7. (a) An impulse turbine has two rows of moving blades separated by fixed blades. The steam leaves the nozzle at an angle of 20° with the direction of motion of blades. The blade exit angles are: first moving 30°, fixed 22°, and second moving 30°. If the isentropic heat drop for the nozzle is 186 kJ/kg and the nozzle efficiency is 90%,
   (i) find the blade speed necessary if the final velocity of steam is to be axial. Assume a loss of 15% in relative velocity for all blade passages.
   (ii) Find also the blade efficiency and the stage efficiency.

   (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.

(3 + 2 + 2) + 5 = 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

   (b) Define (a) condenser efficiency and (b) vacuum efficiency of a surface condenser. Also derive an expression for the mass of cooling water required to condense per kg of steam condensed.

(2 × 4) + (1 + 1 + 2) = 12

9. (a) 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?

   (b) Write short notes on (i) PWR and (ii) BWR.

(3 + 3) + (3 + 3) = 12

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) Stage efficiency of an impulse turbine is
   (a) $\eta_{nozzle} + \eta_{blade}$ (b) $\eta_{nozzle} \times \eta_{blade}$
   (c) $\eta_{nozzle} - \eta_{blade}$ (d) $\eta_{nozzle} / \eta_{blade}$.

   (ii) 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.

   (iii) Steam turbines are governed by
   (a) throttle control (b) nozzle control
   (c) by-pass control (d) all of these.

   (iv) Natural circulation type of boiler works on the principle of
   (a) differential density of hot and cold water
   (b) differential density of hot and cold gases at chimney
   (c) natural draught system with chimney
   (d) all of these.

   (v) In the Rankine cycle, the work output from the turbine is given by
   (a) change in internal energy between turbine inlet and outlet
   (b) change in enthalpy between turbine inlet and outlet
   (c) change in entropy between turbine inlet and outlet
   (d) change in temperature between turbine inlet and outlet.

   (vi) The function of the economizer is
   (a) to utilize the heat of condensing steam
   (b) to increase the internal energy of air supplied to the boiler
   (c) to utilize the heat of flue gases
   (d) to optimize the feed water supply rate.

(vii) 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.

(viii) Referred to a steam boiler, the following is an accessory:
(a) economizer (b) water level indicator
(c) safety valve (d) steam stop valve.

(ix) The following boiler accessory removes the entrained liquid water droplets from the steam conveyed to the steam turbine:
(a) Feed pump (b)Injector
(c) Steam separator (d) Superheater.

(x) 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) $cot^2\alpha_1$.

Group - B

2. (a) Steam at 40 *bar*, 500°C flowing at the rate of 5500 kg/hr expand in a high-pressure turbine to 2 *bar* with an isentropic efficiency of 83%. A continuous supply of steam at 2 bar and 0.87 dryness fraction is available from a geothermal source at a flow rate of 2700 *kg/hr*. This steam is mixed adiabatically with the high-pressure turbine exhaust steam, and the combined flow then expands in a low-pressure turbine to 0.1 bar with an isentropic efficiency of 78%. Assume that 5500 kg/hr of steam is generated in the boiler at 40 bar,500°C from the saturated feedwater at 0.1 bar. Neglect the pump work.
Determine (i) the power output, and (ii) the thermal efficiency of the plant. Had the geothermal steam not been added, what would have been the power output and efficiency of the plant?

(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?

(5+ 3+ 1 + 1) + 2= 12

3. (a) What is heat rate? What is the difference between the net cycle heat rate and the gross cycle heat rate?

(b) What is a supercritical steam cycle?

(c) State five main characteristics of an ideal working in a power cycle.

4 + 3 + 5= 12

B.TECH / ME /7TH SEM/ MECH 4101/2017

Group - C

4. (a) Mention two advantages and two limitations of chimney draught.

(b) The following particulars refer to a steam plant consisting of a boiler, an economiser and a superheater:
Steam pressure=12 *bar*; Mass of steam generated=6000 *kg /hr*;
Mass of coal used=690 *kg/hr*; Calorific value of coal=31500 *kJ/kg*;
Temperature of feed water entering economiser=28°C;
Temperature of feed water leaving economiser=135°C;
Dryness fraction of steam=0.95;
Temperature of steam leaving superheater=350°C.
Determine (i) overall efficiency of the plant, and (ii) the percentage of available heat utilised in the boiler, economiser and superheater respectively.

(2 + 2) + (2 + 6) = 12

5. (a) Describe in brief how coal and ash are handled in a typical thermal power plant.

(b) 5400 kg of steam is produced per hour at a pressure of 750 kN/m² in a boiler when the feed water is at 41.5°C. The dryness fraction of the steam is 0.98.The amount of coal burnt per hour is 670 kg of calorific value 31000 kJ/kg.
Determine the boiler efficiency and equivalent evaporation.

(3 + 3) + (3 + 3) = 12

Group - D

6. (a) An impulse steam turbine is supplied with steam at 35 bar,350°C, the condenser pressure being 0.07 bar. The first stage of the turbine is velocity compounded with two rings of moving blades, separated by a ring of fixed guide blades. The isentropic enthalpy drop for this stage is 1/4 of that for the whole turbine. The nozzle angle is 20° and the nozzle efficiency is 88%.The mean blade velocity of both the moving rings of blades is 0.2 of the velocity of steam leaving the nozzle. The exit blade angles for both fixed and the moving blades are 30° and the blade friction co-efficient for all blades is 0.9. If the internal efficiency of the turbine is 75%, calculate the efficiency of the first stage and the percentage of the total power developed by the turbine in this stage.

(b) What is the function of the governor of a steam turbine? Briefly describe how a steam turbine speed is governed.

(4 + 4) + (1 + 3) = 12