Ref. No. Ex /PE/T/322/2018

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2018

SUBJECT: ***POWER PLANT CYCLES AND SYSTEMS***

Time: Three Hours **100 Marks**

Part 1: 10 Marks

1.

(a) What are the importance of work ratio comparing the performances of two power cycles? Elucidate with the example of a vapor power cycles and a gas turbine cycle. **4**

(b) A high value of h_{fg} is a favorable fluid property for vapor power cycle – why? **2**

(c) A reversible heat engine receives equal amounts of heat from three heat sources at 1000 K, 800 K and a 700 K temperature, while delivering 1 MW of mechanical power. What is the overall cycle efficiency and heat rejection if the entire heat is rejected to the surroundings of 300 K? **4**

OR

(a) What do you mean by combined cycle? Why are they used? **1+1**

(b) Two simple cycles of 40% and 25% efficiencies (for the topping and the bottoming cycles, respectively) are coupled in such a way that the 90% of heat rejection from the topping cycle is used by the bottoming cycle, while the remaining 10% is lost to the surroundings. The bottoming cycle rejects heat directly to the surroundings. Find the overall efficiency of the combined cycle. **5**

(c) What are the merits of organic Rankine cycles over steam power cycles? **3**

Part II: Answer any 2 (40 Marks)

2.

a. 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**

b. Find the ideal cycle efficiency and steam consumption of a reheat cycle operating between a pressure of 30 bar and 0.4 bar, with a superheat temperature of 450° C. Assume that the first expansion is carried out to the point where the steam is dry saturated and the steam is reheated to the original superheat temperature. Neglect pump work. **10**

3.

(a) Show that the efficiency of a simple gas turbine cycle does not depend on the maximum and minimum temperatures of the cycle, but only varies with the pressure ratio. **4**

(b) Draw a neat sketch of a gas turbine cycle employing intercooling, reheating and regeneration. Also draw the T-s diagram of the process. State the effects of intercooling, reheating and regeneration on cycle efficiency, work ratio and specific work output. **6**

Time: Three Hours **100 Marks**

(c) A closed cycle regenerative gas turbine operates with air as working medium. Assume the following data: p_1= 1.4 bar, T_1 = 310 K, p_2/p_1 = 5, T_{max}= 1050 K, effectiveness of regenerator = 90%, net output = 3000 kW. Assuming the compression and expansion processes to be isentropic, calculate the thermal efficiency of the cycle and mass flow rate of air. Also find the heat transferred in the regenerator. **10**

4

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

1. TG output = 210.01 MW,
2. Steam/ water parameters:
   MS at TSV: 540°C and 130 bar; CRH: 340°C and 30 bar; HRH: 540°C and 27 bar, S/H spray water temperature = 162°C, R/H spray water temperature = 102°C; Final feed water temperature = 245°C.
3. Flow Rates:
   MS at TSV: 661.089 t/h; CRH: 572.675 t/h; S/H spray flow rate = 15 t/h; R/H spray flow rate = 10 t/h.
4. Power Consumed by:
   BFP motor: 4.4 MW; CEP motor = 1.6 MW, Bus fed excitation system for the generator = 2.0 MW; Turbine auxiliaries = 1.2 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. Exergy supplied to the cycle
vi. Exergy destroyed in the cycle

Part III (Answer any one 20 Marks)

5.

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 = 4, Pressure ratio = 6, Isentropic efficiencies for compressor and turbine are 85% and 90%, respectively, GT output = 130 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 a boiler and condenser back pressures of 20 bar and 0.02 bars, respectively. Assume steam turbine expansion isentropic, and neglect pump work.

Ambient condition: 1 bar and 25 °C

Determine, (i) GT cycle efficiency, (ii) ST cycle output, (iii) ratio of gas to steam turbine mass flow rates, and (iv) Overall plant efficiency

20

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2018

SUBJECT: ***POWER PLANT CYCLES AND SYSTEMS***

Time: Three Hours **100 Marks**

6.

(a) What do you mean by IGCC? Write down the basic steps of gasification process. What are the primary constituents of Syn Gas? **6**

(b) What are the three basic types of gasifiers used in IGCC power plants? **2**

(c) What is the merit of oxygen-blown gasification? Draw a neat sketch of an IGCC with oxygen-blown gasifier and label the salient components of it. **8**

(c) What do you mean by STIG? Why are they used? **4**

20 Marks

Part IV: <u>any two</u> (30 Marks)

7.

(a) Draw a neat diagram of a three zone feed-water heater and show the extraction and drip line connections. **6**

(b) How are the TTD and DCA of a feed water heater defined? Can the TTD be negative? **4**

(c) What is the purpose of the FW Heater bypass line? What happens to the final feedwater temperature if the HP feedwater heater bypass valve is passing? **3**

(d) Why PDNRVs are installed at the turbine extraction lines to the regenerative feed heaters? **2**

8.

(a) Draw a neat sketch of the HP-LP Bypass system of a modern steam power plant. State its functions during (i) plant start-up and (ii) rapid load throw-off. **5+2**

(c) Draw a neat sketch of steam jet air ejector and describe its operation. **5**

(d) State at least six usages of auxiliary steam in a modern power plant. **3**

9.

(a) Define Station Heat Rate and Net Plant Heat Rate of a coal-based thermal power plant having motor-driven BFP as per ASME PTC. **2**

(b) For a 500 MW power plant that operates on a coal (GCV = 4000 Kcal/kg and Price Rs. 700/ 1000 kg) estimate the additional annual expense of the plant in fuel if the Net Plant Heat Rate of the plant has inadvertently increased by 1 kCal/kWh **3**

(c) What are the types of blow downs from boiler drum? Why are they done? How does blow down affect the GHR? **3**

(d) What do you mean by STEP Factor? How are they evaluated for an operating power plant? **3**

(e) Describe the functions of any two of the following items in DM Plant **2×2**

i. Pressure Sand Filter
ii. Activated Carbon Filter
iii. Degasser
iv. Clariflocculator