Form A: Paper-setting Blank

Ref. No. Ex/PG/PE/T/129A/225/2010)

MASTER OF POWER ENGINEERING EXAMINATION, 2ND SEMESTER 2010

SUBJECT: ***Advanced Power Cycles and Economics***

PAPER:

Time: Three Hours

(Full Marks 100)

Answer Q1, and three from Section A and one from Section B

1.

a. How does the efficiency of a simple, ideal GT cycle depend on the maximum turbine inlet temperature? Justify. **3 marks**

b. What do you mean by incremental heat rate of a cycle? Show that the plant heat rate is minimum when the heat rate is equal to its incremental rate. **4 marks**

c. Describe with a neat sketch why dual pressure cycles are used in GTCC plants. **6 marks**

d. Why in a vapor power plant, it is detrimental to have a continuous SH spray for main steam temperature control? Why is it even more detrimental to have RH spray? **4 marks**

e. How does a poorly maintained cooling tower affect the heat rate of a thermal power plant? **3 marks**

Section A (Answer any three)

2.

a. What do you mean by an EFGT cycle? What are its advantages? Draw a neat sketch of an EFGT cycle and show the process on T-s diagram.

b. Derive the expression of cycle efficiency η and the work ratio δ of a simple gas turbine cycle in terms of the temperature ratio t, compression ratio r, and the isentropic efficiencies of the turbine (η_T) and the compressor (η_C). Neglect any pressure drop in the lines, mass of the added fuel, change of specific heats of the working medium, and assume complete combustion.

c. Find the cycle efficiency and work ratio for the above mentioned simple gas turbine cycle, where the air temperatures at the inlet to the compressor and the turbine are 300 K and 700 K, respectively. The cycle pressure ratio is 4, while the adiabatic index for the working fluid is 1.4.

8+8+4 = 20 marks

3.

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

- TG output = 525.02 MW,

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- Steam/ water parameters: MS at TSV: 540°C and 160 bar; CRH: 320°C and 40 bar; HRH: 540°C and 36.6 bar; Final feed water temperature = 230°C, Superheater Spray water pressure 170 bar, and temperature 170° C.
- Flow Rates: MS at TSV: 454 kg/s, CRH: 411 kg/s; S/H spray flow rate = 0.8 kg/s; R/H spray flow rate = 0 kg/s, continuous blow-down from the drum = 0.2 kg/s (assume saturated water blow down). Cycle make-up water temperature 35°C.
- Power Consumed by: BFP motor: 12.2 MW; CEP motor = 0.6 MW,

Calculate:

i. GHR and NHR of the turbine cycle as per ASME PTC 6
ii. Specific steam consumption
iii. Heat rejected to CW at the condenser
iv. Contribution of boiler blow-down towards the GHR.
v. Work ratio of the cycle
vi. Exergy input rate to the HP turbine
vii. Exergy destruction ratedue to water spray in the superheater.

20 marks

4.

a. What is a combined cycle? Discuss the salient classifications of Combined Cycle Power Plant.

b. What do you mean by STIG? Why is it used?

c. In a supplementary fired GTCC plant, 15% 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 30% while the steam cycle has a net heat rate of 2560 kCal/kWh. The efficiency of HRSG is 87%. Draw a neat schematic of the cycle and derive an expression for the overall plant efficiency and calculate its value.

4+3+13=20 marks

5.

a. What do you mean by a Heat Balance Diagram? What are the utilities of HBD during the following phases of power project: (i) conceptual engineering, (ii) equipment selection, (iii) detailed engineering, and (iv) commissioning?

b. In a direct contact type feedwater heater, water at 200 kPa and 20°C is heated by mixing it with turbine bled steam at 200 kPa and 300°C. Liquid water enters the mixing chamber at a rate of 4 kg/s. If the mixture leaves the chamber at 200 kPa and 100°C, determine (a) the mass flow rate of the bled steam, (b) the exergy destruction in the heater, and (c) the exergy efficiency of the heater.

6+14 = 20 marks

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(Full Marks 100)

Section B (Answer any one)

6.

The following three models of turbine generator sets (including the TG auxiliaries) are proposed for a 500 MW (net) steam power plant:

TG Model	**TG Model A**	**TG Model B**	**TG Model C**
GHR (Kcal/ kWh)	2150	2050	1950
% Auxiliary power consumption	9.5	9.0	9.0
Quoted price of TG set (Including taxes) (Rs. Millions)	4000	5800	10000
Incremental cost of interfacing equipment (assuming model B as the base case) (Rs. Millions)	50	0	450

Other relevant data:

1. Boiler efficiency = 87%
2. landed cost of coal = Rs. 1 per MJ
3. Annual insurance to be paid on the cost of equipment @0.5%
4. **Discounting rate applicable = 11%**
5. **Accounting period = 20 years.**
6. **Predicted plant load factor = 85%**

Select the best model for the power plant. **20 marks**

7.

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

Unit	Capacity (MW)	I/L curves (MW/ MW)
A	20	$I_A = 12.0 + 0.5\ L_A + 0.15\ L_A^2$
B	10	$I_B = 18.5 + 1.5\ L_B + 0.1\ L_B^2$
C	15	$I_C = 9.8 + 1.0\ L_C + 0.08\ L_C^2$

The daily load demand on the grid is as follows:

For 8 hours: 10 MW

For 10 hours: 25 MW

For 6 hours: 45 MW

What will be the daily plant load factors of the units A, B, and C if the total operating cost is to be minimized?

20 marks