Explanation Chapter 10

10.1 An ideal closed Brayton cycle consists of:
a) Two isothermal and two isentropic processes
b) Two isothermal and two isobaric processes
c) Two isobaric and two isentropic processes
Ans: C. The ideal closed Brayton cycle consists of two isobaric processes (heating the gasses in a combustion chamber and reducing the temperature of the gasses in the heat exchanger) and two isentropic (the compressor and the turbine).

10.2 What are the assumptions for standard air? Multiple answers might be correct.
a) Neglect fuel and assume the working fluid to be pure air
b) Combustion is replaced by a heat transfer process in which heat is added
c) All the processes are internally irreversible
d) Constant specific heat at room temperature ($25℃$)
e) The working fluid is not an ideal gas
Ans: A, B & C. The working fluid is air, which continuously circulates in a closed loop and always behaves as an ideal gas. All the processes that make up the cycle are internally reversible. The combustion process is replaced by a heat-addition process from an external source. Assuming constant specific heats at room temperature ($25℃$)) for air is the only difference between air standard assumptions and cold-air assumptions. So it is not part of the air-standard assumptions.

10.3 Which of the following statements is NOT correct?
a) A Brayton cycle can be open as well as closed.
b) A simple Brayton cycle and a simple Rankine cycle consist of the same processes.
c) A pump is more efficient than a compressor
d) The back work in the Rankine cycle is larger than that of the Brayton cycle
Ans: D. A compressor uses more work than a pump. This means that the back work ratio in the Brayton cycle is larger than in the Rankine cycle. The statement that states that the back work in the Rankine cycle is larger is therefore wrong.

10.4 The brayton cycle that is shown in the figure has a pressure ratio of 10, what is the pressure at point 3?
a) $10\ kPa$
b) $1\ MPa$
c) $10\ MPa$
d) $1\ bar$
e) That cannot be derived from the given information
Ans: B. This is an open Brayton cycle, so the pressure at point 1 and point 4 is $1\ bar$. If the pressure increases by a factor of 10, it becomes $10\ bar$ at point 2 and 3. $10\ bar$ is equal to $1\ MPa$, therefore that is the correct answer.

10.5 Consider the Brayton cycle that is shown in the figure. At the compressor inlet, the temperature is $20\ ℃$ and the pressure is $1\ bar$. What are the values for pressure and temperature at the turbine outlet?

a) T and P cannot be derived from the given information
b) $T = 20\ ℃$, $P = 1\ bar$
c) $T = 46\ ℃$, $P = 0.1\ bar$
d) $T = 20\ ℃$, P cannot be derived from the given information
e) $T = 100\ ℃$, P cannot be derived from the given information
f) T cannot be derived from the given information, $P = 1\ bar$
g) T cannot be derived from the given information, $P = 0.1\ bar$

Ans: F. This is an open Brayton cycle, so the pressure at point 1 is the same as at point 4, $1\ bar$. The temperature at the outlet cannot be derived from the information given. Therefore, you need more information like the temperature at point 3 and the isentropic efficiency of the turbine, however it is impossible that it is $20\ ℃$.

10.6 Consider a simple Brayton cycle, which statements are correct? 1) A real cycle has a lower temperature at the outlet of the compressor than an ideal cycle. 2) A real cycle has a lower temperature at the outlet of the turbine than an ideal cycle.

a) 1 & 2 are true
b) 1 is true, 2 is not true
c) 1 is not true, 2 is true
d) 1 & 2 are not true

Ans: D. Both statements are not true as can be seen in the Ts - diagram in the picture. The real cycle has a higher temperature at the compressor outlet and a higher temperature at the turbine outlet. Note that this is a Ts - diagram of a closed Brayton cycle.

10.7 Which of the measures can be taken to increase the efficiency of a simple Brayton cycle? 1) Increase the pressure ratio. 2) Decrease the temperature of the turbine inlet. 3) Decrease the friction in the turbine. 4) Use a higher mass flow.

a) 1 & 3
b) 1, 2 & 3
c) 2 & 4
d) 3 & 4

Ans: A. 1) Increasing the pressure ratio will increase the efficiency. 2) Decreasing the temperature of the turbine inlet results in a lower efficiency. 3) Decreasing the friction in the turbine results in a higher efficiency. 4) The mass flow has no influence on the efficiency, it only determines the power output and input: e.g. mass flow times specific work output gives the power output. The efficiency is not affected by this as the power input scales with the same mass flow.

10.8 Which of these options will NOT increase the efficiency of a Brayton cycle?

a) Increasing the inlet temperature of the compressor

b) Increasing the compression ratio

c) Increasing the turbine inlet temperature

d) Increasing the value of k

Ans: A. The efficiency increases when the compression ratio is increased, when the turbine temperature is increased or when $k = c_p/c_v$ is increased (which is dependent on the working fluid).

10.9 Which of the following variables has NO influence on the efficiency of the Brayton cycle?

a) Pressure ratio

b) Working fluid

c) Temperature ratio

d) None of the variables above

Ans: D. The efficiency of the Brayton cycle with regeneration is given by:

$$\eta_{Brayton} = 1 - \frac{1}{r_p^{(k-1)/k}}$$

Therefore, we can conclude that the efficiency of the Brayton cycle depends on the pressure ratio (rp), the working fluid (k) and the temperature ratio (cycle with regeneration).

10.10 Consider an aircraft powered by a jet propulsion cycle. Improving the isentropic efficiency of the turbine:

a) Increases the net work output

b) Decreases the fuel consumption rate

c) Increases the thrust

d) Increases the thermal efficiency

Ans: C.