BASIC THERMAL POWER ENGINEERING
(ELEC 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) PMM 2 is impossible because it violates
(a) Zeroth law (b) 1st law of thermodynamics
(c) calorimetric principle (d) 2nd law of thermodynamics.

(ii) In case of pure impulse turbine ,enthalpy drop happens
(a) both in fixed and moving blades (b) only in fixed blades
(c) only in moving blades (d) only in nozzles.

(iii) Second law of thermodynamics defines a property called
(a) entropy (b) temperature
(c) internal energy (d) enthalpy

(iv) If V_{r1} and V_{r2} are the relative velocities of steam at entry and exit of the blade of a reaction turbine, then ,
(a) $V_{r1} \geq V_{r2}$ (b) $V_{r1} \leq V_{r2}$
(c) $V_{r2} > V_{r1}$ (d) $V_{r1} = V_{r2}$

(v) In an ideal Rankine cycle, if the degree of superheat is increased at the same pressure, then,
(a) turbine work increases
(b) heat input to boiler increases
(c) exhaust steam from turbine becomes more dry
(d) all of these.

(vi) In a Parson's reaction turbine, the enthalpy drop in fixed blade is 20 kJ/kg. Enthalpy drop in moving blade in kJ/kg is
(a) 40 (b) 20
(c) 10 (d) 80

(vii) The vacuum maintained in the surface condenser is mainly to
(a) increase the specific output from the turbine
(b) increase the heat input in the boiler
(c) reduce the boiler feed water pump work
(d) reduce the turbine work.

(viii) A regenerative feed water heating in a vapour power cycle with infinite number of feed water heaters has an efficiency equal to
(a) Otto cycle (b) Carnot cycle
(c) Diesel cycle (d) Brayton cycle

(ix) The maximum efficiency of De-Laval turbine is with nozzle angle α_1
(a) $\sin^2\alpha_1$ (b) $\cos^2\alpha_1$
(c) $\tan^2\alpha_1$ (d) $\cot^2\alpha_1$

(x) Ideal working fluid for vapour power cycle should have
(a) high critical temperature
(b) saturation pressure at the temperature of heat rejection should be above atmospheric pressure
(c) specific heat of liquid should be low
(d) all of these.

Group – B

2. (a) 1 kg of air at 1 bar 300 K is compressed adiabatically till its pressure becomes 5 times its original pressure.Subsequently it is expanded at constant pressure and then cooled at constant volume to return to its original state.Calculate the heat and work interactions and the change of internal energy for (i) each process and also for (ii) the cycle.

(b) The mass flow rate of steam into a steam turbine is 1.5 kg/s and the heat is lost from the turbine 10 kw.The steam is entering to the turbine at 20 bar,400^0C with velocity 50 m/s and the steam leaving the turbine at 0.1 bar with 0.95 dryness fraction and with 200 m/s.Determine the power output from the turbine.

6 + 6 = 12

3. (a) A reversible heat engine operates between 875K and 310K and drives a reversible refrigerator operating between 310K and 250K.The engine receives 2000 kJ of heat and net work output from the arrangement equals 350 kJ . Calculate the cooling effect of the refrigerator.

(b) Three Heat engines HE1,HE2 and HE3 operate between temperatures 1000K and 300K.Ratio of the work produced by them are 4:3:2.What are the intermediate temperatures of this arrangement?

6 + 6 = 12

Group – C

4. (a) 4 kg of water at 27^0C is mixed with 1kg of ice at 0^0 C. Assuming adiabatic mixing, determine the final temperature of the mixture of water and ice.Calculate the net change in entropy.Assume the latent heat of fusion of ice as 335 kJ/kg.

   (b) Steam at 8 bar, 400^0C flowing at the rate of 1.3 kg/s, converges into a pipe carrying wet steam at 8 bar,0.90 dry at the rate of 1 kg/s.After adiabatic mixing of steam , the steam flows in pipe at the same pressure. Find (i) the enthalpy, (ii) temperature and (iii) quality of the mixed steam.

