ELEC 6115 Conventional Generation Technology Coursework

Coursework 2, Part II | 2012-2013

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Student Name

Assignment on steam plant analysis (PART II)

(*This assignment (PART I + PARTII) carries 25% of the total mark*)

The two main flaws in the initial proposed system shown in figure 1 are:

- The quality of the steam leaving the Low Pressure turbine is 0.8, this value is unacceptable (the steam is too wet at the output of the turbine). The condensed water will cause erosion of the turbine blades resulting in premature failure. As a rule of thumb the quality of the output steam should be kept above 90% at the output of the turbine.
- The outlet pressure of Low Pressure turbine is 10 kPa, this is well below atmospheric pressure (see-level pressure is 101.325 kPa). This extremely low pressure in the condenser will allow air to leak into the system eventually deteriorating the performances.

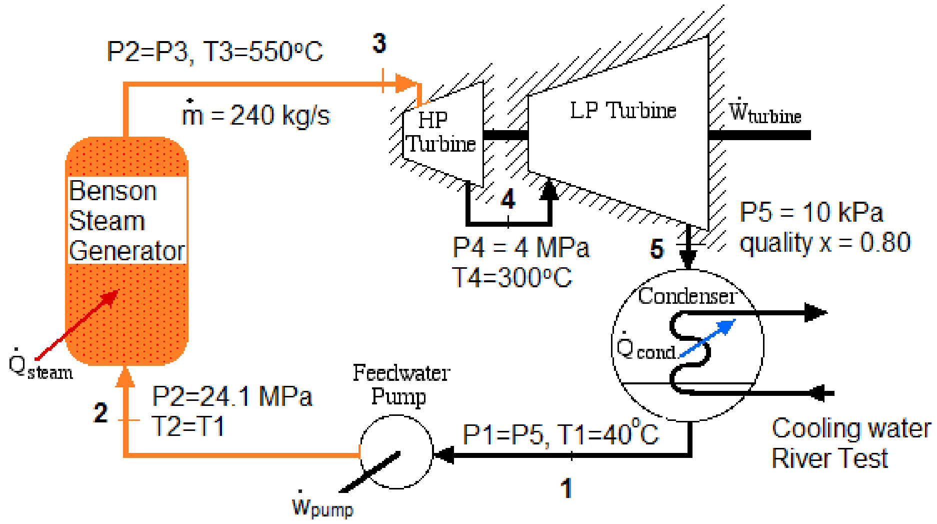

Figure 1. Flawed proposed steam plant for a combine cycle power plant

A revised system was proposed and is shown in figure 2. Both flaws are corrected as follow:

- The steam entering the low pressure turbine is reheated first to 550°C. This is done through a reheater introduced between the high pressure and low pressure turbines and routed through the steam generator (see figure 2). Reheating will ensure a much better quality of the steam at the output (in this case 0.93).
- To solve the low pressure problem at the condenser, a condensate pump is used to raise the pressure to 800 kPa and pass the liquid through a de-aerator before being pumped by the feedwater pump to the high pressure of 24.1 MPa.

