Ref. No. Ex/PG/PE/T/115A/2024

M.E. Power Engineering First Year First Semester Examination 2024

Subject: Power Plant Cycles and Systems

Full Marks: 100 **Time: 3 hours**

Answer from all three groups

Group A

1. Answer any **five** questions. **5×4=20**
   (a) Define work ratio and specific steam consumption of a steam power cycle and explain their physical significance.
   (b) In a thermal power station, steam enters the turbine at 10 MPa pressure and 500°C temperature and expands isentropically till it becomes saturated. It is then sent back to the boiler for reheating. Determine the reheat pressure. Do you think that this reheat pressure will give the maximum benefit in terms of efficiency for the cycle?
   (c) Show that for a gas turbine cycle with ideal regeneration, the cycle thermal efficiency can be expressed as,
   $$\eta = 1 - \frac{1}{t} r_p^{\frac{\gamma-1}{\gamma}}$$
   where, t is the temperature ratio and r_p is the pressure ratio.
   (d) Compare the tower type and two pass utility boiler layouts based on their relative merits and demerits.
   (e) What are the various coal firing systems used in a coal fired power station boiler? Which of these is the most suitable for a low volatile matter coal and why?
   (f) In a coal mill, it is required to carry the pulverized coal from the mill to the boiler furnace and also to dry the coal as far as possible. How are these two requirements met in practice?

2. Consider the "Heat Balance Diagram" in the attached figure with valve wide open (VWO) condition and answer the following questions: **8×2.5=20**
   (a) Determine the pressure ratio between CRH line and Main Steam line and the pressure drop across the reheater?
   (b) What fraction of the output power is generated by the High Pressure Turbine?
   (c) Determine the dryness fraction of steam at the LPT exhaust.
   (d) What is the cooling water flow rate in the condenser if the TTD for the condenser is 5°C?
   (e) Determine the power consumed by the BFP and CEP.
   (f) From the data, ensure the conservation of mass and conservation of energy for the deaerator.
   (g) What is the DCA temperature for the heater DJ1?
   (h) What is the saturation temperature of the extraction steam for the heater GJ7?

Group B

Answer any **two** questions from this group **2×20=40**

3. In a Reheat-Rankine cycle, steam enters the high pressure turbine at 8 MPa pressure and 520°C temperature. The steam expands in the high pressure turbine to 1.8 MPa and is then

reheated to 520°C temperature again. The reheated steam is expanded in the low pressure turbine to 8 kPa. The isentropic efficiency of both stages of the turbine is 90%. The net power output of the cycle is 100 MW. Determine:

(a) The rate of heat transfer in the reheater as a percentage of the total heat transfer in the steam generator.
(b) The quality of steam at the exit of the low pressure turbine.
(c) Specific steam consumption and thermal efficiency.
(d) Cooling water flow rate in the condenser if the temperature rise of cooling water is 8 °C. **(20)**

4. In an ideal regenerative steam power cycle, steam leaves the final superheater at 15 MPa pressure and 550°C temperature. The steam is expanded in the turbine till 10 kPa and the exhaust steam is condensed in a condenser. Two extractions are drawn from the turbine at 3.6 MPa and 0.4 MPa pressures and the bled steam are taken to an open feedwater heater and a closed feedwater heater, respectively. The TTD of the closed feedwater heater is 3°C and it does not have a drain cooling section. The condensate from the closed feedwater heater is cascaded back to the condenser. The power generated from the cycle is 200 MW.
   (a) Draw the flow diagram and temperature-entropy diagram for the cycle.
   (b) Determine the steam flow rate at the entry to the turbine and those extracted for the two heaters.
   (c) Determine the thermal efficiency and work ratio of the cycle. **(20)**

5. The following data refer to a gas turbine set employing a regenerator:
   Isentropic efficiency of the compressor = 82%, Isentropic efficiency of the turbine = 85%, Mechanical transmission efficiency = 99%, Pressure ratio = 7:1, Maximum cycle temperature = 1000 K, Mass flow rate of air = 20 kg/s, Air-fuel ratio = 90:1, Regenerator effectiveness = 70%, Ambient temperature and pressure = 327 K and 1 bar, respectively.
   Calculate (a) power output from the plant, (b) fuel flow rate considering a combustion efficiency of 98%, (c) overall thermal efficiency, (d) Heating value of the fuel.
   Assume that there is no pressure loss in the system, specific heat of air at constant pressure is 1.005 kJ/kg K and that of product gas is 1.1 kJ/kg K. **(20)**

