Ref. No. Ex/ME(M2)/PC/B/T/321/2022

B. E.MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2022

ENERGY CONVERSION SYSTEM

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 600^0 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 water tube boiler. Explain balanced draught. 10+5

b) 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 fuel burning rate, actual air supplied per kg of coal, and the amount of dry flue gas produced/kg of coal. Take specific heat of dry flue gas as 1.88 kJ/kg-K 14

b) Explain with sketch any two arrangement of straight flow burners. 6

4. 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

[Turn over

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. 10

6.a) With the help of velocity diagram derive the condition of maximum blade (diagram) efficiency. 10

b) An impulse steam turbine has nozzles inclined at 20^0 to the plane of rotation of the wheel. The blades are equiangular, the blade friction factor is 0.8 and the mean diameter of the wheel is 0.5 m. The steam leaves the nozzle with a velocity of 750 m/s. Determine the optimum value of the blade angles, the steam flow rate required to produce 20 kW and the blade efficiency. 10

7.a) Explain briefly about different losses in a steam turbine. 10

b) Explain with the help of suitable diagram pressure compounding (Rateau staging). 10

8. Write short notes on any four: 4x5=20
   a) Reheating in Rankine Cycle
   b) Proximate and Ultimate Analysis
   c) Closed type pulverization system
   d) Natural Circulation Boiler
   e) Supersaturated flow in steam nozzle
   f) 50 % Reaction Turbine