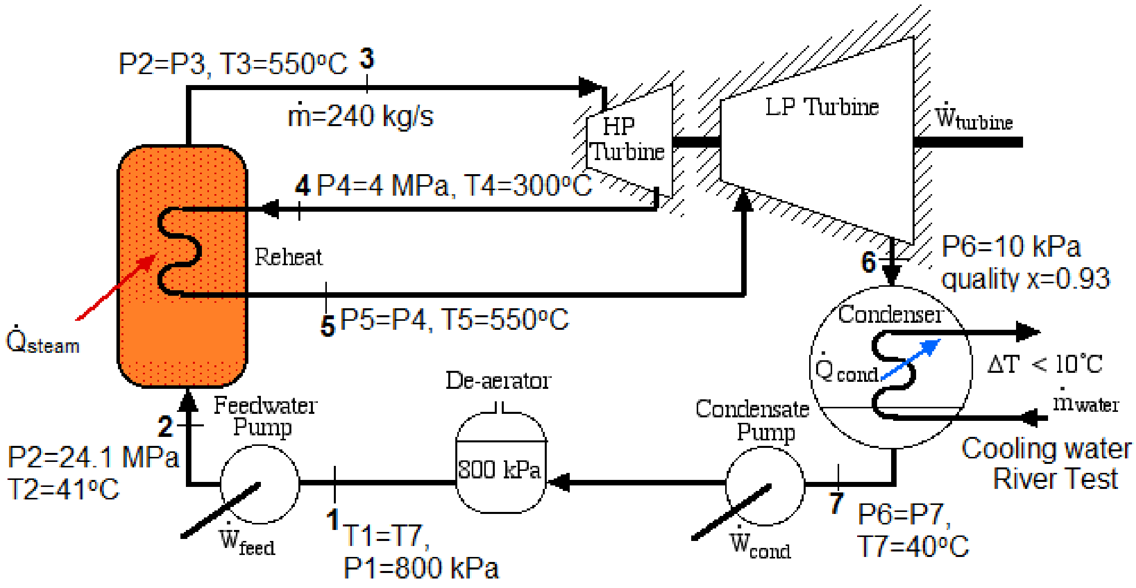

Figure 2. Revised steam plant – with reheat and de-aerator

Draw the T-s diagram of the revised plant and explain in some details the processes of this plant.

As in the first part of this assignment do the following calculations:

Calculate the power needed to drive the condensate and feedwater pumps (both pumps are considered to be adiabatic). Determine the thermal efficiency of this cycle. Compute the heat rejected to the cooling water in the condenser. As in the previous case all heat should be absorbed by cooling water from the river Test, knowing that to prevent thermal pollution the cooling water is not allowed to experience a temperature rise above 10^{o}C determine the required minimum volumetric flow rate of the cooling water (the steam leaves the condenser as saturated liquid at 40^{o}C). To decide if this plant can be cooled by river Test, use the information from the following web page (http://www.environment-agency.gov.uk/research/library/publications/99556.aspx - http://www.environment-agency.gov.uk/static/documents/Research/TestFlow.pdf). Compare the thermal efficiency of the revised plant with the initial design. Comment on all of your results.

A single regenerative reheat cycle plant based on the initial system is depicted in figure 3. Note that regeneration process was implemented by “bleeding” steam from the low pressure turbine at 800 kPa. This steam is then fed at the same pressure into the de-aerator thus converting it into an open feedwater heater.

Draw the T-s diagram for this reheat regenerative plant. Explain why such an arrangement would be useful.

Determine the mass fraction of steam ***y*** required to be extracted from the low pressure turbine such the fluid in the de-aerator is in saturated state. You can assume that the open FWH is adiabatic.

