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MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : ME-301

APPLIED THERMODYNAMICS

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Work done is zero for

a) isochoric process

b) free expansion

c) throttling

d) all of these.

ii) Which of the following is the correct relationship between enthalpy and entropy ?

a) $dh = Tds - vdp$ b) $dh = Tds - pdv$

c) $dh = Tds + pdv$ d) $dh = Tds + vdp$.

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iii) According to Kelvin Plank's statement, a perpetual motion machine of

a) first kind is possible

b) first kind is impossible

c) second kind is possible

d) second kind is impossible.

iv) AT Triple point

a) Ice on heating becomes superheated vapour

b) Solid, liquid amd vapour exist

c) Ice occupies maximum specific volume

d) Liquid water, dry saturated steam co-exist.

v) Maxwell's thermodynamic relations are applicable to

a) Reversible processes

b) Irreversible processes

c) Mechanical system in equilibrium

d) Thermodynamic processes.

vi) During a throttling process which of the following properties does not change ?

a) Internal energy b) Entropy

c) Pressure d) Enthalpy.

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vii) For the same peak pressure and work output

a) $\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$

b) $\eta_{Otto} > \eta_{Diesel} > \eta_{Dual}$

c) $\eta_{Diesel} > \eta_{Otto} > \eta_{Dual}$

d) $\eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$

viii) The work input to air compressor will be least if the exponent n in the process $pv^n = C$ equals

a) $n = 1$

b) $n = 1.2$

c) $n = \gamma = 1.4$

d) n takes the infinite value.

ix) When dry bulb and wet bulb temperatures of air are same, the relative humidity will be

a) 0% b) 50%

c) 66 - 67% d) 100%.

x) Cycle used in thermal power plant is

a) Carnot cycle b) Reversed Carnot

c) Rankine d) Brayton.

GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Derive the thermal efficiency of Otto cycle.
3. What do you understand by quality of energy ? Define 2nd law efficiency.
4. What is pure substance ? What do you understand by triple point ? Draw the phase equilibrium diagram for a pure substance on T-S plot with relevant constant property lines.

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5. Derive the Maxwell's equations.
6. Steam from a boiler is delivered at an absolute pressure of 15 bar and dryness fraction of 0.95 into a steam superheater in which the steam receives additional heat at constant pressure and its temperature increases up to 300°C. Determine the amount of heat added and the change in internal energy for unit mass of steam.
7. What is the effect of reheat on the specific output, the cycle efficiency, steam rate, heat rate ?

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

8. a) Explain the advantages of multistage compression. Derive the ideal intermediate pressure for obtaining minimum work of compression. 2 + 4

b) A single stage reciprocating air compressor has a swept volume of 2000 cm^3 & runs at 800 r.p.m. It operates on a pressure ratio of 8 with a clearance volume 5% of the swept volume. Assume NTP room condition & at inlet (P = 101.3 kpa, t = 15°C) & polytropic compression & expansion with n = 1.25, calculate :

i) Indicated power

ii) Volumetric efficiency

iii) Mass flow rate

iv) FAD

v) Isothermal efficiency. 9

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9. a) What do you mean by steam reheating ? Why is it required ?

b) What are the advantages of regeneration in Rankine cycle ?

c) In a single heater regenerative cycle the steam enters the turbine at 30 bar, 400°C and the exhaust pressure is 0.10 bar. The feedwater heater is a direct contact type which operation at 5 bar. Find the efficiency and the steam rate of the cycle.

4 + 3 + 8

10. a) A Diesel engine has a compression ratio of 20 and cut-off takes place at 5% of the stroke. Find the air-standard efficiency. Assume $\gamma = 1.4$. 4

b) A lumped steel of mass 10 kg at 627°C is dropped in 100 kg of oil at 30°C. The specific heats of steel and oil are 0.5 kJ/kg K and 3.5 kJ/kg K, respectively. Calculate the entropy change of steel, the oil and the universe. 5

c) A heat engine operates between two thermal reservoirs; source at temperature T_1 and sink at temperature T_2. Show that maximum work obtainable from the heat engine is given by $W_{max} = C_p\left(\sqrt{T_1} - \sqrt{T_2}\right)^2$. 6

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11. a) Draw a vapour compression refrigeration cycle in *p-h* and *h-s* diagrams. What are the purpose of superheat and sub-cooling in an actual vapour compression cycle ? 7

b) A refrigerator using *R*-134*a* operates on an ideal vapour compression cycle between 0.12 and 0.7 MPa. The mass flow of refrigerant is 0.05 kg/s. Determine (i) the rate of heat removal from the refrigerated space, (ii) the power input to the compressor, (iii) the heat rejection to the environment and (iv) the COP. 8

12. a) Exhaust gases leave an internal combustion engine at 800°C and at 1 atm. After having done 1050 kJ of work per kg of gas in the engine. The temperature of surroundings is 30°C.

How much available energy per kg of gas is lost by throwing away the exhaust gages ? 7

b) A large insulated vessel is divided into two chambers, one containing 5 kg of dry saturated steam at 0.2 MPa and other 10 kg of steam, 0.8 quality at 0.5 MPa. If the partition between the chambers is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure, steam quality and entropy change in the process. 8

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13. a) Explain heating and humidification, cooling and dehumidification on a psychrometric chart. 4

b) What is specific humidity ? Show that specific humidity $W = 0.622 \times p_w / (p - p_w)$ where p_w is the partial pressure of water vapour and p is the atmospheric pressure. 2 + 3

c) A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it.

i) Find the velocity at exists from the nozzle.

ii) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187 m^3 /kg, find the mass flow rate.

iii) If the specific volume at the nozzle exit is 0.498 m^3 /kg, find the exit area of the nozzle.

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