6 + 6 = 12

5. A power plant operates on reheat regenerative vapour power cycle with a feed water heater and generates 120 MW.The steam enters the hp turbine at 150 bar, 600^0C, and expands to 20 bar.Then the steam is reheated to 600^0C at the same pressure.The Steam for the feed water heater is extracted from the lp turbine at the pressure of 5 bar and the remaining steam is expanded to condenser pressure of 0.1 bar. Assuming ideal processes, determine (i) mass flow rate of steam in kg/h (ii) fraction of steam bled for feed water heating (iii) thermal efficiency of the cycle.

(4 + 4 + 4) = 12

Group – D

6. (a) Steam enters a convergent-divergent nozzle at 15 bar, 300^0C and leaves at 2 bar.The inlet velocity to the nozzle is 150 m/s.Find the required throat and exit area for steam flow rate of 1kg/s.Take C_{ps}=2.4 kJ/kg-K and nozzle efficiency is 90%.

   (b) The nozzles of a De-Laval turbine deliver 1.5 kg/s of steam at a speed of 800m/s to a ring of moving blades having a speed of 200m/s.The nozzle angle is 18^0 and the exit angle of the moving blades is 25^0.The blade velocity co-efficient is 0.75.Calculate
   (i) the diagram efficiency
   (ii) the power developed
   (iii) the axial thrust on the turbine rotor

6 + 6 = 12

7. The following particulars refer to a two row velocity compounded impulse turbine

Steam velocity at the nozzle outlet:	650m/s
Mean blade velocity	130 m/s
Nozzle angle:	16^0
Outlet angle, first row of moving blades:	18^0
Outlet angle, fixed guide blades:	22^0
Outlet angle, second row of moving blades:	36^0
Steam flow rate :	2.6 kg/s

The ratio of relative velocity at the outlet to that at the inlet is 0.84 for all blades.Determine (i) the velocity of whirl (ii) the tangential thrust on the blades (iii) the axial thrust on blades (iv) the power developed and (v) the blading efficiency.

(4 + 2 + 2 + 2 + 2) = 12

Group – E

8. The following data were obtained in a boiler trial:
Mass and temperature of feed water = 680 kg/hr and 20°C
Steam pressure and its temperature = 15 bar and 300°C
Coal used and its calorific value = 98 kg/hr and 26500 kJ/kg
Flue gas formed = 18 kg/kg of coal supplied
Flue gas temperature at chimney = 300°C
Ash and unburnt coal is ash-pit = 4 kg/hr with 2200 kJ/kg calorific value
Mean specific heat of flue gases and feed water = 1.025 kJ/kg K and 4.18 kJ/kg K
Moisture of fuel : 2 % by mass
If the ambient temperature in the boiler room is 28°C, determine the
(i) boiler efficiency
(ii) equivalent evaporation from and at 100°C
(iii) also draw up a heat balance sheet.

(4 + 4 + 4) = 12

9. (a) Calculate the power required to drive a fan which maintains a draught of 50 mm of water under the following conditions for (a) an induced draught fan and (b) a forced draught fan.
Temperature of the flue gas leaving the boiler = 250^0C
Temperature of boiler house : 35^0 C.
Air supplied per kg of fuel is 16.5 kg.
Amount of coal fired per hour is 1850 kg. Assume both induced draught fan and the forced draught fan operate at 90 % efficiency.

(b) A boiler uses 16 kg of air per kg of fuel when the fuel consumption is at the rate of 1800 kg/h. Actual draught required is 20 mm of water. The surrounding temperature is 27^0 C and the flue gas temperature is 280^0 C. Determine the chimney height and its diameter if actual velocity of the flue gas is 0.35 times the theoretical velocity due to roughness of the interior surfaces of the chimney.

6 + 6 = 12

Department & Section	Submission Link
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