B.TECH/ME/7TH SEM/MECH 4101(BACKLOG)/2021

POWER PLANT ENGINEERING
(MECH 4101)

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) 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 [(CO3)(Analyse/IOCQ)]
(a) 40 (b) 20 (c) 10 (d) 80.

(ii) Ultimate analysis of fuel aims at determining [(CO6) (Remember/LOCQ)]
(a) HCV (b) LCV
(c) % of C,H,N,S and moisture (d) ignition point.

(iii) Governing of steam turbine is done by [(CO3) (Understand/LOCQ)]
(a) throttle control (b) nozzle control
(c) by pass governing (d) all of these.

(iv) If V_{r1} and V_{r2} are the relative velocities of the steam at entry and exit of the blade of a reaction turbine then [(CO3)(Remember/LOCQ)]
(a) $V_{r1} \geq V_{r2}$ (b) $V_{r1} \leq V_{r2}$
(c) $V_{r2} > V_{r1}$ (d) none of these.

(v) The maximum efficiency of De-Laval turbine is with nozzle angle α_1 [(CO3) (Remember/LOCQ)]
(a) $\sin^2\alpha_1$ (b) $\cos^2\alpha_1$ (c) $\tan^2\alpha_1$ (d) $\cot^2\alpha_1$

(vi) The following is not a part of hydro-electric power plant [(CO1)(Remember/LOCQ)]
(a) catchment area (b) spillways
(c) conduits (d) BWR.

(vii) A plant has a peak load of 1000 MW but the average annual load is 350 MW.The annual load factor of the plant is [(CO1)(Evaluate/HOCQ)]
(a) 0.35 (b) 28.5 (c) 35 (d) 3.5.

(viii) The steam is expanded isentropically from 40 bar, 500°C in a turbine to 5 bar from where it is reheated to 400°C. The quality of exhaust steam from turbine at 5 bar is [(CO2)(Analysis/IOCQ)]

(a) saturated liquid (b) saturated vapour
(c) wet steam (d) superheated steam.

(ix) In a binary Mercury-vapour cycle, Hg cycle operates at 50% efficiency and steam cycle operates at 40%. The combined cycle efficiency will be [(CO2)(Evaluate/HOCQ)]

(a) 45% (b) 80% (c) 35% (d) 70%.

(x) The steam is expanded isentropically from 80 bar, 500°C in a turbine to 33 bar from where it is reheated to 500°C. The temperature of the exhaust steam from turbine at 33 bar is approximately [(CO2)(Evaluate/HOCQ)]

(a) 240°C (b) 360°C (c) 500°C (d) 400°C.

Group – B

2. (a) A power plant works on Rankine cycle with superheat and reheat. The steam enters the first stage turbine at 8.0 MPa, 480°C and expands to 0.7 MPa. It is then reheated to 440°C before entering the second stage turbine, where it expands to the condenser pressure of 0.008 MPa. The net power output of the cycle is 100 MW. Determine
   (i) thermal efficiency of the cycle
   (ii) mass flow rate of steam in kg/h
   (iii) specific steam consumption in kg/kWh
   (iv) the rate of heat transfer from the condensing steam as it passes through the condenser in MW. [(CO2)(Evaluate/HOCQ)]

   (b) In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle, and the overall plant are 0.96, 0.94, 0.91, 0.41 and 0.32 respectively. What percentage of the total electricity generated is consumed in running the auxiliaries? [(CO2)(Analyse/IOCQ)]

9 + 3 = 12

3. A binary vapour cycle operates on mercury and steam. Standard mercury vapour at 4.5 bar is supplied to the mercury turbine, from which it exhausts to 0.04 bar. The mercury condenser generates saturated steam at 15 bar which is expanded in a steam turbine to 0.04 bar. Determine
   (i) The overall efficiency of the plant.
   (ii) The flow through the mercury turbine if 48000 kg/h of steam flows through the steam turbine.
   (iii) Useful work done for the steam flow mentioned above. Assume all processes are reversible.

   The properties of mercury values are given below: [(CO2) (Evaluate/HOCQ)]

p (bar)	t (°C)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kg-K)	s_g (kJ/kg-K)	v_f (m^3/kg)	v_g (m^3/kg)
4.5	450	62.93	355.98	0.1352	0.5397	79.9×10^{-6}	0.068

0.04	216.9	29.98	329.85	0.0808	0.6925	76.5×10^{-6}	5.178

12

Group – C

4. The following data were recorded in a steam power plant consisting of a boiler , an economiser, and a superheater.
Steam pressure = 15 bar
Mass of steam generated = 5800 kg/h
Mass of coal used = 690 kg/h
Calorific value of coal = 31500 kJ/kg of coal
Temperature of feed water entering the economiser = 28°C
Temperature of feed water leaving the economiser = 135°C
Dryness fraction of steam the boiler is 0.90
Temperature of feed water leaving the economiser = 350°C
Determine (i) the overall efficiency of the plant. (ii) the percentage of heat utilized in economiser, boiler and superheater. [(CO4) (Evaluate/HOCQ)]

