Ref. No. Ex /PE/T/322/2017

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2017

SUBJECT: ***POWER PLANT CYCLES AND SYSTEMS***

Time: Three Hours **100 Marks**

Answer Question No. 1

1.

(a) What are the merits of IGCC power plants over GTCC plants? **2 Marks**

(b) Steep saturation lines are favorable working fluid property for vapor power cycle – why? **3 Marks**

(c) A cogeneration power plant operates with two heat sources at 1200K and 800 K, while it reject heat to the atmosphere at 300K and to a process plant at 400 K. If the known heat and work transfers are as shown in Fig. 1c, find the values of Q_{H2}, Q_{L2}, and the thermal efficiency of the power plant. Consider the plant to be reversible. **4 Marks**

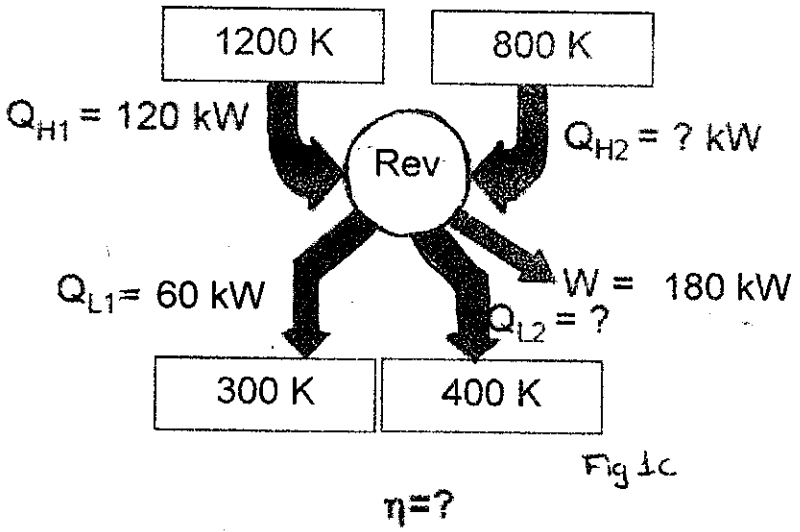

Fig 1c

(d) An ideal GTCC cycles has a gas turbine cycle that operates with air (γ = 1.4) and a pressure ratio of 12. The exhaust from the GTCC is fed to ah HRSG that has efficiency of 85%. The HRSG raises steam for a Rankine cycle having an efficiency of 30%. What is the efficiency of the combined cycle? **5 Marks**

(e) What do you mean by PG test? Why are they conducted? **3 Marks**

(f) What are the problems of excessive silica in boiler water? **1 Mark**

(g) What is a STIG cycle? **2 Marks**

Answer any two from Q 2, 3 and 4

2.

(a) For a given throttle steam flow rate, state the effects of regeneration on (i) Turbine work output, (ii) Condenser heat rejection, (iii) Cycle heat rate, and (iv) Heat transfer in boiler.

(b) For a regenerative cycle employing n number of direct contact type feedwater heaters, show that the cycle efficiency is maximized when the feedwater enthalpy rise in each heater is the same. Also evaluate, for such a condition, the heat rate improvement factor $f_{HR} = (HR_k - HR_\infty)/(HR_0 - HR_\infty)$ in terms of the number of heaters n (here HR_k denotes the turbine heat rate with k number of feedwater heaters). **4 + (10 +6) = 20 Marks**

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3.

A GTCC plant operates with simple GT cycle with a HRSG. The GT, HRSG and ST operating parameters are as follows:

GT Cycle: Temperature ratio = 3.33, Pressure ratio = 6.5, Isentropic efficiencies for compressor and turbine are 85% and 90%, respectively, GT output = 100 MW

HRSG: Pinch point temperature difference=15 °C, Acid dew point = 160 °C. Exit gas temperature is to be maintained at least 10 °C above the acid dew point.

Steam Cycle: Simple Rankine cycle with boiler and condenser back pressures of 30 bar and 0.02 bars, respectively. Assume steam turbine expansion isentropic, and neglect pump work.

Determine, (i) GT cycle efficiency, (ii) ST cycle output, and (iii) Overall plant efficiency

20 Marks

4.

(a) What do you mean by HBD? What are the utilities of HBD during planning, designing, commissioning and O&M stages?

(b) Heat balance diagram of a 210 MW power plant is provided in the Fig. P4b under full-load condition with blow-down. Find the followings:
(i) GHR and NHR as per ASME PTC 6R. Consider the BFP to be motor-driven, and the pump and motor efficiencies to be 90% and 96%, respectively.
(ii) Mean temperature of heat rejection of the cycle.
(iii) CW flow rate
(iv) Cycle make-up flow rate.
(v) Steam pressure drop in the superheater and main steam pipeline.
(vi) Specific steam consumption

(1+4)+15 = 20 Marks

Answer <u>any two</u> from Q 5, 6 and 7

5.

(a) What are the roles of 'primary air' and 'secondary air' in a pulverized fuel fired boiler? Why is it necessary to preheat the primary air and secondary air?

(b) Draw a neat sketch of the PA and SA systems in a modern power plant and label its salient components

(c) What is a deaerator? Why is it provided in a vapor power cycle? State the working principle of deaerator with a neat sketch.

(2+2)+(4+4)+(2+2+4) = 20 Marks

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Time: Three Hours **100 Marks**

6.