Group C

Answer any **one** question from this group **20**

6. (a) Draw a schematic diagram of the air and flue gas system of a thermal power plant and label it. **(8)**
   (b) What is draft? What type of draft is used in modern thermal power plant and why? For this system, draw a representative pressure distribution plot across the flow path. **(2+3+2)**
   (c) Describe how the primary and secondary air flow rates into the boiler are controlled. **(5)**

7. (a) Why is it required to seal the turbine? With a neat schematic diagram explain how the sealing is done. What is the purpose of the seal steam condenser? **(2+6+2)**
   (b) With a neat schematic explain the HP-LP bypass system and explain why this system is required. Why can't we have a single bypass from the Main steam line to the condenser? Why spray water is injected in the bypass lines? **(6+2+2)**

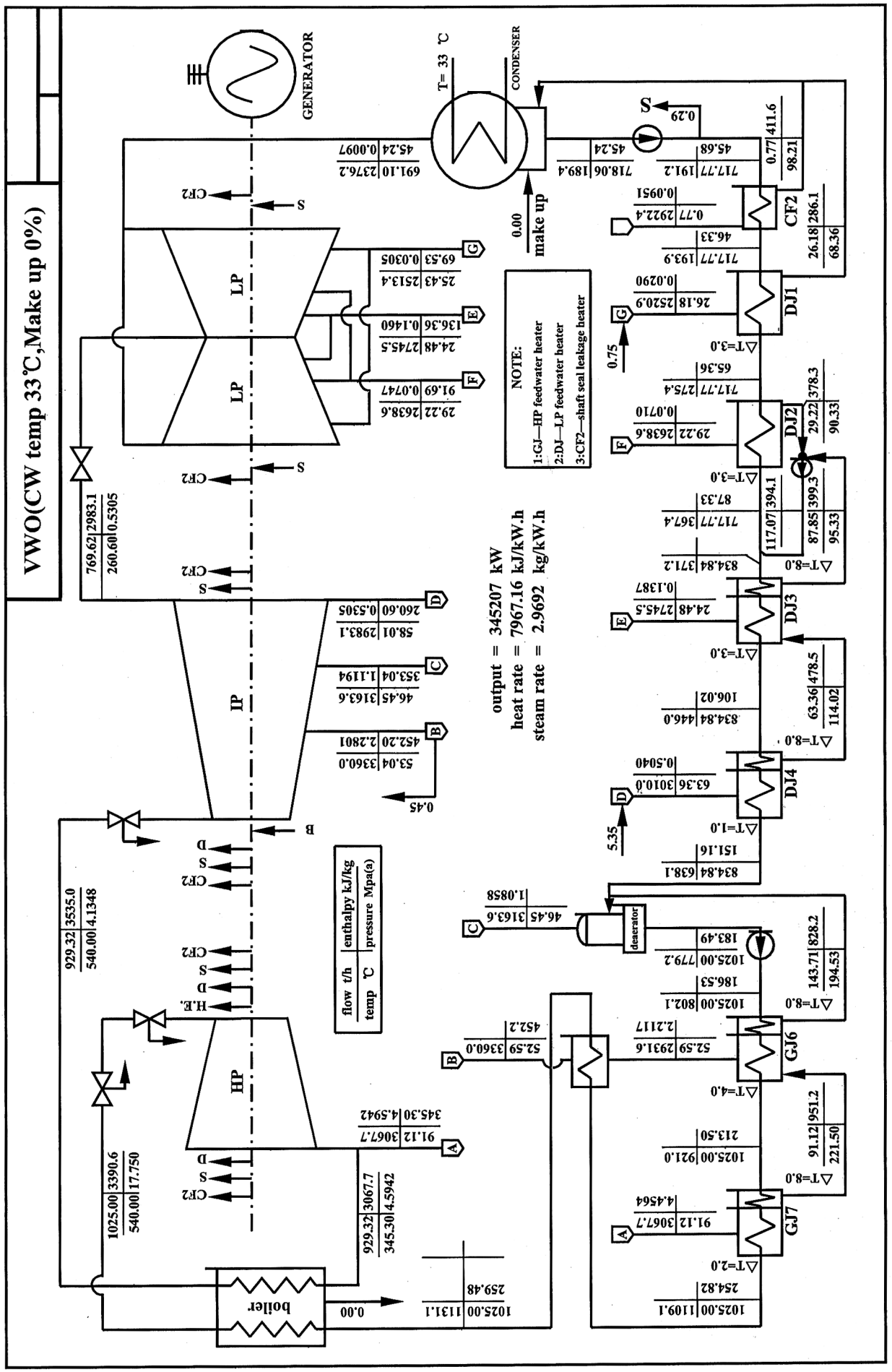

Fig. - Q. No. 2 : Heat Balance Diagram