12

5. (a) A sample of coal contains 78 % carbon, 6% hydrogen, 1.2% nitrogen, 7.8% oxygen and 7 % incombustible substance. Find the minimum quantity of air required for complete combustion of 1 kg of coal. [(CO 6)(Evaluate/HOCQ)]

(b) A chimney of height 28 m is filled with hot gases at a temperature of 300°C.The temperature of outside air is 35°C. If the available draught is 85 % of the theoretical draught, calculate the available draught in terms of water head. The boiler is supplied with 15 kg of air per kg of fuel burnt. Also find out the velocity of the gases passing out through the chimney. [(CO4)(Evaluate/HOCQ)]

6 + 6 = 12

Group – D

6. (a) Show that the maximum discharge of steam through the nozzle takes place when the ratio of steam pressure at the throat to the inlet pressure is given by,

$$\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n+1}}$$ [(CO3)(Remember/LOCQ)]

(b) In a stage of an impulse turbine, provided with single row wheel, the mean diameter of the blade ring is 800mm and the speed of rotation is 3000rpm.The steam ejects from the nozzles with a velocity of 300 m/s and the nozzle angle is 20°. The rotor blades are equiangular and the blade friction factor is 0.85. What is the power developed in the blading when the axial thrust on the blades is 140 Newtons. [(CO3)(Evaluate/HOCQ)]

6 + 6 = 12

7. (a) The first stage of a turbine is a two-row velocity-compounded impulse wheel. The steam velocity at inlet is 600m/s, the mean blade velocity is 120m/s, and the blade velocity co-efficient for all blades is 0.9. The nozzle angle is 16° and

the exit angles for the first row of moving blades, the fixed blades, and the second row of moving blades, are 18°, 21°, and 35° respectively. Calculate:

(i) the blade inlet angles for each row ;
(ii) the driving force for each row of moving blades and the axial thrust on the wheel, for a mass flow rate of 1kg/s;
(iii) the diagram power per kilogram per second steam flow, and the diagram efficiency for the wheel;
(iv) the maximum possible diagram efficiency for the given steam inlet velocity and the nozzle angle. [(CO3)(Evaluate/HOCQ)]

(b) Prove that for a single stage impulse turbine the maximum blading efficiency will occur when the speed ratio is $\frac{\cos \alpha 1}{2}$, where α_1 is the nozzle angle. [(CO3)(Remember/LOCQ)]

8 + 4 = 12

Group – E

8. (a) The peak load on a power plant is 60MW. The loads having maximum demands of 30MW, 20MW, 10MW and 14MW are connected to the power plant. The capacity of the power plant is 80MW and the annual load factor is 0.50. Estimate

(i) the average load on the power plant
(ii) the energy supplied per year
(iii) the demand factor
(iv) the diversity factor. [(CO5)(Analyse/IOCQ)]

(b) Describe how hydroelectric power is generated with particular reference to the following:
Catchment Area, Reservoir, Dam, Spillways, Conduits & Power house. [(CO1)(Remember/LOCQ)]

6 + 6 = 12

9. (a) The following observations were taken during a test on a surface condenser:
Vacuum in condenser = 710 mm of Hg, Barometer reading = 760 mm of Hg, Temperature in condenser = 31°C, Hot-well temperature = 29°C, Cooling water circulated = 800 kg/min, Inlet and outlet temperatures of cooling water = 13°C and 27°C respectively. Condensate = 25 kg/min.
Find

(i) the mass of air in kg per m^3 of condensate volume
(ii) the dryness fraction or quality of steam entering the condenser
(iii) the vacuum efficiency. [(CO5) (Evaluate/HOCQ)]

(b) How can total annual cost of a power plant be calculated? Describe the various components of the cost .How cost of generation of power be reduced? [(CO5) (Remember/LOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	21.69%	14.16 %	64.15%

Course Outcome (CO):

After going through the course, the students will be able to:

CO1: Identify sources of energy and the types of power plants that are in operation in the world, List their advantages and disadvantages with respect to cost of power generation and pollution.

CO2: Analyze and evaluate different types of thermodynamic cycles (Reheat cycle, Regenerative cycle, Dual cycle, Combined Heat and Power Cycle) used in thermal power plants and List their advantages and disadvantages.

CO3: Compare between Impulse and Reaction turbine, Analyze the work output and efficiency of Impulse and Reaction Turbine, List the advantages and disadvantages of pressure compounding and velocity compounding, Explain the need of Governing of steam turbine.

CO4: Calculate the chimney height and diameter, Draw up a heat balance sheet of a boiler and Compute the boiler efficiency.

CO5: Assess the operating efficiency of various power plants based on their load factor, diversity factor, capacity factor, Understand the economics of setting up of power plants, Compare the cost of power generation by various power plants, Analyse the surface condensers used in power plants.

CO6: Understand the importance of coal and ash handling system, Analyse the coal on proximate and ultimate analysis method, Devise methods to curb emission of pollutants to

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

Department & Section	Submission link:
ME	https://classroom.google.com/c/NDY0NTE2MTg5NTA3 Class Code hqzfmh2