(a) Draw a neat sketch of the HP-LP Bypass system of a modern steam power plant. State its functions during (i) plant start-up and (ii) rapid load throw-off.

(b) What are the standard capacities of HP-LP Bypass system in terms of mass flow rate?

(c) What is the function of steam throw-off device in the LP-bypass system?

(d) Why would a turbine cycle require make-up water? Where from the make up water is fed to the cycle?

(e) What are the functions of Gland Steam Condenser in a power plant?

(6+3)+2+2+3+4= 20 Marks

7.

(a) State how the following factors influence the heat rate of a 500 MW power plant?

i. Main and reheat steam spray
ii. Operating under HP heaters bypassed condition
iii. Poor pulverization of coal
iv. Increase in condenser vacuum
v. Increase in cycle make up water
vi. Poor maintenance of cooling tower fill materials

(b) What are the roles of ACF and degasser in a DM plant?

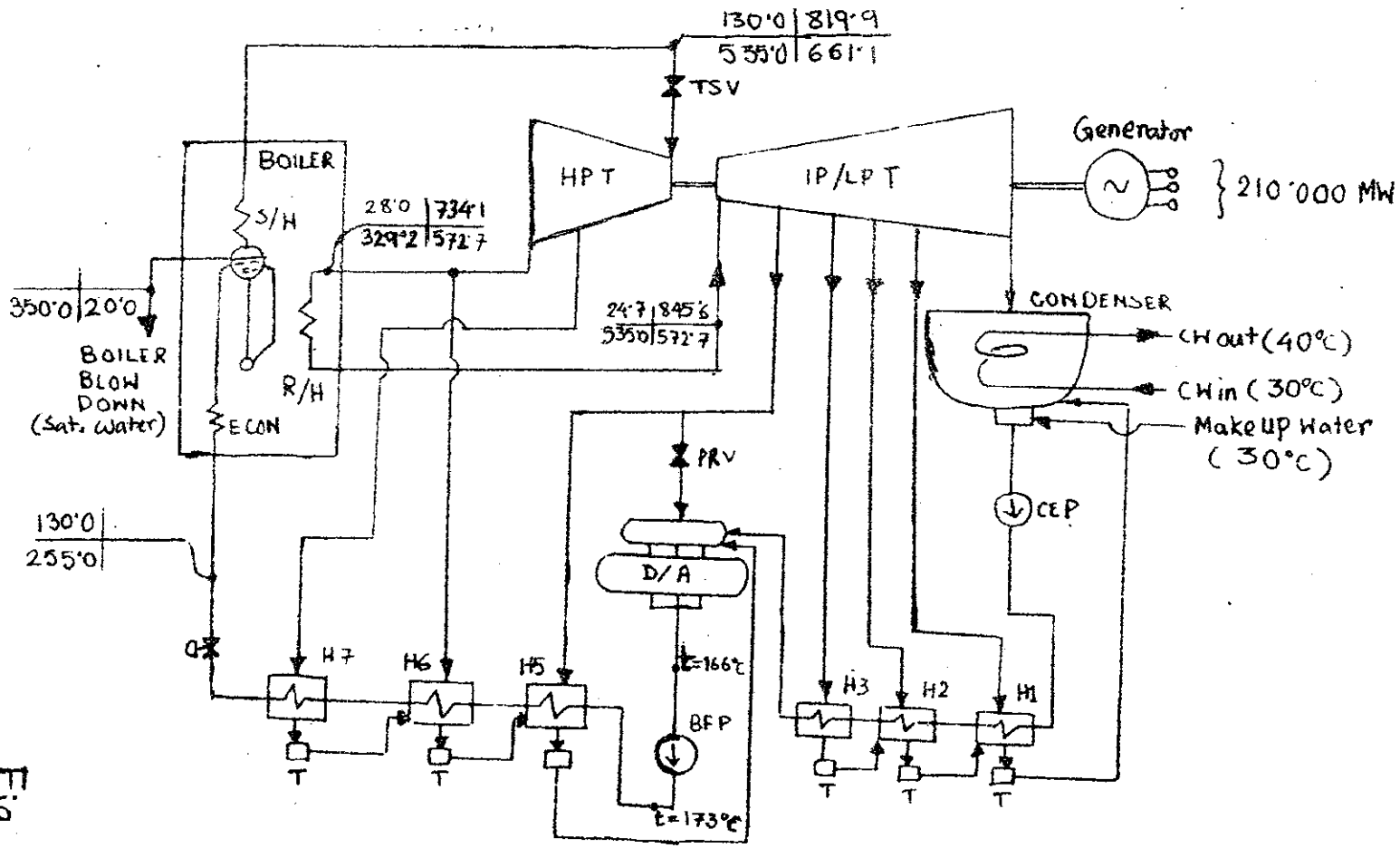
(c) At what approximate size coal in a power plant is

i. Unloaded
ii. Stored
iii. Fed to the coal bunker
iv. fired

(d) What is STEP factor?

(6×2)+3+2+3= 20 Marks

Fig. P4(a)



HEAT BALANCE DIAGRAM

LEGEND: H1 to H3 = L.P. Heaters, PRV = Pressure reducing valve
H5 to H7 = H.P. Heaters, ECON = Economiser
PRV = Pressure Reducing Valve
D/A = Deaerator, T = Trap
R/H = Reheater, S/H = Superheater

Supplement to Fig. P4(a)