Energy and Exergy Analysis of Vapour Power Plant

Figure 1 overleaf shows the general layout of a steam power plant in which the heat is supplied by a separate CO_2 circuit which cools a nuclear reactor. The cycle contains one reheat stage and an open-type feedwater heater (mixing chamber) to which 23.4% of the steam supplied to turbine 2 is bled at an intermediate pressure. All the components in the plant, with the exception of the H.P. Pump, are well-lagged so that heat losses can be ignored. The isentropic efficiencies of the two turbines are 0.87 for the first turbine and 0.85 for the second. The heat loss from the H.P. Pump is 5 kJ/kg H_2O. The environment is at a temperature of 293.15K.

1. Draw and label the operating cycle of the steam plant on the T-s plane.

2. Complete Table 1 detailing the property values for H_2O at the various stages around the plant.

3. Complete Table 2 detailing the changes in **ENERGY** (kJ/kg H_2O) through the various components of the plant and accounting for these energy changes as a percentage of the total energy input to the plant and the total energy out.

4. Complete Table 3 detailing the changes in **EXERGY** (kJ/kg H_2O) through the various components of the plant and accounting for these exergy changes as, respectively, a percentage of the total exergy input to the plant and the total exergy loss.

5. Complete Table 4 detailing the 1^{st} and 2^{nd} law efficiencies of the named components.

6. Compare the results of the two analysis methods; answer the following questions:

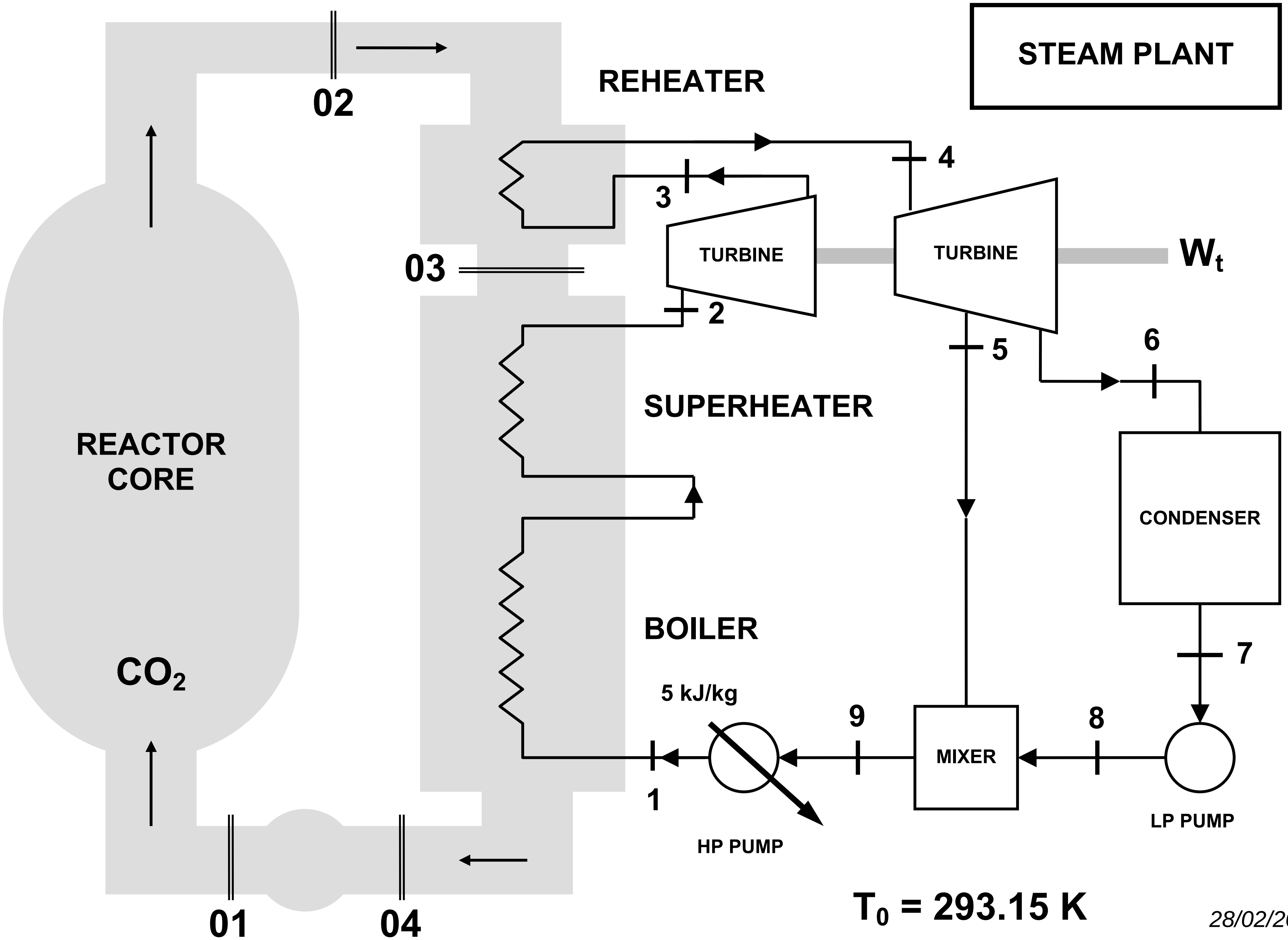
    a. What does the exergy analysis tell you about the importance of the energy (heat) lost in the condenser?
    b. What does the exergy analysis tell you regarding the importance of the reheat process with respect to the power output from the plant? Can this be seen from the simple energy analysis?
    c. What does the exergy analysis tell you about the mixing process? Why can this not be seen from the simple energy analysis?