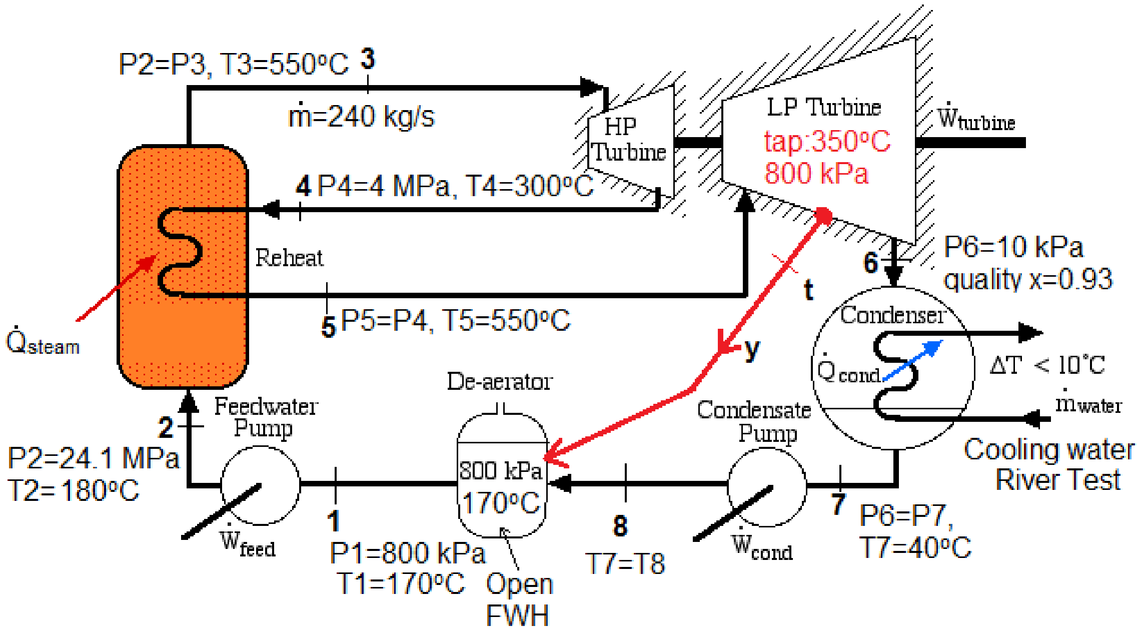

Figure 3. Supercritical steam power plant with open feedwater heater

Recalculate for this system the thermal efficiency. It is expected that your report will show in details all the stages in your calculations. Determine the power output of both turbines. How this value compares with the previous cases, comment on your result. Calculate the power necessary to drive both pumps. As before you can consider that the pumps and turbines are adiabatic. Find out what is the total heat transfer to the steam generator (including the reheat system), and calculate the heat rejected to the cooling water in the condenser. Calculate the flow rate of the cooling water in the same condition as before (40°C and Δt≤10°C). Once more use the information available at http://www.environment-agency.gov.uk/research/library/publications/99556.aspx - http://www.environment-agency.gov.uk/static/documents/Research/TestFlow.pdf and decide if the Test River is suitable to cool this plant.

In many situations the flow of water near a steam plant may not be suitable to provide all the cooling necessary without thermal pollution. In such situations a cooling tower should be provided, hence part of the heat will be dissipated into atmosphere and the stringent requirements for thermal pollution of the river are fulfilled. Through individual study find out what is the procedure to compute the volumetric flow rate of air necessary to cool the water of the condenser of the plant showed in figure 3 (this type of calculation is usually used to size the cooling tower).

Using the flow rate of the cooling water ($\dot{m}_{water}$) that you have calculate in your previous set-up (figure 3) compute the volumetric flow rate of dry air required to cool this water from 40°C to 11°C (11°C is an average temperature of river Test). Determine also the mass flow of the makeup water required from the river Test. Comment on you results. All the necessary starting information for this calculation is given in figure 4. The psychrometric chart given in figure 5 should be used to obtain the specific humidity, specific volume and specific enthalpy of the air flowing in the cooling tower.

