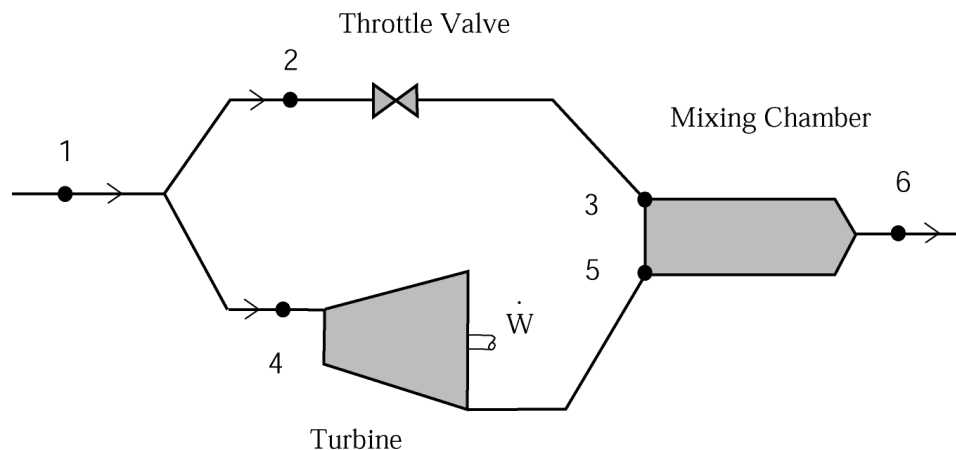


Concepts Assessed: application of laws of thermodynamics, knowledge of thermodynamic processes, phenomenological description of reversible / irreversible processes

The power system shown below consists of an adiabatic throttle valve, an ideal turbine, and a flow mixing chamber. All components operate at steady state. The mass flow at station 1 is 10 kg/s. One half of the fluid flows through the throttle valve, one half flows through the turbine. The temperature and pressure are $T_1 = 500$ K and $p_1 = 7$ bar respectively. The pressure at the inlet to the mixing chamber is uniform, $p_3 = p_5$. The flow exits the mixing chamber at a temperature and pressure of $T_6 = 400$ K and $p_6 = 1$ bar respectively. Kinetic and potential energy effects can be neglected and the working fluid can be assumed a perfect gas with $R = 287$ J/kgK and $\gamma = 1.4$. You can assume that all components of the power system are adiabatic and there is no heat transfer to the environment.



- Determine the temperature at the exit of the throttle, T_3 . What type of work is done, if any?
- Find the temperature at the exit of the turbine, T_5 .
- Determine the shaft power output of the turbine.
- What is the thermodynamic process through the turbine? Determine pressures p_3 and p_5 .
- Draw the processes 4 to 5 and 2 to 3 in the same p-V diagram (note that 1 = 2 = 4 as described above). Mark state 6 on the same diagram, indicating the temperature T_6 .
- Identify the components of the power system where irreversible processes are at play. Discuss in a sentence or two why you say so (i.e. what would have to happen if the process is to be reversed to return to initial state, what impact would that have on the surroundings?).