PROBLEM 6-13N QUESTION

Optimizing The Pressure Ratio Of The Brayton Cycle In A Brayton-Rankine Combined Cycle

A. A Brayton cycle is presented in Figure 1. The Brayton cycle uses helium as the working fluid. The constraints for this cycle are that the highest temperature achievable, T_4, is 972K and the atmospheric reservoir is 290K. The temperature of State 1 is 10K above the atmospheric reservoir temperature, e.g., T_1 = 300K Cycle parameters are given in Table 1.

- Draw the T-S diagram for this cycle and the temperature distribution diagram within the regenerative heat exchanger.
- Demonstrate how to find the compression ratio that will result in the maximum value of cycle thermal efficiency in terms of only the given temperatures T_4 and T_1 and other given constants.

B. The Brayton cycle above has a Rankine bottoming cycle added as shown in Figure 2. The Rankine cycle uses H_2O. The mass flow rates in each cycle are equal. The constraints for this combined cycle are analogous to those above, e.g., T_4, is 972K and T_7 is 300K. Cycle parameters are given in Tables 1 and 2.

- Draw the T-S diagram for this cycle and the temperature distribution diagrams within the regenerative heat exchangers.
- Demonstrate how to find the compression ratio that will result in the maximum value of cycle thermal efficiency in terms of only the given temperatures T_4 and T_7 and other given constants.

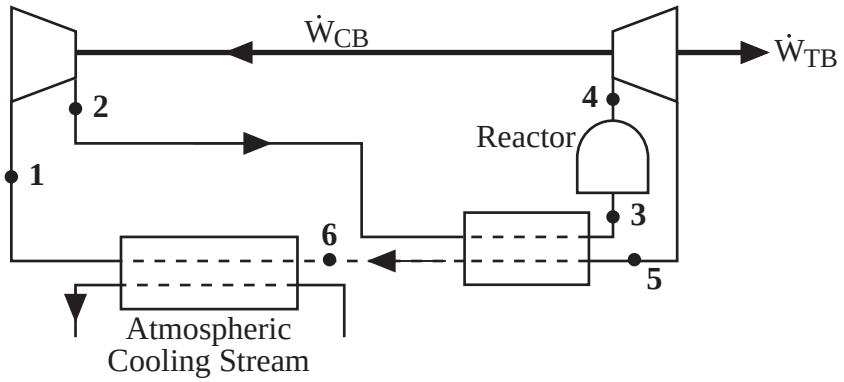

Figure 1 Brayton Cycle

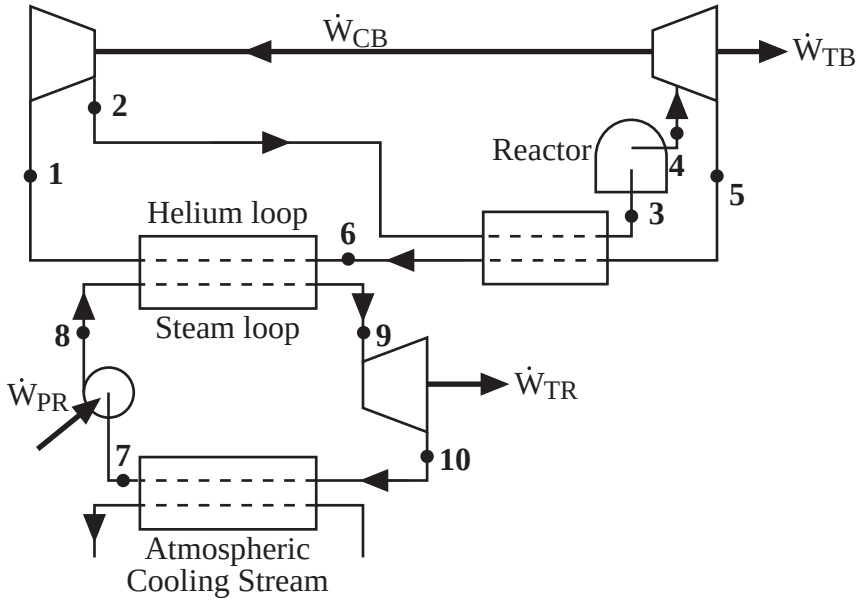

Figure 2 Combined Brayton-Rankine Cycle

Table 1

γ for Helium = 1.658	c_p for Helium = 5,230 J/kg˚K

Efficiency of the regenerative heat exchanger = 0.75
The pump and turbine are ideal, e.g., η_s = 100%
Both heat exchange processes are conducted at constant pressure

Table 2

Efficiency of both regenerative heat exchangers = 0.75
All pumps and turbines are ideal, e.g., η_s = 100%
All heat exchange processes are conducted at constant pressure
The pinch point of the helium-steam heat exchanger = 10 K

State 7 is saturated liquid state State 9 is a saturated vapor state