Ref. No. Ex/PE/PE/H/T/324A/2024

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2024

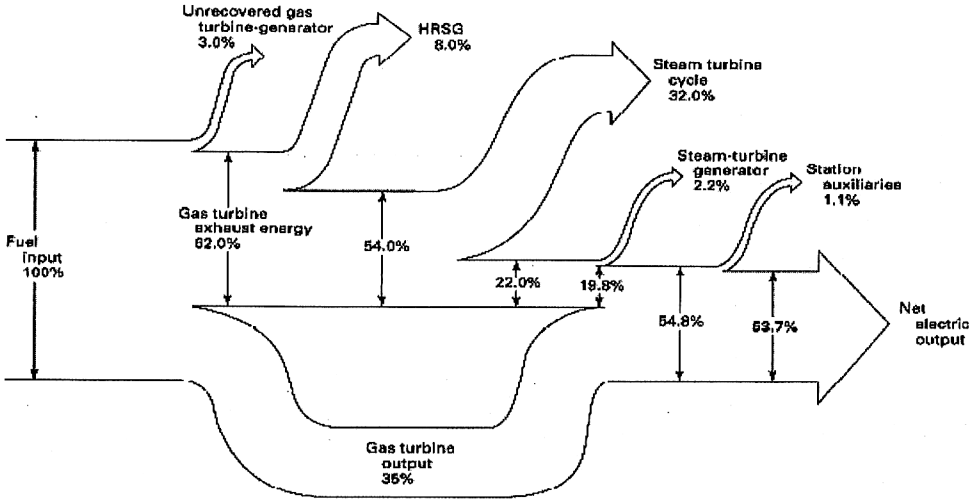
*SUBJECT: **ADVANCED POWER CYCLES (HONS.)***

Time: Three Hours **100 Marks**

CO I (10 Marks)

1.

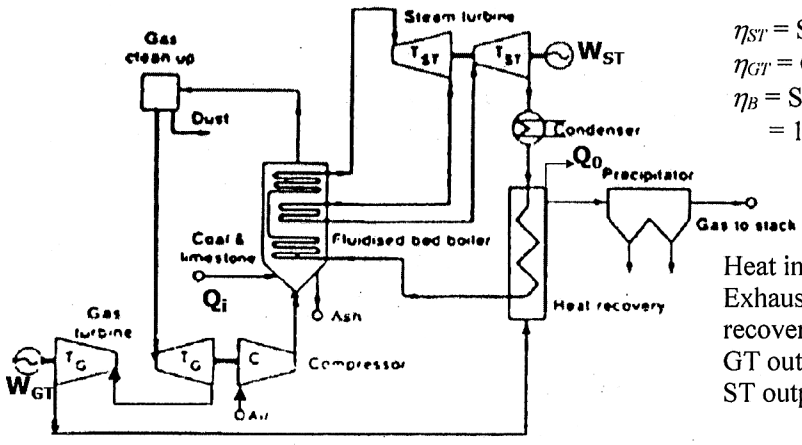
The Sankey diagram of a typical 250 MW GTCC plant is shown below:



Find the followings:

(i) Efficiencies of the GT cycle and the ST cycle.	**2 marks**
(ii) Station heat rate and Net plant heat rate of the GTCC plant.	**2 mark**
(iii) HRSG efficiency.	**1 mark**
(iv) Heat rejected in the condenser	**1 mark**
(v) ST and GT outputs.	**2 marks**
(vi) Heat supply rate.	**1 mark**
(vii) Station auxiliary power and steam TG auxiliary loss.	**1 mark**

OR



η_{ST} = ST cycle efficiency
η_{GT} = GT cycle efficiency
η_B = Steam generator efficiency
$= 1 - Q_o/Q_i$

Heat input = Q_i
Exhaust heat loss from heat recovery boiler = Q_o
GT output = W_{GT}
ST output = W_{ST}

The above figure shows a GTCC combined cycle with a PFBC boiler. Assuming that a fraction x of the supplied heat is received by the gas turbine cycle, calculate the combined cycle efficiency in terms of η_{ST}, $\eta_{GT}\,x$ and η_B. **10 marks**

Ref. No. Ex/PE/PE/H/T/324A/2024

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2024

*SUBJECT: **ADVANCED POWER CYCLES (HONS.)***

Time: Three Hours **100 Marks**

CO II: Answer any two (40 Marks)

2.

A steam power plant operates on an ideal non-reheat, regenerative Rankine cycle and has a net power output of 120 MW. Steam enters the high-pressure turbine at 13 MPa and 600°C and leaves at 8 kPa. Seam is extracted at 1 MPa to heat the feedwater in an open feedwater heater. 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 marks

3.

(a) Deduce the expression of a regenerative GT cycle efficiency in terms of the pressure ratio r, adiabatic index γ, temperature ratio t, combustion chamber efficiency η_{cc}, and the isentropic efficiencies η_c of the compressor and η_T of the turbine, and the heat exchanger effectiveness R. Also deduce the expression for work ratio. **14 marks**

(b) The following data refers to a gas turbine set employing a regenerator: Isentropic efficiency *of* the compressor: 82%, Isentropic efficiency of the turbine: 85%, pressure ratio: 7:1, Maximum cycle temperature: 1000 K, Combustion efficiency: 97%, Calorific value of fuel: 43.1 MJ/kg, Air mass flow rate: 20 kg/s, Effectiveness of the regenerator: 75%, Ambient temperature and pressure: 327 K, 1 bar. Calculate the output, specific fuel consumption and overall thermal efficiency of the cycle. **6 Marks**

4.

Consider the HBD of a 330 MW steam power plant (see at the end of the question paper). Boiler blowdown takes place as saturated water at a drum pressure of 180 bar, and the ambient make-up water temperature is 33° C. CW temperatures at the condenser terminals are 33 and 39 °C. Find (a) Gross Heat Rate as per the ASME PTC 6, (b) net power and net heat rate of the cycle as per the ASME PTC, considering the electromechanical efficiencies of the BFP and CEP drives to be 95%, (c) exergy efficiency of the turbine cycle, (d) Exergy efficiency of the Deaerator. (e) CW mass flow rate, (f) Dryness fraction of the steam at LPT exhaust, (g) Feed water temperature rise in the heater with pumped ahead configuration, (h) the % pressure drop in the extraction lines to heaters DJ3, (i) Steam pressure at the outermost sealing pocket of the turbine gland, (j) TTD and DCA of the DJ1. **20 marks**

5.

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?

20 Marks

CO III: Answer any two (40 Marks)

6.

(a) Draw a neat sketch of an EFGT cycle and the TS diagram. What is the advantage of EFGT cycle? **6 marks**

(b) What is the purpose of steam injection gas turbine? **4 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

Ref. No. Ex/PE/PE/H/T/324A/2024
B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2024
*SUBJECT: **ADVANCED POWER CYCLES (HONS.)***

Time: Three Hours **100 Marks**

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, Assume isentropic processes for the compressor and gas turbine. 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) With schematics, compare the design and performances of an entrained-flow and a moving bed gasifier.

(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?

(e) Part-load efficiency of a steam power plants is generally lower than that at the TMCR condition.

[Turn over

Ref. No. Ex/PE/PE/H/T/324A/2024

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAM 2024

*SUBJECT: **ADVANCED POWER CYCLES (HONS.)***

Time: Three Hours **100 Marks**