Ref. No. **Ex/PG/PE/T/129A/2024**

M. POWER ENGINEERING 1ST YR. 2ND SEM. EXAMINATION, 2024

SUBJECT: ***ADVANCED POWER CYCLES AND ECONOMICS***

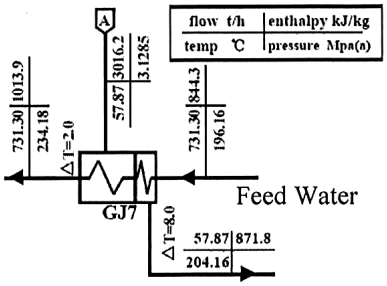
Time: Three Hours **(Full Marks 100)**

CO 1 (25 Marks)

1.

i. What do you mean by exergy? Write the expressions of non-flow and flow exergies of a unit mass of a fluid. **2+3=5**

ii. The regenerative HP feed heater (surface type) of a power plant has the design parameters as described in the figure in the right. But, because of scale formation in the tubes, actual measurements show that the TTD and DCA have increased by 2 °C each (the bled steam (A) parameters have remained unchanged). If the cost of electricity produced by this power plant is Rs. 4.5/ kWh, estimate the net financial loss you would incur in one year if you decide not to carry out a proper maintenance to restore its performance. **15**



iii. In an industrial furnace, why is it important to match the source and the end-use temperatures? Why is co-generation a thermodynamically favorable option for plants that require process heat at low-temperature? **5**

OR

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

- TG output = 210.01 MW,
- 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.
- 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.
- 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

CO 2 (25 Marks)

2.

i. State the purpose of inlet fogging in GT and steam injection in gas turbines. **5**

ii. Deduce an expression of an ideal regenerative GT cycle efficiency in terms of the pressure ratio r, adiabatic index γ, and temperature ratio t, and show that the cycle efficiency decreases as r increases. Deduce the expression of the pressure ratio, below which the purpose of regeneration is defeated. **10**

iii. Deduce the expression of efficiency of an actual regenerative GT cycle in terms of the three above parameters (r, γ, t), the combustion chamber efficiency (η_{cc}), and isentropic efficiencies of the turbine (η_T) and compressor (η_C). **10**

OR

[Turn over

Ref. No. **Ex/PG/PE/T/129A/2024**

M. POWER ENGINEERING 1ST YR. 2ND SEM. EXAMINATION, 2024

*SUBJECT: **ADVANCED POWER CYCLES AND ECONOMICS***

Time: Three Hours **(Full Marks 100)**

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

GT Cycle: Temperature ratio = 3.33; Pressure ratio = 6; Isentropic efficiencies for compressor and turbine are 85% and 90%, respectively; GT output = 100 MW; Ambient Air temperature = 25 °C.

HRSG: Pinch point temperature difference 20°C; Acid dew point = 170 °C. Exit gas temperature is to be maintained at least 5 °C above the acid dew point.

Steam Cycle: Simple Rankine cycle with boiler and condenser back pressures of 30 bar and 0.02 bars, respectively. Assume steam turbine expansion isentropic, and neglect pump work.

Determine, (i) GT cycle efficiency, (ii) ST cycle output, and (iii) Overall plant efficiency

25

CO 3 (25 Marks)

3.

i. What do you mean by EFGT? What is the salient advantage of EFGT over conventional GT cycle? **5**

ii. Draw a neat sketch of an EFGT-Combined cycle with gasifier and label different salient components of it. **5**

iii. In a supplementary fired GTCC plant, a fraction (x) of the total heat is supplied, in terms of vacuum residue fuels, to the duct burners of the HRSG. The open cycle GT operates in a simple cycle (consider ideal cycle) at a pressure ratio of 5, while the steam cycle has a net heat rate of 10,000 kJ/kWh. The efficiency of HRSG is 85%. (i) Derive an expression for the overall plant efficiency for the configuration and (ii) calculate its value for x=10%. **7+8 = 15**

OR

i. Write down the basic steps of gasification process. **5**

ii. What are the three basic types of gasifiers used in IGCC power plants? Compare with brief schematics, the difference between an entrained flow and a moving bed gasifier operation and syn gas composition. **10**

iii. With a neat sketch of the basic building blocks, explain the working procedure of an oxygen blown IGCC cycle. **10**

CO 4 (25 Marks)

4.

As a project manager of a power project, you are to select a 250 MW (**gross**) steam turbine-generator set (including the turbine auxiliaries) out of the following 3 models of proposed by three TG manufacturing companies:

TG Model	**TG Model A**	**TG Model B**	**TG Model C**
GHR (Kcal/ kWh)	2040	2000	1980
Quoted price of TG set (Incl. taxes) (Rs. Millions)	1600	1800	2000
Incremental cost of interfacing equipment (assuming model B as the base case) (Rs. Millions)	20	0	60
Interfacing Boiler Efficiency	87%	87%	90%

Other data:

1. Landed cost of coal = Rs. 8 per kg, GCV of coal = 4000 kCal/ kg
2. Annual insurance to be paid on the cost of equipment @0.5%
3. Discounting rate applicable = 10%
4. Accounting period = 20 years.
5. Predicted plant load factor = 80%

Select the best model for the power plant. **25**

Ref. No. **Ex/PG/PE/T/129A/2024**

M. POWER ENGINEERING 1ST YR. 2ND SEM. EXAMINATION, 2024

SUBJECT: ***ADVANCED POWER CYCLES AND ECONOMICS***

Time: Three Hours **(Full Marks 100)**

OR

a) The input-output relationship of a thermal power plant is expressed as:
$I = a_0 + a_1 L + a_2 L^2 + a_3 L^3$,
While I = input and L = output (load) of the plant, expressed in the same unit. Explain the significance of a_0, a_1, a_2, and a_3. **5**

b) Show that the best-efficiency point of operation of a power generating unit is obtained when the *Incremental Rate* on the machine is equal to the *Heat Rate*. **5**

c) The input-output expressions for two coal-fired generating stations connected to the same grid are as follows:

Unit	Capacity (MW)	I/L curves (MW/ MW)	C.V. of Coal (kCal/ kg)	Cost of Coal (Rs. / 1000 kg)
A	60	$I_A = 12.0 + 0.5\ L_A + 0.03\ L_A^2$	4000	1200
B	40	$I_B = 25.0 + 0.3\ L_B + 0.05\ L_B^2$	3500	1000

What will be the load sharing between the units for a total load of 20 MW, 50 MW and 100 MW? **15**