Submit your completed T-s diagram, Tables 1 - 4, written answers to part 6, <u>AND ALL OF YOUR CALCULATIONS</u> related to the above before **FRIDAY 18TH MARCH (5.00 P.M.)**

NO LATE SUBMISSIONS WILL BE ACCEPTED, <u>SUBMISSIONS THAT DO NOT INCLUDE FULL DETAILS OF CALCULATIONS WILL NOT BE MARKED.</u>

M.H.D

28/02/2005



STEAM PLANT
REHEATER
02
4
3
03
TURBINE
TURBINE
W$_t$
2
5
6
SUPERHEATER
REACTOR CORE
CONDENSER
BOILER
7
CO$_2$
5 kJ/kg
9
8
MIXER
1
LP PUMP
HP PUMP
01
04

T_0 = 293.15 K

TABLE 1
Property Table

STAGE	PRESSURE	TEMPERATURE	h	s	T_0s	ε
	Bar	ºC	kJ/kg	kJ/kgK	kJ/kg	KJ/kg
01	8.5	240				
02	8	477				
03	7.75	460				
04	7.5	227				
1	150	200				
2	150	450				
3	80					
4	80	450				
5	15	244				
6	0.066	38				
7	1	25				
8	15	26				
9	15	180.5				

TABLE 2
Energy Accounting for H_2O – Conventional Method

Energy In	**kJ/kg**	**%**
Boiler & Superheater		
Reheater		
L.P. Pump		
H.P. Pump		
		100

Energy Out	**kJ/kg**	**%**
H.P. Turbine		
L.P. Turbine		
Condenser		
Mixer		
		100

TABLE 3
Energy Accounting for H_2O – Exergy Method

Exergy In	**kJ/kg**	**%**
Boiler & Superheater		
Reheater		
L.P. Pump		
H.P. Pump		
		100

Exergy Out	**kJ/kg**	**%**
H.P. Turbine		
L.P. Turbine		
Condenser		
Mixer		
		100

TABLE 4
Plant and Component Efficiencies

	Thermal	**2^{nd} Law**
H.P Turbine		
L.P. Turbine		
Overall Plant Efficiency		