MASTER OF POWER ENGINEERING 1st SEMESTER EXAMINATION, 2017

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

Time: Three Hours **100 Marks**

Section A (compulsory)

1.

(a) The Heat Balance Diagram of a 330 MW unit at TMCR with 3% make-up condition is furnished in Fig. 1 (attached). Assume a boiler drum pressure of 18 Mpa. Find the following quantities:

i. Gross Heat Rate as per ASME PTC 6.

ii. Isentropic efficiency of the HP Turbine.

iii. Internal power developed by the IP turbine.

iv. % pressure drop in the extraction to deaerator.

v. TTD and DCA of the HP heater #6.

vi. Total heat rejected from the cycle.

vii. Dryness fraction of the steam at LPT exhaust.

viii. Feed water temperature rise in the heater with pumped ahead configuration.

ix. Theoretical power consumed by BFP if the motor efficiency is 95%.

x. FW temperature rise across the gland steam condenser.

20

(b)

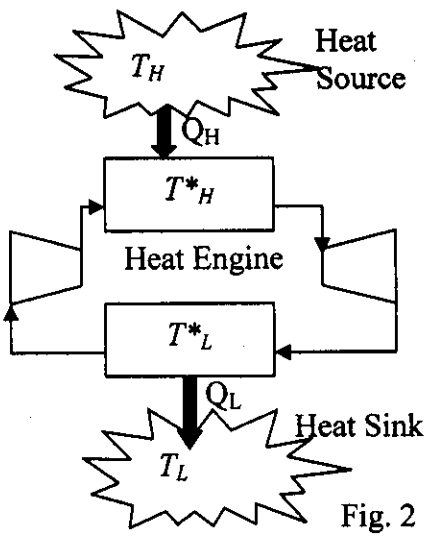

Fig. 2

In a real heat engine, the working medium is at temperatures T_H^* and T_L^* during the heat addition and heat rejection, respectively. This is to enable heat transfers Q_H and Q_L under a finite temperature difference. If

$Q_H = (hA)_H(T_H - T_H^*)$ and $Q_L = (hA)_L(T_L - T_L^*)$ where h = heat transfer coefficient, A = heat transfer area.

Show that for a given set of values for h, A, T_H and T_L, the work output is maximum when $\frac{T_H^*}{T_L^*} = \left(\frac{T_H}{T_L}\right)^{1/2}$.

Also, show that, the maximum net power output is

$$W_{max} = \frac{(hA)_H T_H}{1+(hA)_H/(hA)_L}\left[1-\left(\frac{T_L}{T_H}\right)^{1/2}\right]^2.$$

10

(c) What is the purpose of superheater and reheater sprays in a power plant? Why is reheater spray more detrimental than superheater sprays? **5**

(d) Poor maintenance of cooling tower can lead to an increase in plant heat rate – explain. **5**

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Section B (Answer any TWO)

2. A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 15 MPa and 10 kPa. The mass flow rate of steam through the cycle is 12 kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 12 percent, determine (a) the pressure at which reheating takes place, (b) the total rate of heat input in the boiler, and (c) the first-, and second-law efficiencies of the cycle. Also, show the cycle on a T-s diagram with respect to saturation lines. **20**

3.

(a) Draw a neat sketch and T-s diagram of a gas turbine cycle deploying regeneration. Also deduce the expression of cycle efficiency (η) of an ideal regenerative GT cycle in terms of pressure ratio (r) and temperature ratio (t). Explain, with the plots of η *versus* r, at different t, the benefit of regeneration. **4 +3+ 3 = 10**

(b) A 100 MW regenerative gas turbine cycle operates with a pressure ratio of 6 and temperature ratio of 4, respectively. The compressor takes in air at 300 K and 1 bar, while the regenerator has an effectiveness of 0.9. Assuming C_p=1 kJ/kgK and γ=1.4 for both air and flue gas, estimate the efficiency, work ratio and the air flow in the compressor. Assume isentropic expansion and compression. **10**

4.

(a) What do you mean by combined cycle? Why do they have a higher efficiency? **5**

(b) Draw a neat sketch of a binary vapour power cycle, labelling its components. Also draw the corresponding T-s diagrams. Deduce the expression of cycle efficiency. **15**

5.

(a) What are the merits of Organic Rankine Cycles? Cite the desired properties of the working fluid for an ORC. Name 3 working fluids that are generally deployed in ORC. **3+3+2=8**

(b) Draw a neat sketch of an ORC, citing the functions of each major sub-component. Also draw the corresponding T-s diagram. **(4+4)+4=12**

Section C (Answer any ONE)

6.

