Ref. Ex/PG/POW/PC/T/115/2025

ME. POWER ENGINEERING 1st YEAR FIRST SEMESTER EXAMINATION 2025

SUBJECT: ***Advanced Power Generation Methodologies***

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

Use of Steam Table permitted; Air Table is supplied with the Question Paper

PART I

CO 1: 20 Marks; Answer any two

1.

a. A solar thermal collector runs on a primary fluid which is heated to a maximum temperature of 200 °C. Using this hot fluid as heat source, and the ambient as the heat sink, you are required to run a vapor power cycle. What should be the ideal working fluid properties for such an application? Justify. **5**

b. Draw a neat sketch of such a cycle. **5**

2.

a. Describe different factors conducive for selection of a site for a coal-based thermal power plant. **5**

b. What are the merits and demerits of an air-cooled condenser? **5**

3.

a. What is the role of energy storage in renewable energy technology? Cite four examples of energy storage technologies and state their advantages and disadvantages. **5**

b. Indian rural areas are always rich in biomass and agro-mass like rice husk, bagasse, stubbles of rice and wheat. If you are to use these as fuels to develop a distributed generation system, what technology do you recommend? Draw a neat sketch of "fuel-to-electricity" process of such a plant. **5**

CO 2: 30 Marks; Answer any two

4. 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. **15**

5.

a. What do you mean by combined cycle? What is the main advantage of using combined cycle? **5**

b. 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**

[Turn over

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6.

a. State the distinct advantages of GT plant over steam power plants. **3**

b. Draw a neat sketch of a regenerative gas turbine plant and deduce the expression of efficiency of an ideal regenerative GT cycle in terms of the pressure and temperature ratios. **6**

c. What is the purpose of reheating and intercooling in gas turbine cycle? **3**

d. What is the purpose of GT inlet fogging? **3**

CO 3: 20 marks

7.

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

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NAME OF THE EXAMINATIONS: M.E. POWER ENGINEERING FIRST YEAR FIRST SEMESTER - 2025

SUBJECT: ADVANCED POWER GENERATION METHODOLOGIES

FULL MARKS: 30

Part II

[Use separate answer scripts for Part I and Part II]

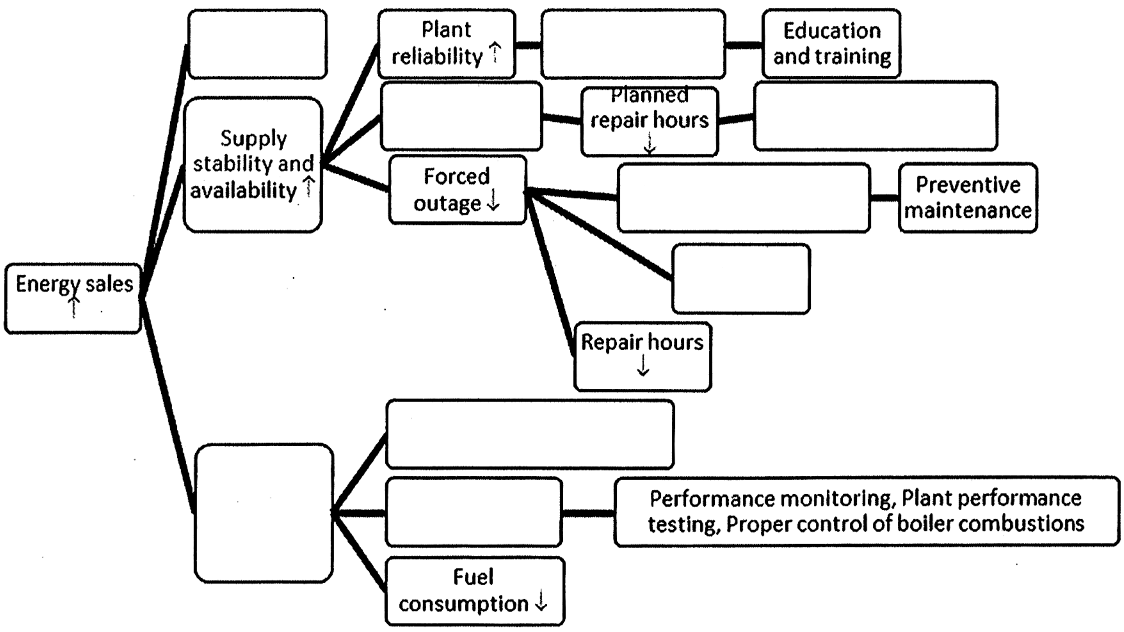
(Answer any 3 questions) **3@10 = 30** **[CO4]**

