B. E.MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2017

STEAM POWER PLANT

Time: Three hours | Full Marks: 100

(Use of steam table and charts are allowed.)

Answer any five questions

1..a) State the advantages of regenerative heating in a steam power plant. 5

b) Consider a steam power plant operating on the ideal regenerative Rankine Cycle with one open feedwater heater. Steam enters the turbine at 15 MPa and 500^0 C and is condensed in a condenser at a pressure of 60 kPa. Some steam leaves the turbine at a pressure of 1.2 MPa and enters the open feedwater heater. Determine the fraction of steam extracted from the turbine and the thermal efficiency of the cycle. 15

2.a) Sketch and label a Cochran boiler. Show all mountings clearly. 10

b) State the difference between mountings and accessories. 5

c) Explain-'Coal with a high volatile matter is ignited easily' 5

3.a) A steam generator operates under the following conditions: Coal analysis: Carbon 60, Hydrogen 4, Nitrogen 2, Sulphur 1.5, oxygen 3, moisture 4.5 and ash 25. The dry flue gas analysis: CO_2 12, CO 1.5, O_2 7 and N_2 79.5. Steam condition at boiler outlet: 100 bar, 500^0 C, feedwater inlet temperature: 170^0 C. Steam generation rate 160 tonnes/hr. Steam generator efficiency 85 %, HHV of coal 21 MJ/kg. Determine the excess air percentage, the fuel burning rate, and the amount of dry flue gas produced/kg of coal 12

b) Sketch and label a turbulent burner. Explain corner firing arrangement. 8

4. a A 200 MW power plant has steam condition at boiler outlet as 150 bar, 550^0C and the condenser pressure is 0.1 bar. The boiler efficiency is 88 percent and calorific value of coal is 25 MJ/kg. The feedwater temperature at boiler inlet is 170^0C.The steam generator has risers in the furnace wall 45 m high and unheated downcomers. The boiler operates on natural circulation and the circulation ratio is 16. A maximum exit velocity of water-steam mixture leaving a riser is required to be 1.7 m/s. The risers have 60 mm O.D and 3 mm thickness. Taking η_{gen}=0.94 and η_T=0.92 and neglecting any heat loss and pressure drop, as well as pump work, estimate the steam generation rate, the fuel burning rate, the evaporation factor, the pressure head due to natural circulation and the quality of the steam at the top of the riser. 20

5.a) Derive the critical pressure ratio required for maximum flow rate through a steam nozzle. 10

b) Steam at 7 bar, 200^0 C expands isentropically in a convergent nozzle into a space at 3 bar. Neglecting the inlet velocity, estimate the exit area required for a mass flow rate of 0.1 kg/s i) when the flow is equilibrium throughout, ii) when the flow is supersaturated with $pv^{1.3}$= constant. Also find the degree of supercooling and degree of supersaturation. 10

6.a) Explain three stage pressure compounding of impulse turbine. Show the pressure and velocity distribution. 10

b) A single stage impulse turbine rotor has a mean blade ring diameter of 500 mm and rotates at a speed of 10000 rpm. The nozzle angle is 20^0 and the steam leaves the nozzle with a velocity of 900 m/s. The blades are equiangular and the blade friction factor is 0.85. Construct the velocity diagrams for the blades and determine the inlet angle of the blades. Determine the diagram power for a steam flow of 750 kg/hr, the diagram efficiency, and the axial thrust 10

7.a) Define gross stage efficiency. Derive the optimum velocity ratio for maximum gross stage efficiency for a 50 % reaction turbine. 12

b) Explain supersaturated flow in a nozzle. 8