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) Which processes do the Rankine cycle contain?
(a) two isothermal and two isochoric processes
(b) two isentropic and two isobaric processes
(c) two isentropic and two isothermal processes
(d) two isothermal and two isobaric processes

(ii) Keeping the boiler pressure constant, if the temperature of the superheat is increased in steam cycle, then,
(a) mean temperature of heat addition increases
(b) efficiency of the cycle improves
(c) exhaust steam quality from turbine improves
(d) all of the above

(iii) The points where the minimum temperature difference occurs between the working fluid and the flue gas in a power plant is called
(a) the pinch points (b) critical points
(c) triple point (d) melting point.

(iv) A single stage impulse turbine with a diameter of 125 cm runs at 3000 rpm. If the blade speed ratio is 0.43 then, the inlet velocity of steam will be
(a) 446 m/s (b) 350 m/s
(c) 396 m/s (d) 456 m/s

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

(vi) Orsat's apparatus is employed to determine
(a) Ultimate analysis of fuel
(b) Gravimetric analysis of fuel

(c) Volumetric analysis of dry products of combustion
(d) Gravimetric analysis of dry products of combustion.

(vii) Load duration curve indicates _____
(a) the variation of load during different hours of the day
(b) total number of units generated for the given demand
(c) total energy consumed by the load
(d) the number of hours for which the particular load lasts during a day.

(viii) Evaporative condensers have
(a) steam in pipes surrounded by water
(b) water in pipes surrounded by steam
(c) both (a) & (b)
(d) none of these.

(ix) Which of the following statement/s is / are true for Back Pressure Turbine?
(a) It produces power only (b) It produces process heating steam
(c) Both (a) & (b) (d) It does not produce work.

(x) A plant has a peak load of 1500 MW but the average annual load is 750 MW. The annual load factor of the plant is
(a) 0.3 (b) 0.5 (c) 0.4 (d) 0.6.

Group – B

2. The net power output of an ideal reheat regenerative steam cycle is 100 MW. Steam enters the high pressure turbine at 80 bar, 500° C and expands till it becomes saturated vapour. Fraction of steam goes into an open feed water heater and the balance steam is reheated to 400°C, after which it is expanded in a low pressure turbine to 0.06 bar.
Find (i) the reheat pressure (ii) the steam flow rate to the hp turbine (iii) the cycle efficiency (iv) the diameter of the connecting pipe between the turbine and the condenser if the maximum flow velocity is restricted to 150 m/s.

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3. (a) Mention five characteristics of an ideal working fluid for vapour power cycle.

(b) A mercury cycle is superposed on the steam cycle operating between the boiler outlet condition at 40 bar, 400°C and the condenser temperature of 40°C. The heat released by mercury condensing at 0.2 bar is used to impart the latent heat of vaporization to the water in the steam cycle. Mercury enters the steam turbine as saturated vapour at 10 bar.
The property values of saturated mercury are given below:

$p\ (bar)$	t (°C)	$h_f(kJ/kg)$	$h_g(kJ/kg)$	$s_f(kJ/kgK)$	$s_g(kJ/kgK)$	$v_f(m^3/kg)$	$v_g(m^3/kg)$
10	**515.5**	**72.23**	**363.0**	**0.1478**	**0.5167**	$\mathbf{80.9 \times 10^{-6}}$	**0.0333**
0.2	**277.3**	**38.35**	**336.55**	**0.0967**	**0.6385**	$\mathbf{77.4 \times 10^{-6}}$	**1.163**

Compute (i) kg of mercury circulated per kg of water (ii) the efficiency of the combined cycle.

5 + (4 + 3) = 12

Group – C

4. The gravimetric analysis of fuel was 86% Carbon, 6% hydrogen and 8% ash. The moisture in the fuel was nil. The partial analysis of dry flue gas showed 13.2% CO_2 and 3.2% O_2 by volume. Some CO was probably present but its percentage was not measured. Assuming all the carbon and hydrogen have been burnt, estimate (a) the complete volumetric composition of the dry flue gas, (b) the actual amount of air supplied per kg of coal (c) mass of water vapour formed per kg of coal, and (d) the dew point temperature of the flue gas.

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5. (a) Calculate the mass of flue gases flowing through the chimney when the draught produced is equal to 2 cm of water. Temperature of flue gas is 295°C and the ambient temperature is 25°C. The flue gas formed per kg of fuel burnt is 23.5 kg. Neglect losses and take the diameter of the chimney as 1.8 m.

   (b) A chimney of height 32 m is used for producing a draught of 19 mm of water. The temperature of ambient air and the flue gases are 27°C and300°C respectively. The coal burned in the combustion chamber contains 81% carbon, 5% moisture and remaining ash. Neglect losses. Assume the value of burnt products as equivalent to the volume of air supplied. Also assume complete combustion of fuel. Hence find the percentage of excess air supplied

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,

$$\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n+1}}$$

   (b) In a stage of an impulse turbine, provided with single row wheel, the mean diameter of the blade ring is 800 mm and the speed of rotation is 3000 rpm. 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?

6 + 6 = 12

7. (a) Draw the inlet velocity diagram and outlet velocity diagram of an impulse turbine and derive an expression for (i) power developed (ii) Axial thrust and (iii) blading efficiency for unit mass flow rate of steam.

   (b) A stage of a 50% reaction turbine delivers dry saturated steam at 2.7 bar from the fixed blades at 90 m/s. The mean blade height is 40 mm, and the moving blade exit angle is 20°. The axial velocity is ¾ th of the mean blade velocity. Steam flow rate is 9000 kg/h. Calculate (i) the wheel speed in rpm (ii) the diagram power (iii) the diagram efficiency and (iv) the enthalpy drop of steam at this stage.

4 + 8 = 12

Group – E

8. (a) A power station supplies the following loads to the consumers:

Time in Hours	0-6	6-10	10-12	12-16	16-20	20-22	22-24
Load (MW)	30	70	90	60	100	80	60

(i) Draw the load curve and estimate the load factor of the plant.
(ii) What is the load factor of a standby equipment of 30 MW capacity if it takes up all loads above 70 MW. Also find out the use factor of the stand by unit.

(b) Describe the advantages and disadvantages of hydro electric power plant.

6 + 6 = 12

9. (a) Exhaust steam having a quality of 0.92 enters a surface condenser at an absolute pressure 0.13 bar and comes out as water at 45°C. The circulating water enters at 30°C and leaves at 45°C. Estimate the quantity of the circulating water and the condenser efficiency.

(b) Define approach and range of a cooling tower. What is surge tank and spillway?

6 + 6 = 12

Note: Use steam table and Mollier Chart wherever necessary.

Department & Section	Submission link:
ME A	https://classroom.google.com/c/MTIyNDQ5NjI5ODM0/a/Mjc0NDMzODYyMTgw/details
ME B	https://classroom.google.com/c/MTIyNDQ5NjI5ODM0/a/Mjc0NDMzODYyMjE2/details