Ref. No. Ex/PE/PE/H/T/324A/2022

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2022

SUBJECT: ADVANCED POWER CYCLES(HONS.)

Time: Three Hours **100 Marks**

Part I

1.

Draw a neat sketch of a reheat steam cycle and deduce an expression for the change of cycle efficiency upon reheating. Draw a plot showing how the reheat cycle efficiency varies with the reheat-to-main-steam pressure. **10**

OR

Draw a neat sketch of a gas turbine cycle with reheating, regeneration and intercooling, citing the salient purpose of each. Assuming that the reheating is done to the level of turbine inlet temperature, the intercooling is perfect, and the reheating and intercooling pressures correspond to the maximum specific output condition, write (no need to derive) the expression of reheat and intercooling pressures in terms of the compressor inlet (p_1) and outlet (p_2) pressures. Draw the corresponding T-s diagram of the cycle. **3+3+2+2=10**

Part II: Answer any two (40 Marks)

2.

A steam power plant operates on an ideal reheat– regenerative Rankine cycle and has a net power output of 100 MW. Steam enters the high-pressure turbine at 10 MPa and 550°C and leaves at 0.8 MPa. Some steam is extracted at this pressure to heat the feedwater in an open feedwater heater. The rest of the steam is reheated to 500°C and is expanded in the low-pressure turbine to the condenser pressure of 10 kPa. Show the cycle on a T-s diagram with respect to saturation lines, and determine (a) the mass flow rate of steam through the boiler and (b) the extraction flow the feedwater heater. (c) Also calculate the net and gross heat rates of the cycle:– **20**

3.

The full-load rating of a TG Set of a nuclear power plant with other cycle parameters are given below:

1. TG output = 523.68 MW,
2. Steam/ water parameters:
   MS at TSV: 538°C and 162 bar; CRH: 323°C and 40 bar; HRH: 538°C and 36.6 bar; RH Flow Rate 410.75kg/s. Final feed water temperature = 228.4°C.
3. Flow Rates:
   MS at TSV: 453.6 kg/s, CRH: 410.75 kg/s; S/H spray flow rate = 0t/h; R/H spray flow rate = 0 t/h, Blow Down = 0 t/h.
4. Power Consumed by:
   BFP motor: 12.19 MW; CEP motor = 0.57 MW,

Calculate:

i. GHR of the turbine cycle as per ASME PTC 6
ii. NHR of the same as per ASME PTC 6
iii. Specific steam consumption
iv. Heat rejected to CW at the condenser
v. Work ratio of the cycle

20 Marks

4.

Show that, for a non-reheat, regenerative cycle employing 'n' number of direct contact type feedwater heaters, the maximum gain in efficiency is achieved when the enthalpy rise in each feedwater heater is same. What is the expression for improvement of heat rate for such a regenerative cycle as compared to a nonregenerative cycle operating between the same steam parameters?

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Part III: Answer any two (40 Marks)

5.

(a) What is the importance of work ratio and specific work output for power cycle performance?
(b)What are the problems of using water and Hg for a simple vapor power cycle?
(c) What are the purposes of GT inlet fogging and GT blade-cooling?
(d) With a neat sketch, show the T-s diagram of an externally-fired gas turbine cycle. What are the advantages of using this cycle?

5x4=20 Marks

6.

(a) What do you mean by combined cycle? What is the main advantage of using combined cycle? **5 marks**
(b) Discuss the classification of combined cycles and cite examples of each. **5 marks**
(c) In a supplementary fired GTCC plant, 10% of the total heat is added to the HRSG in terms of direct firing of vacuum residue fuels. The open cycle GT operates at an efficiency of 32% while the steam cycle has a net heat rate of 2500 kCal/kWh. The efficiency of HRSG is 85%. Draw a neat schematic of the cycle and derive an expression for the overall plant efficiency and calculate its value. **10 marks**

7.

A GTCC plant operates with simple GT cycle with a HRSG. The GT, HRSG and ST operating parameters are as follows:

GT Cycle: Temperature ratio =3.6, T_{amb} = 300 K, r_p = 5, isentropic efficiencies for compressor and turbine are 85% and 90%, respectively, GT output = 200 MW

HRSG: Pinch point temperature difference 15 °C, Acid dew point = 170 °C. Exit gas temperature is to be maintained at least 10 °C above the acid dew point.

Steam Cycle: Simple Rankine cycle with boiler and condenser back pressures of 16 bar and 0.08 bars, respectively. Assume steam turbine expansion isentropic, and neglect pump work.

Draw the cycle arrangement and the T-Q diagram for the HRSG. Also determine, (i) GT cycle efficiency, (ii) mass flow rates of the GT and ST cycles, (iii) ST cycle output, and (iii) Overall plant efficiency **20 Marks**

Part IV (10 Marks)

8. Answer any two (5x2):

(a) What do you mean by "coal gasification"? State the basic steps of coal gasification process.
(b) What is the function of Gland Steam Condenser in a vapor power plant?
(c) What do you mean by fluidized-bed combustion? What are the merits of a fluidized-bed boiler?
(d) What are the merits of Organic Rankine Cycle?