(a) Draw a neat sketch of a deaerator and label its components. State the function and operating principle of deaerator. **6+4=10**

(b) Where in a power house are the deaerators located, and why? **2**

(c) What are the cause and effects of air ingress in the condenser? **4**

(b) State the function of a gland steam condenser. **4**

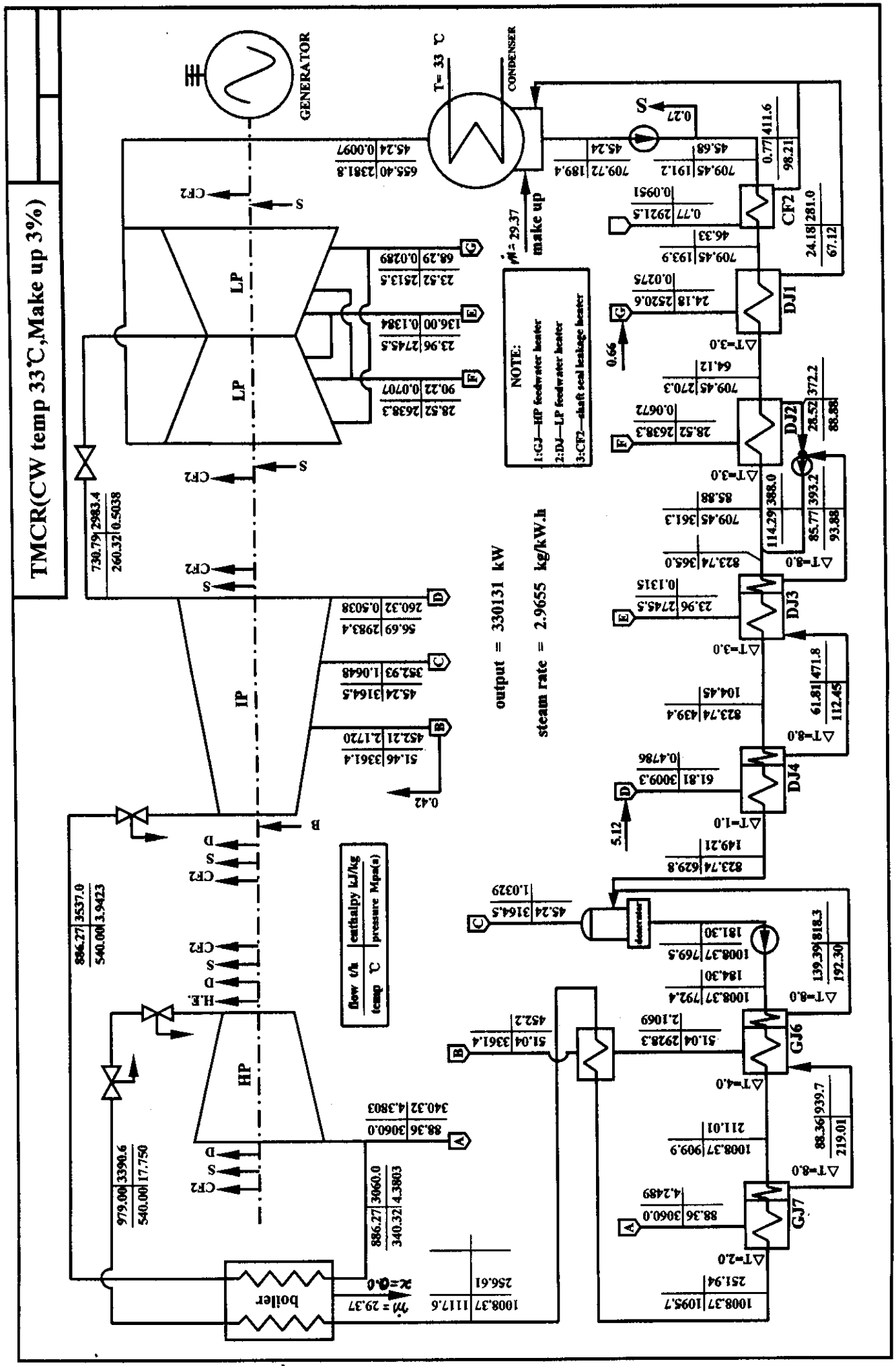
7.

(a) Draw a neat cross-section view of a Π-type boiler, labelling different heat transfer sections, and showing the flue gas path. What is the purpose of soot blowers? **8+2 = 10**

(b) With neat line-diagram, explain the operation of different components of a DM water system. **8**

(c) What are the problems of excessive silica in boiler water? **2**

Fig 1


TMCR(CW temp 33℃,Make up 3%)
GENERATOR
CONDENSER
T= 33 ℃
make up
LP
LP
IP
HP
boiler
output = 330131 kW
steam rate = 2.9655 kg/kW.h
NOTE:
1:GJ—HP feedwater heater
2:DJ—LP feedwater heater
3:CF2—shaft seal leakage heater
flow t/h | enthalpy kJ/kg
temp ℃ | pressure Mpa(a)
CF2
DJ1
DJ2
DJ3
DJ4
GJ6
GJ7
deaerator
H.E.