Q1) Following are some scopes of power plant instrumentation, and list of possible measuring devices. Segregate the scopes in two separate vertical columns based on where they are to be used, (A) coal mill, or (B) Furnace and Boiler. Identify which instrument is to be used for which measurement. [*Same sensor may be used in more than one site*]

Scopes of measurement: boiler temperature distribution, burner flame, carbon in fly ash, coal storage tower level for coal delivery, coal/air temperature, economizer O_2 and CO levels, economizer temperature, heat exchanger differential pressure, mill/pulverizer feeder speeds, O_2 levels at air heater inlet & outlet, PA fan motor speed, primary air flow, pulveriser differential pressure, pulveriser exhaust pressure, pulverized fuel flow rate, reheater pressure, reheater temperature, steam temperature, superheater temperature, boiler pressure

Measuring instruments: Displacement sensor, DP transmitter, flame sensor, flow meter, humidity sensor, Hydra step probes, level sensor, load cell, LVDT, O_2 sensor, Optical transducers, particulate sensor, pressure gauge, RTD, speed sensor, thermocouple, thermometer, CO sensor

Q2) In relation to operation and management of power plants, one of the main focuses is on increasing energy sales. The following flowchart outlines the possible avenues for doing so. Fill in the blank boxes in the flowchart with the following list of probable strategies (there are some dummy entries to confuse you). [*Redraw the chart in your copy and fill in the vacant boxes*]



Probable strategies:

Maintenance and operation skill ↑, Sell off redundant assets ↑, Production cost ↓, Maintenance cost ↓, Installation cost ↓, Industrial accident ↓, Measures against exhaust gas ↑, Maintenance skill ↑, Equipment degradation accident ↓, Human error ↓, Thermal efficiency ↑ Utilization factor ↑, Plant efficiency ↑, Planned outage ↓, Unit selling price ↑

[Turn over

Q3) Given below are some potential applications of IoT in power system. Identify and list along three separate vertical columns, which of them are applicable to (A) power generation, which are to (B) power transmission & distribution, and which are to (C) power consumption. [*Note that some applications may be applicable to all three domains*].

IoT applications: Decentralized Energy Generation, Digital Twin Energy Infrastructure, Distributed Energy Resources (DER) Management, Emissions Monitoring & Reduction, E-Mobility (Electric Vehicle), Generation Optimization & Load Balancing, Grid asset maintenance, Grid Balancing, Home Energy Management, Improved adaptability, Improving unit efficiency and resilience, Intelligent Decision Making, New Business Opportunities through E-Mobility, Optimization of Grid Contribution, Outage management, Predictive Load Forecasting, Process optimization, Remote Asset Management, Remote Infrastructure Maintenance, Smart Electricity Metering for Smart Homes, Smart Grid Automation, Workplace Safety, Relaying predictive data

Q4) **(a)** The list below contains certain types of power resources. Identify and list them along three separate vertical columns, which of them can be used as (A) Base-load plant (B) Peak-load plant (C) Load-following plant. [*Note that some of these sources may be used for more than one purpose*] [5]

Generating sources: Coal fired thermal power plants, Combined cycle gas turbine power plant, Combined heat and power plants (CHP), Concentrated solar power plants, Demand response, Diesel engine power plant, EV batteries, Gas engine power plant, Hydro power plants, Hydrogen based fuel cell power plants, Modern nuclear power plants, pumped hydro power plant, Solar PV and wind power plants, Traditional nuclear power plants,

(b) Suppose you need to **black-start** a 400 MW thermal power plant so that power supply to the grid can be restored. Below is the possible list of events that one has to follow to do so. Arrange these events sequentially so that black-starting can be successfully executed. [5]

List of events:

- The power from a nearby 60 MW hydroelectric station is used to start one of the nuclear/fossil-fuel-fired base load plants
- The power from the 100 kVA diesel generator is used to bring the hydroelectric generating station into operation
- The power from the 100 MW base load plant is used to restart all of the other power plants in the system
- Power is finally re-applied to the general electricity transmission/distribution network and sent to the consumers
- Key tie-lines between this station and other areas are energized
- A 2000 Ah battery starts a small diesel generator installed in a hydroelectric generating station

Q5) Two units in the same thermal power station have the following cost models:

$$F_1 = 793.22 + 7.74P_1 + 0.00107P_1^2$$
$$F_2 = 1194.6 + 7.72P_2 + 0.00072P_2^2$$

Find the optimal power generated P1 and P2 by the two units, and their respective incremental costs, when they together have to supply a total load demand of 400 MW.

[***Hint:*** *Incremental cost of* P_1 *is* $\lambda_1 = \frac{dF_1}{dP_1}$, *and incremental cost of* P_2 *is* $\lambda_2 = \frac{dF_2}{dP_2}$.
For optimal power generation by both units together, the condition is $\lambda_1 = \lambda_2$]

--- End of Question Paper ---