

EEN-E2005 Bioenergy I Exam

24.10.2016, 9:00 – 12:00, K1, hall 215

Please write on every page you hand in:

* EEN-E2005 Exam 24.10.2016

* Your name, department, student number

Please return the paper exam with the papers of the answers. Use the h-s chart and the data given at the end of page 2 in your calculation and you could use a calculator but the use of a smart phone is forbidden.

There are four questions. Points: 12 + 6 + 6 + 6 = 30

1. An advanced 1100 MW coal fired **single reheat regenerative** ultra-supercritical steam power plant is operating under the following conditions (See Figure 1 below):
 - a. Live Steam condition: Pressure $p_1=300$ bar; Temperature $t_1=650^\circ\text{C}$
 - b. HP reheat steam conditions $p_2=30$ bars and $t_3=650^\circ\text{C}$
 - i. Steam extraction from turbine for feed water heating in an open-type heater at $p_3=1.6$ bars
 - c. Condenser pressure is 0.04 bar
 - d. Boiler efficiency is 0.92 and turbine isentropic efficiency is 0.9
 - e. Plant capacity factor = 0.8

The plant administration has recently started to put lot of emphasis on switching to biomass based system and have hired to you to evaluate whether the current coal based system or biomass based system will be a better option to develop the plant. In order to proceed further, you are required to estimate the following factors (ignoring turbine energy losses and pump work):

- a. Plant specific net-work output (kJ/kg) and specific heat rate (kJ/kg) (4 p)
- b. Plant thermal efficiency (1 p)
- c. Plant annual electricity production (1 p)
- d. Fuel flow rate required in case of coal (kg/s) (1 p)
- e. Fuel flow rate required in case of biomass (Grass pellets) and corresponding air flow rate at 20% excess air (3 p)

	Coal : wt. %	Biomass : wt. %
C	72%	39%
H	5%	5%
S	1%	0%
O	9%	33%
N	1%	2%
H ₂ O	4%	7%
Ash	7%	14%
HHV (MJ/kg)	29.38	14.86
LHV (MJ/kg)	27.93	13.67

- f. Compare the two option and give a suggestion with supporting argument of why would you choose one over the other. (2 p)
Hint: Feel free to mention at least four factors affecting the decision that you have learned in the course.

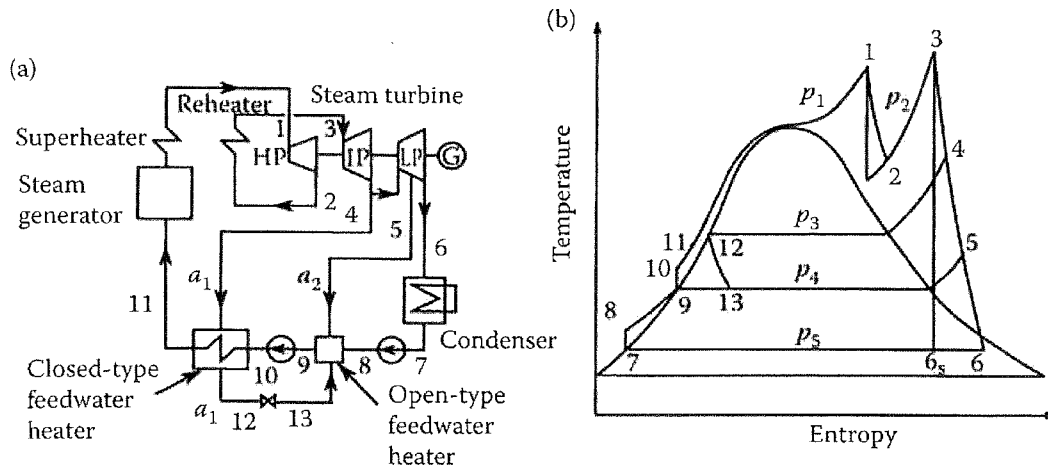


Figure 1 Supercritical Rankine cycle with regeneration and single reheat

2.
 - a. What are the objectives of the preparation and pre-treatment of biomass fuel (woody or herbaceous biomass) before combustion? (3 p)
 - b. What co-firing means? And what are the concepts of co-firing? (3 p)

3. Diesel fuels (6 p)
 Make a short note, what these fuels are, their most important properties, how they are made and a note on usability aspects too
 - a. Biodiesel
 - b. Hydrotreated Vegetable Oil
 - c. Renewable diesel
 - d. Synthetic diesel
 - f. Straight vegetable oil
 - g. HFO

4. E85 (6 p)
 - a. Please, point out the differences between gasoline (98E5) and E85 in terms of chemical composition, energy content, specific gravity and Octane number. (Exactly correct numbers are not necessary. Order of magnitude and the difference is essential) (4 p)
 - b. How does Air to fuel ratio (AFR) in stoichiometric combustion differ while operating the engine with gasoline and E85? (1p)
 - c. What kind of adjustments do fuel distributors make in E85 blends for usage in vehicles, according to the seasons (summer and winter months)? (1 p)

DATA needed for the calculation of the first question:

Mass of oxygen (O_2) required = $2.67C + 7.94H + S - O$

Molar masses: $H_2 : 2 \text{ g}$ $N_2 : 28 \text{ g}$ $O_2 : 32 \text{ g}$ $CO_2 : 44 \text{ g}$

$C : 12 \text{ g}$ $S : 32 \text{ g}$ $H_2O : 18$ $SO_2 : 64 \text{ g}$ $Air = 28.9 \text{ g}$

Air = $23.2 \text{ \% -wt } O_2 + 76.8 \text{ \% -wt } N_2$

