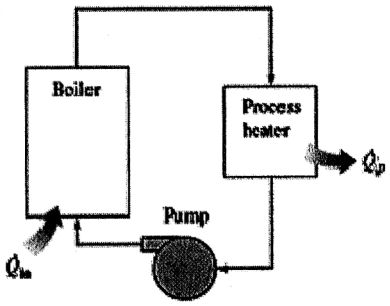
BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
FOURTH YEAR FIRST SEMESTER EXAM 2024

Advanced Power Generation

Time: Three hours (*Answer any **FIVE** questions*) Marks: 100

Different parts of the same question should be answered together. Use of steam tables are allowed. Assume any relevant data if necessary.

1.	a) What do you mean by Base load and Peak load power plants? Explain the function of Purulia Pump Storage Project (PPSP) in maintaining grid frequency.	6
	b) A thermal power plant consists of two 70MW units each running for 8000hr and one 30MW unit running for 2000hr per year. The energy produced by the plant is 876×10^6 kWh per year. Determine plant load factor and plant use factor. Consider maximum demand is equal to plant capacity.	7
	c) The peak load on a power station is 35MW. The loads having maximum demands of 15, 10, 5 & 7 MW are connected to the power station. Capacity of the power station is 40MW & annual load factor is 50%. Calculate: average load, energy supplied per year, demand factor and diversity factor.	7
2.	a) The net power output of an ideal reheat regenerative steam cycle is 80MW. Steam enters the high pressure turbine at 80bar, 500^0C and expands till it becomes saturated vapour. Some of the steam then goes to an open feed water heater and the balance is reheated to 400^0C, after which it expands in a low pressure turbine to 0.07bar. Compute (i) the reheat pressure, (ii) the steam flow rate to the high pressure turbine (iii) the cycle efficiency and (iv) the rate of flow of cooling water in the condenser if the temperature rise of water is 8^0C (v) if the velocity of steam flowing from the turbine to the condenser is limited to 130m/s, find the diameter of the connecting pipe.	16
	b) Consider a simple Rankine cycle and an ideal Rankine cycle with three reheat stages. Both cycles operate between the same pressure limits. The maximum temperature is 700°C in the simple cycle and 450°C in the reheat cycle. Which cycle do you think will have a higher thermal efficiency?	4
3.	a) Show that the thermal efficiency of a combined gas-steam power cycle is equal to the sum of the individual efficiencies of the two cycles minus their product.	5
	b) A combined cycle power plant has a total power output of 310MW. The gas turbine operates with a pressure ratio of 10, air inlet temperature of 27^0C and the maximum gas temperature is 1100^0C. There is the provision for supplementary firing in which	

	the combustion of additional fuel raises the gas temperature to 900^0C. The exhaust gas from the GT flows to a HRSG from which the gas leaves at 120^0C. In the bottoming cycle stem plant, the steam is supplied to the turbine at 80bar, 500^0C and the condenser pressure is 0.2 bar. The calorific value of fuel burned is 42.2 MJ/kg. Neglect the effect of the mass flow rate of fuel on the air flow and take c_p=1.11kJ/kgK and γ=1.33 for combustion gases and c_p=1.005kJ/kgK and γ=1.4 for air. Neglect pump work. Draw the flow and T-s diagrams of the combined plant. Determine (i) the flow rates of air and steam supplied, (ii) the power outputs of the gas turbine and steam turbine (iii) the overall efficiency of the combined plant, and (iv) the air-fuel ratio.	15
4.	a) What is process heat? Why is the simple process-heating plant shown in the figure below not a realistic model? 	5
	b) In a cogeneration plant, 10^6 kg/s of steam at 80bar, 500^0C expands in the high pressure turbine to 10bar. From the exhaust 4×10^5 kg/h of steam is extracted for process heating. The remaining steam expands in the low pressure turbine to 0.08bar. Saturated liquid at 0.08 bar leaving the condenser is pumped 9.5bar where it mixes with the condensate from the process heater leaving at 9.5 bar, 120^0C. The entire flow is then pumped to 80 bar. The isentropic efficiencies of the turbines and the pumps are 90% and 85% respectively. Determine (i) the heating load in kJ/h, (ii)the power developed by the turbines in kW, (iii) the rate of heat transfer in the steam generator in kJ/h	15
5.	a) What do you mean by coal gasification? How is coal gasification important from emission view point?	5
	b) What are the basic reactions taking place in coal gasifiers?	5
	c) Explain with neat sketch an IGCC plant.	10
6.	a) What is a supercritical boiler? What are its merits and demerits?	8
	b) Why is spiral water wall adopted over vertical wall in supercritical boilers?	6
	c) State various challenges of supercritical power generation.	6
7.	Write short note on the followings (***any FOUR***) a) Fuel cell, b) Regeneration, c) Load factor, d) Cogeneration, e) IGCC	20