M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER 2025

Advanced Energy Conversion

Time: 3 hours Marks: 100

Use separate answer script for each part

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

Part I

Question number **Q1** *is* ***compulsory*** *and answer any* ***two*** *from the rest*

Q1. Answer in maximum five sentences: 2x5 = 10

a) Why Rankine cycle, not the Carnot cycle is the basic one for steam power plants?
b) Why is reheat adopted in Rankine cycle of steam power plants?
c) Is regeneration suitable for CCGT? Why?
d) Draw the schematic of a cogeneration for higher heat load but at a lower temperature. What is it called?
e) Why Kalina cycle is more efficient than steam power cycle?

Q2. a) Draw the schematic layout of a two pressure CCGT. Will it be more or less efficient than a single pressure CCGT with the same gas turbine? Why? 15

b) In a mercury-steam-CO2 cycle, heat rejected by the mercury is received by the steam and heat rejected by the steam is received by the CO2. If the efficiencies of the mercury, steam and CO2 cycles are 0.5, 0.4 and 0.25 respectively, find the overall efficiency of the composite cycle. 5

Q3. a) A back-pressure cogeneration plant is operating between pressures 40 bar and 10 bar. The condition of steam at turbine inlet is 40bar, 5000C and outlet condition is saturated. Calculate the energy utilization factor and the power to heat rate ratio of the plant neglecting pump work and assuming 70% of rejected heat is utilized as process heat. 10

b) What is fuel energy savings ratio (FESR)? Explain. What is the significance of a -ve value of it? 6

c) What is artificial thermal efficiency? Why is it 'artificial'? 4

Q4. a) Draw the schematics and T-s diagrams of both trans-critical and supercritical CO2 cycles. Why regeneration is done in supercritical but not in trans-critical CO2 cycles? 6+6+2 =14

b) What is ORC? Draw the schematic and T-s diagrams of a ORC. 'Working fluid of ORC is flexible' – why? 1+4+1 =6

Part II

Question number **Q1** *is* ***compulsory*** *and answer any* ***two*** *from the rest*

Q1. Answer any ***two***

a) Show an IGCC plant with the help of certain relevant blocks. 10

b) What is the main chemical reaction involved in the FGD process, especially in a wet limestone scrubber?

c) Write a short note on Fuel cells.

Q2. a) Explain with neat sketch the working of a fuel cell integrated combined cycle. 7

b) A 1.0 MW_{DC} fuel cell stack is operated with a cell voltage of 700 mV on pure hydrogen with a fuel utilization, U_f of 80 percent. (i) How much hydrogen will be consumed in kg/hr? (ii) What is the required fuel flow rate? (iii) What is the required air flow rate for a 25 percent oxidant utilization, U_{ox}? 10

c) What are the basic reactions taking place in coal gasifiers? 3

Q3. a) What is Flue Gas Desulfurization (FGD) and how does it work? 5

b) What do you mean by carbon capture and sequestration (CCS)? 5

c) Explain in brief different types of carbon capture technologies. 10

Q4. a) Draw and explain a supercritical boiler. 10

b) Why is spiral water wall adopted over vertical wall in supercritical boilers? 5

c) State various challenges of supercritical power generation. 5