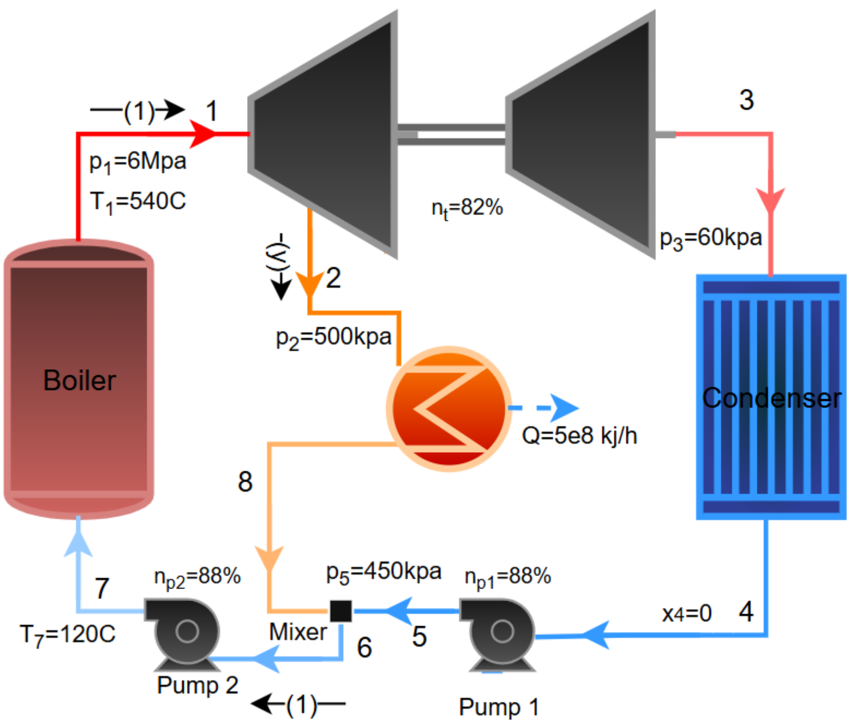
THERMODYNAMICS 1

ME8106090

COURSE PROJECT

DESCRIPTION

The figure below depicts a steam power plant system. Steam enters a two-stage turbine at 6 MPa and 540 °C. At an intermediate stage, when the pressure reaches 500 kPa, a fraction of the steam (y) is extracted for use in an external heat exchanger ($Q_{process}$). The remaining steam continues to expand until it reaches the condenser pressure $60kpa$, at which point it exits the turbine to enter the condenser. The resulting saturated liquid from the condenser is pressurized by Pump 1 to the extraction pressure. Subsequently, the entire flow is pressurized by Pump 2 to the boiler pressure. The total mass flow rate through the system is 150 kg/s. There is a pressure drop of 50 kPa in heat exchanger ($p_2 \neq p_8$). The isentropic efficiency of pumps and turbine are 88% and 82% respectively. The ambient temperature is 25°C. We aim to extract heat from the high-temperature steam at a rate of $5 \times 10^8\ kJ/h$ kJ/h as it passes through the external heat exchanger.



1. With the help of (1), simulate the cycle in EES and determine the following parameters:

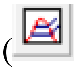
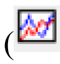
Heat transfer in the boiler	Heat rejected by the condenser	Work produced by turbine
Work needed for pumps	Entropy generation in mixer	Mass fraction of the turbine exit (y)
P,T,h,v,s, and x of all states	Entropy generation in turbine	Efficiency of the cycle

2. Plot the T-s diagram and and discuss the reasoning for the convergence of states (4, 5) and states (6, 7) into single points.
3. Plot the variations of Q_H & Q_L against condenser pressure in the range of 60 kPa to 195 kPa. Use a single plot with dual y-axes for this comparison. Also, Plot the variation of thermal efficiency against the same condenser pressure range (60 kPa to 195 kPa) in a separate graph. Based on these results, determine the maximum thermal efficiency and the corresponding condenser pressure at which this efficiency is achieved.

BONUS

4. What the maximum condenser pressure could be in this cycle?

SOLUTION GUIDELINES

1. The first 7 states can be determined without using energy equations.
2. Use RealThermoProps to compute fluid properties at each state. (`Call RealThermoProps(Acetone,T=T,P=P : T,P,v,h,s,u,x)`).
3. Apply energy equations to solve for enthalpy and any remaining properties for the last state.
4. Once all states are fully defined, proceed to calculate the cycle parameters.
5. To generate the T-s diagram, first plot the saturation dome () in EES. Use the overlay option () to plot the state points, ensuring you disable the "connect points" (line) option. Activate the "label points" option so that the state numbers are visible, and finally, use the polyline tool () to manually draw the process curves.
6. For any additional tutorials you may need, refer to this YouTube channel.

SUBMISSION GUIDELINES

The following elements must be included in your report:

1. A detailed description of the cycle based on the T–s diagram you have drawn.
2. A clear statement of all assumptions made for the thermodynamic states and the processes occurring in each cycle component.
3. Application of the First Law of Thermodynamics to the cycle components used in the analysis.
4. Application of the Second Law of Thermodynamics to the cycle components used in the analysis.
5. Explicit and complete answers to all questions stated in the project description.
6. The report should follow a standard technical format and include an introduction, methodology and analysis, results and discussion, conclusion, and any other sections necessary to clearly explain the procedures, assumptions, calculations, and findings.
7. If you have any questions regarding the project, you may contact Mr. Saeedi through Telegram (@Ho3inSdi) or Dr. Afshari via email at (afsharia@ut.ac.ir).

The project must be completed individually. You are required to submit a single .ZIP or .rar file containing the PDF version of your report and the EES code developed for this project.

Good luck