22.06 ENGINEERING OF NUCLEAR SYSTEMS - Fall 2010

Problem Set 8

Power Cycles

Reference Textbook:

[T&K] = Todreas, N. E., and M. Kazimi.
Nuclear Systems Volume I: Thermal Hydraulic Fundamentals. New York, NY: Taylor & Francis, 1989. ISBN: 9781560320517.

1) [T&K] Chapter 6, Problem 6-2

2) [T&K] Chapter 6, Problem 6-3

3) [T&K] Chapter 6, Problem 6-5

4) Consider a helium Brayton Cycle with regeneration, pressure losses, and real machines. These are characterized by the following parameters:

$\xi = 0.92$

$\beta = 1.025$

$\eta_t = \eta_c = 0.92$

The cycle operates at a pressure ratio of $r_p = 2.2$ between limiting temperatures of 303 K and 1083 K. For helium:

$\gamma = 1.66$

$c_p = 5.230$ kJ/kg K

For this cycle, find the thermal efficiency, η_{th}.

5) In Example 6-10 it is shown that the cycle thermal efficiency of the simple Brayton cycle shown in Figure 6-24 can be increased by utilizing regeneration. Specifically, it was found that, with the addition of a regenerator of effectiveness 0.75, the cycle thermal efficiency was increased from 42.3% to 48.1%. Another way of improving the efficiency of the simple Brayton cycle is to use a bottoming cycle. To this end, consider the system shown in Figure 1. It shows the simple Brayton cycle with a Brayton bottoming cycle. For this system, the following parameters and information are known:

T_1 = 278 K

T_3 = 972 K

$T_9 = T_1$

$(\Delta T_p)_1$ = pinch point of heat exchanger #1
= 15°C = T4-T7

All turbine and compressors in both cycles are ideal

r_p for the simple Brayton cycle = 4.0

c_p for both cycles = 5230 J/kg K

γ for both cycles = 1.658

Mass Flowrate for the simple Brayton cycle = twice the mass flowrate for the Brayton bottoming cycle

No duct pressure losses in either cycle

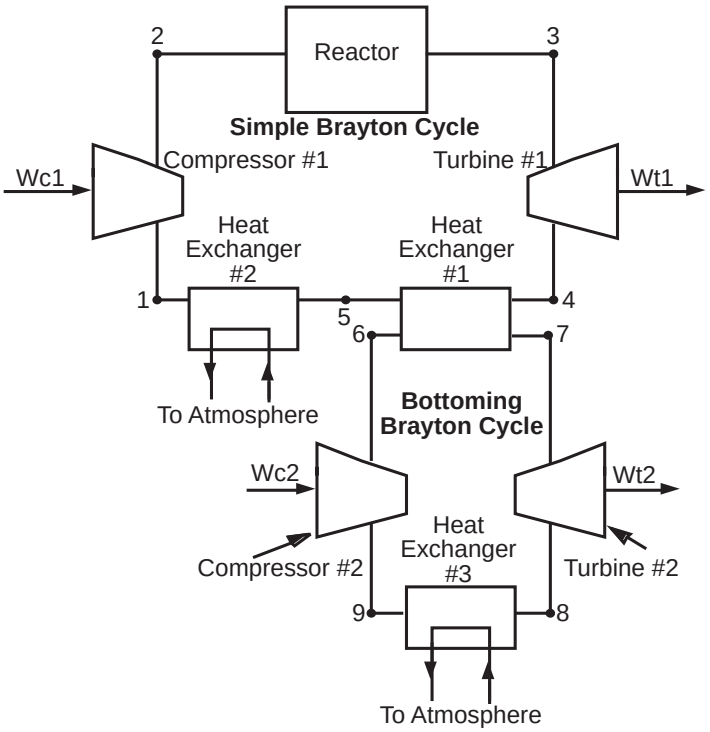

Figure 1

QUESTIONS

A . Draw the T-Vdiagram for the entire system.

B . What must be the pressure ratio of Turbine #2 and Compressor #2 such that the cycle thermal efficiency of the entire system is maximized?

C . What is the maximum cycle thermal efficiency?

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