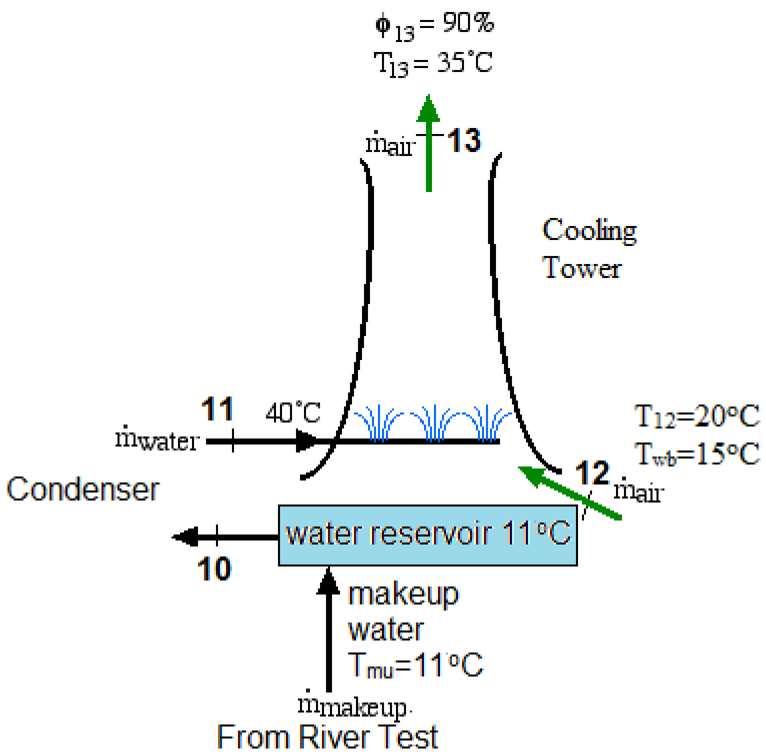

Figure 4. Cooling tower sketch

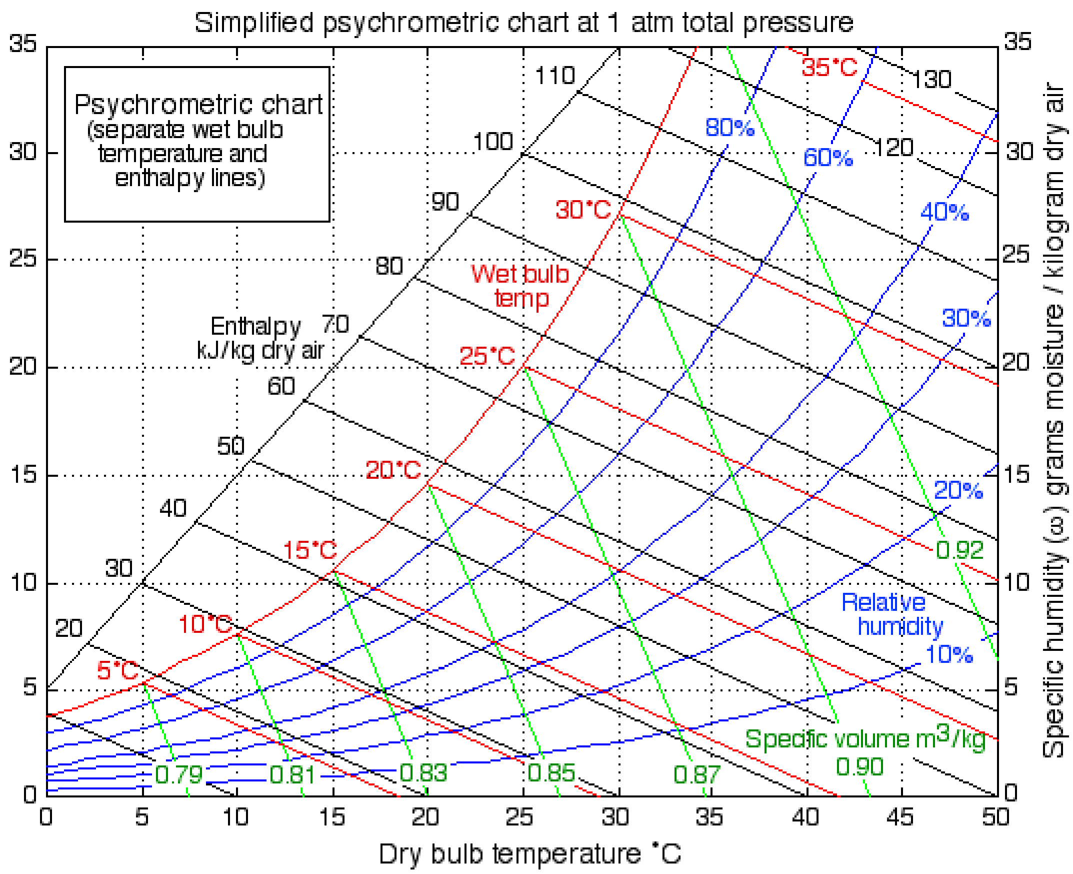

Figure 5. Psychrometric chart at 1 atm

Some reference books are listed below; however you are not limited to these resources only. Use any resources (books, magazines, web sites) that you might need but make sure that all the cited information is properly referenced in your report. Use an IEEE reference style.

References:

1. Yunus A. Cengel, Michael A, Boles, Thermodynamics An Engineering Approach, fifth edition, McGraw-Hill, 2006.
2. Chih Wu, Thermodynamic Cycles – computer aided design and optimization, Marcel Dekker, Inc. 2004
3. Louis Theodore, Francesco Ricci, Timothy Van Vliet, Thermodynamics for the Practicing Engineer, John Wiley & Sons, Inc. Publications, 2009

Deadline

Please note that you are expected to complete your report by Tuesday 18 December 2012 (week 12). Any delay in handing in the report will incur a penalty in the form of a reduced final mark (at the rate of **10% reduction for each day of late submission** – up to **five working days.** No submission is allowed after that).

The report should be submitted at the **Zepler Reception** (Building 59). Please write clearly: "ELEC6115 - Conventional Generation Technology – Steam Plant-Part II" and do not forget to put your name on the cover.

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