Textbook Reading 9.3-9.7

**HW – 38**

An ideal air-standard dual cycle consisting of the following five internally reversible processes.

Process 1-2: Adiabatic compression
Process 2-3: Constant volume energy addition by heat transfer
Process 3-4: Constant pressure energy addition by heat transfer
Process 4-5: Adiabatic expansion
Process 5-1: Constant volume energy rejection by heat transfer

Data at various states in the cycle is provided in the table below.

| State | P, kPa | T, K | u, kJ/kg | h, kJ/kg |
|---|---|---|---|---|
| 1 | 95 | 300 | 214.1 | 300.1 |
| 2 | 4372.8 | 862.5 | 643.5 | 891 |
| 3 | 9125.9 | 1800 | 1486 | 2003 |
| 4 | 9125.9 | 1980 | 1658.8 | 2227.2 |
| 5 | 266 | 840 | 624.9 | 866 |

Use air tables that consider variable specific heats. Molecular weight of air = 28.97 kg/kmol.

(a) Find the compression ratio and cut-off ratio of the cycle.
(b) Calculate the specific heat transfer during the energy addition and energy rejection processes, in kJ/kg.
(c) Determine the thermal efficiency of the cycle using values in (b), in %.
(d) Find the mean effective pressure for the cycle, in kPa.
(e) Show the cycle on *P-v* and *T-s* diagrams and the appropriate lines of constant temperature and lines of constant pressure for the five states. Label states and identify process directions with arrows.

**HW – 39**

A gas turbine power plant is modeled using an air-standard Brayton cycle consisting of the following four processes.
Process 1-2: Adiabatic compression
Process 2-3: Constant pressure energy addition by heat transfer
Process 3-4: Adiabatic expansion
Process 4-1: Constant pressure energy rejection by heat transfer

Air enters the adiabatic compressor at 1 bar and 300 K with a volumetric flow rate of 5 $m^3/s$ (State 1) and is compressed to 10 bar and 600 K (State 2). Air leaving the compressor is heated to 10 bar and 1400 K (State 3) before entering the turbine. Air then expands to 1 bar and 810 K (State 4) through the adiabatic turbine. Data at various states in the cycle is provided in the table below.

| State | P, bar | T, K | u, kJ/kg | h, kJ/kg | $s^0$, kJ/(kg-K) |
|---|---|---|---|---|---|
| 1 | 1 | 300 | 214.1 | 300.1 | 1.703 |
| 2 | 10 | 600 | 434.8 | 607.2 | 2.410 |
| 3 | 10 | 1400 | 1114 | 1515 | 3.362 |
| 4 | 1 | 810 | 600.4 | 832.9 | 2.732 |

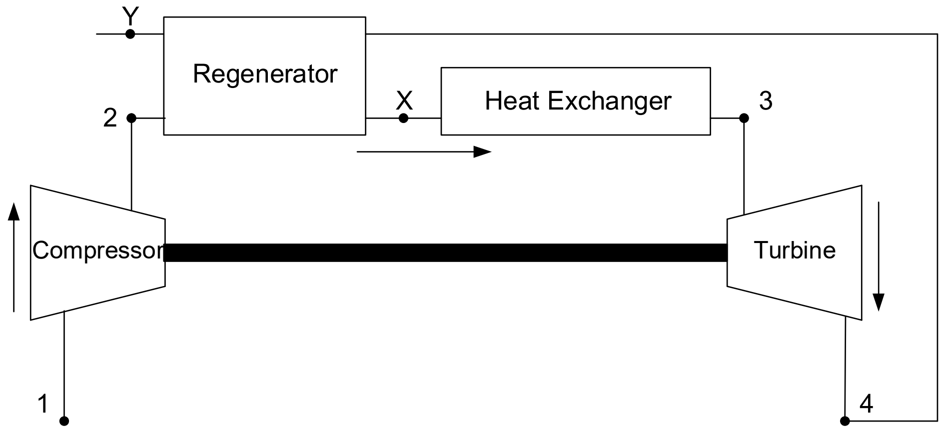
Use air tables that consider variable specific heats. Molecular weight of air = 28.97 kg/kmol.

(a) Calculate the isentropic efficiency of the compressor and of the turbine, in %.

(b) Determine the net power developed by the plant, in MW.
(c) Find the thermal efficiency of the cycle, in %.
(d) Calculate the back work ratio of the cycle.
(e) Determine the rate of entropy generation for the compressor and for the turbine, in kW/K.
(f) Show the cycle on *T-s* diagram and the appropriate lines of constant pressure for the four states. Label states and identify process directions with arrows.

**HW – 40 (See HW-39)**

Air enters the adiabatic compressor of a regenerative gas turbine power plant at 1 bar and 300 K with a volumetric flow rate of 5 $m^3/s$ (State 1) and is compressed to 10 bar and 600 K (State 2). Air leaving the compressor is heated at constant pressure to State X in a regenerative heat exchanger of 85% effectiveness. Air leaving the regenerative heat exchanger is heated to 10 bar and 1400 K (State 3) before entering the turbine. Air then expands to 1 bar and 810 K (State 4) through the adiabatic turbine. Air leaving the turbine enters the regenerative heat exchanger and exits at State Y.




Use air tables that consider variable specific heats. Molecular weight of air = 28.97 kg/kmol.

(a) Find the thermal efficiency of the cycle, in %.
(b) Compare the value calculated in HW-40(a) with that calculated in HW-39(c). Is it higher or lower? Explain.
(c) Determine the rate of entropy generation for the regenerative heat exchanger, in kW/K.
(d) Show the cycle on *T-s* diagram and the appropriate lines of constant pressure for the six states. Label states and identify process directions with arrows.