iv) It is impossible to construct an engine while working in a cycle, produces no effect other than to extract heat from a single thermal reservoir and perform and equivalent work. This statement refers to

(a) Clausius statement (b) Kelvin – Planck statement

(c) Carnot's theorem (d) PMM 2

(v) The coefficient of performance of a beat pump is given by

(a) $\frac{T_1 - T_2}{T_1}$ (b) $\frac{T_1}{T_1 - T_2}$

(c) $\frac{T_2}{T_1 - T_2}$ (d) $\frac{T_1 - T_2}{T_2}$

(vi) The condition for a reversible cyclic process

(a) $\oint \frac{\partial Q}{T} > 0$ (b) $\oint \frac{\partial Q}{T} < 0$

(c) $\oint \frac{\partial Q}{T} = 0$ (d) $\oint \frac{\partial Q}{T} = 1$

(vii) If m_g = mass of dry steam and m_f = mass of water particles in suspension, then the dryness fraction of steam is equal to

(a) m_f / m_g (b) m_g / m_f

(c) $m_f / (m_g + m_f)$ (d) $m_g / (m_g + m_f)$

(viii) The process, in which the change in internal energy is equal to the change of enthalpy, is known as

(a) Hyperbolic process (b) Isentropic process

(c) Polytropic process (d) Throttling process

(ix) A cycle which consists of two reversible adiabatic processes and two constant pressure processes is known as

(a) Otto cycle (b) Diesel cycle

(c) Dual cycle (d) Brayton cycle

(x) The ultimate analysis of coal relates to the determination of percentage by weight of

(a) Moisture and volatile matter only

(b) Moisture, volatile matter, fixed carbon and ash

(c) Carbon, hydrogen, oxygen, nitrogen, sulphur and ash

(d) Carbon, hydrogen and oxygen

2. (a) What is a quasi – static process? What is its characteristic feature? (5)

(b) A closed vessel contains 2 kg of CO_2 at a temperature of 20°C and a pressure of 0.7 bar. Heat is supplied to the vessel till the gas acquires a pressure of 1.4 bar. Calculate the value of heat supplied. Take $C_v = 0.657$ kJ/kgK. (5)

(c) 0.016 m^3 of gas at constant pressure of 2 Gpa expands to a pressure of 215 kPa by following the law $pv^{1.35} = C$. Determine the work done by the gas during expansion process. (5)

3. (a) Apply the steady flow energy equation for a nozzle and deduce an expression for the exit velocity considering the velocity of approach is very small. (5)

(b) In a gas turbine, the gas enters at the rate of 5 kg/s with velocity of 50 m/s and enthalpy of 900kj/kg and leaves the turbine with a velocity of 150 m/s and enthalpy of 400 kj/kg. The loss of heat from the gases to the surrounding is 25 kj/kg. Assume for gas, R = 0.285 kj/kg K and $C_p = 1.004$ kJ/kg K. The inlet condition is at 100 kPa and 27°C. Determine the power output of the turbine. (10)

4. (a) To produce network in a thermodynamic cycle, a heat engine has to exchange heat with two thermal reservoirs. Explain. (7)

(b) A refrigerating machine works on a reversed Carnot cycle. It consumes 6 kw and the refrigerating effect is 1000 kj/min. The sink temperature is –40° C. Determine the source temperature and the COP of the refrigerating machine (8)

5. (a) Calculate the internal energy of 1 kg of steam when its pressure is 10 bar and its dryness fraction is 0.9. (9)

(b) Find the enthalpy, entropy and volume of steam at 1.2 MPa and 380°C. (6)

6. (a) Show that for the Otto cycle, the air standard efficiency can be expressed as

$$\eta = 1 - \frac{1}{n^{r-1}}$$

Where r is the compression ratio. (5)

(b) An engine 20 cm bone and 30 cm stroke works on Otto cycle. The clearance volume is 1600 cubic centimeter. The enitial pressure and temperature are 1 bar and 60 °C. If the max. Pressure is limited to 24 bar, find the following :

(i) The air standard efficiency of the cycle.

(ii) Mean effective pressure for the cycle. (Assume the ideal conditions).

(10)

7. (a) Differentiate between H.C.V. and L.C.V. of a fuel and state which value is used in calculations and why. (5)

(b) The fuel sample has the percentage analysis by mass as follows :

C = 81%, H_2 = 5%, O_2 = 5%, Moisture = 2% and Ash = 7%.

Calculate theoretical minimum air required for complete combustion of 1 kg of given fuel. Also calculate the volumetric analysis of dry flue gases, if actual air supplied is 16 kg per kg of fuel. Assume that 80% of carbon is burnt to CO_2 and remaining to CO. Hydrogen from fuel burns completely.

(10)