Code : 021512

B.Tech 5th Semester Exam., 2019

STEAM POWER SYSTEM

Time : 3 hours Full Marks : 70

Instructions :

(i) The marks are indicated in the right-hand margin.
(ii) There are **NINE** questions in this paper.
(iii) Attempt **FIVE** questions in all.
(iv) Question No. **1** is compulsory.
(v) Use of steam tables and Mollier Chart is permissible.

1. Choose the correct answer from the following (any *seven*) : 2×7=14

(a) Which of the following is a low pressure boiler?
  (i) Babcock and Wilcox
  (ii) Velox
  (iii) Lamont
  (iv) Cochran

(b) Which of the following is used to heat the feed water by using waste heat of flue gases?
  (i) Air preheater
  (ii) Superheater

  (iii) Economizer
  (iv) Steam separator

(c) A steam nozzle converts
  (i) heat energy of steam into kinetic energy
  (ii) potential energy of steam into kinetic energy
  (iii) kinetic energy of steam into mechanical energy
  (iv) heat energy of steam into mechanical energy

(d) In pressure velocity compounding
  (i) moving blades are used
  (ii) fixed nozzles are used
  (iii) fixed blades are used
  (iv) All of the above

(e) Maximum efficiency in reaction steam turbine, where α is nozzle angle, is
  (i) $2\cos^2 2\alpha / (1 + \cos^2 2\alpha)$
  (ii) $\cos 2\alpha / (1 + \cos^2 2\alpha)$
  (iii) $\cos(\alpha / 2) / (1 + \cos^2 2\alpha)$
  (iv) $\cos\alpha / (1 + \cos^2 2\alpha)$

(f) The critical pressure ratio of a convergent nozzle is defined as

(i) the ratio of outlet pressure to inlet pressure of nozzle

(ii) the ratio of inlet pressure to outlet pressure of nozzle

(iii) the ratio of outlet pressure to inlet pressure only when mass flow rate per unit area is minimum

(iv) the ratio of outlet pressure to inlet pressure only when mass flow rate is C

(g) The effect of considering friction losses in steam nozzle for the same pressure ratio leads to

(i) increase in exit velocity from the nozzle

(ii) decrease in exit velocity from the nozzle

(iii) increase or decrease depending upon the exit quality of steam

(iv) no change in exit velocity from the nozzle

(h) In a steam power plant, the function of a condenser is

(i) to maintain pressure below atmospheric to increase work output from the prime mover

(ii) to receive large volumes of steam exhausted from steam prime mover

(iii) to condense large volumes of steam to water, which may be used again in boiler

(iv) All of the above

(i) Draught produced by chimney is described as

(i) induced draught

(ii) natural draught

(iii) forced draught

(iv) balanced draught

(j) In case of reaction steam turbine

(i) there is enthalpy drop both in fixed and moving blades

(ii) there is enthalpy drop only in fixed blades

(iii) there is enthalpy drop only in moving blades

(iv) None of the above

2. (a) What is boiler draught? How are draughts classified? Explain in detail.

(b) What are the functions of preheaters, economisers and superheaters? Where is reheater located? Draw a schematic diagram also.

3. (a) Why is there a need of makeup feed water treatment? Describe the treatment of feed water in brief.

(b) The effective heat drop in a steam turbine nozzle is 606 kJ. The velocity of approach is negligible. The inlet pressure of steam is 10 bar and temperature is 300 °C. The back pressure is 0·3 bar. The steam rate is 3 kg/s. Find the nozzle efficiency, throat area, exit area and gain in entropy between entrance and throat. 8

4. (a) Explain the phenomenon of supersaturated expansion of steam through nozzles. 6

(b) In a condenser, the air leakage is estimated to be 38 kg/h. The vacuum near the outlet to the air pump is 72·5 cm of Hg and the temperature at

this point is 20 °C. The barometer reads 76 cm of Hg. Calculate the minimum capacity of the air pump in mm^3 / min and the mass of vapour extracted with air per minute. 8

5. (a) Discuss the effects of friction on the performance of nozzles. Show these effects in *T-S* and *h-S* diagrams. 6

(b) The full-load steam consumption of a 11000 kW turbo-alternator is measured to be 49500 kg/h with steam conditions of 100 bar at the temperature of 500 °C and exhaust pressure of 0·07 bar. Assuming an alternator efficiency of 94% and mechanical losses due to bearing friction, governor, etc., of 100 kW, estimate the internal efficiency of the turbine. During a part load operation of the turbine, the steam consumption was measured to be 34000 kg/h with the same conditions at the stop valve and at exhaust. Assuming the same alternator efficiency and mechanical losses as obtained at full load, determine the alternator output under this condition. The turbine is governed by throttling. 8

6. *(a)* Differentiate between impulse and reaction turbine. Show the pressure and velocity distribution. 6

(b) The isentropic heat drop in given stage of a multistage impulse turbine is 33·5 kJ/kg of steam. The nozzle outlet angle is 20°. The efficiency of the nozzle, defined as the ratio of the actual gain in kinetic energy in the nozzle to the adiabatic (isentropic) heat drop is 90 percent. The mean diameter of the blade is 95·5 cm and the revolution per minute is 3000. The curry over factor is 0·88. Blades are equiangular with a velocity coefficient of 0·87. Calculate the steam velocity at the outlet of the nozzle, blade angles and gross stage efficiency. 8

7. *(a)* What are the main methods of governing steam turbines? Mention various types of speed governors and their relative merits and demerits. 6

(b) The steam velocity at inlet to the first stage of a turbine having two-row velocity compounded impulse wheel is 600 m/s and the mean blade velocity is 120 m/s. 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. Find the blade inlet angles for each row. Find also for each row of moving blades, the driving force and the axial thrust on the wheel for a mass flow rate of 1 kg/s of steam. Find the diagram efficiency for the wheel and the diagram power. What is the maximum possible diagram efficiency for a given inlet velocity and nozzle angle? Take $K = 0·9$ for all blades. 8

8. *(a)* What is circulation? Differentiate between natural and forced circulation boiler. 6

(b) A steam generator comprises of evaporator (boiler), superheater, economiser and air preheater. The feed water enters the economiser at 50 °C. Air enters the preheater at 30 °C and leaves at 150 °C. The steam is generated in the steam drum at 100 bar, 0·99 dry and leaves the superheater at 500 °C. The fuel used is oil, having calorific value 42 MJ/kg. The evaporation rate is 10 kg steam per kg of fuel and the

air-fuel ratio is 20 : 1 by mass. Neglecting heat losses and pressure drops, calculate the heat transfer per kg of fuel in each component and the steam generator plant efficiency. 8

9. (a) Discuss the advantages and disadvantages of reheating in steam power plants. Discuss on the necessity of adopting reheat cycle with high steam pressure. 8

(b) A power plant operates on the regenerative cycle. Steam is supplied to the turbine at 80 bar and 400 °C. It is exhausted to condenser at 0·05 bar. The plant has two feed heaters where steam extracted from the turbine is directly mixed with the feed water. Steam is extracted from the turbine at a pressure of 10 bar and 1·5 bar. Determine the mass of steam extracted at each of these pressures per kg mass flow at the turbine inlet, the heat rejected in the condenser per kg mass flow at the turbine inlet, the cycle efficiency and the gain in cycle efficiency over a Rankine cycle operated under the same initial and final conditions. Assume expansion of steam is isentropic. 8

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