Explanation Chapter 11

11.1 What is the advantage of reheating in a Brayton cycle compared to a Brayton cycle without it?
a) A higher maximum temperature can be reached in the cycle
b) The net work output increases
c) The thermal efficiency increases
d) The amount of heat rejected in the exhaust gasses decreases
e) None of the answers above
Ans: B. Explanation for A - The maximum temperature is determined by the materials of the gas turbine. Explanation for C - If reheating is used without regeneration the thermal efficiency decreases as the average temperature at which heat is rejected increases. Explanation for D - The amount of heat rejected in the exhaust gasses increases as the temperature at the turbine outlet will be higher. Explanation for B - The advantage of reheating is that the net work output increases.

11.2 Indicate which of the following statement about a Brayton cycle is true:
a) Intercooling increases net work output.
b) Intercooling increases efficiency.
Ans: A. Intercooling increases the net work output as the work input in the compressor is decreased by intercooling. The work output is not affected and as $W_{net} = W_{out} - W_{in}$ the net work output W_{net} will increase. That the work input in the compressor is decreased by intercooling is because the specific volume of the colder air is smaller than the volume of hotter air and the work is proportional to the volume. The efficiency decreases as the average temperature at which the heat is added decreases.

11.3 A Brayton cycle with intercooling and reheating is modified to improve the thermal efficiency by adding a regenerator. The effect of adding the regenerator on the net power output and the temperature of the exhaust gases is:
a) The net power output increases and the temperature of the exhaust gases decreases
b) The net power output remains the same and the temperature of the exhaust gasses decreases
c) The net power output decreases and the temperature of the exhaust gases decreases
d) The net power output increases and the temperature of the exhaust gases increases
e) The net power output remains the same and the temperature of the exhaust gasses increases
f) The net power output decreases and the temperature of the exhaust gases remains the same
g) The net power output increases and the temperature of the exhaust gases remains the same

Ans: B. In a cycle with intercooling and reheating the temperature at the outlet of the compressor is relatively low and the temperature at the outlet of the turbine is relatively high. Regeneration increases the thermal efficiency of a Brayton cycle by capturing some of the waste heat from the exhaust gases and preheating the air before it enters the combustion chamber. This results in a lower temperature of the exhaust gases since a part of the energy in the exhaust gases is transferred to the high pressure air at the compressor outlet to preheat it. The net work output remains the same as the regenerator has no influence on the power input of the compressor or the power output of the turbine.

11.4 Which of the following statements is NOT correct?
a) Reheating in a Brayton cycle increases the output work
b) Intercooling in a Brayton cycle increases the net work
c) Reheating in a Brayton cycle increases the input heat
d) Regeneration in a Brayton cycle increases the input heat
e) None of the above
Ans: D. Explanation for A. & C - During reheating processes, we use at least two turbines and a reheater in between. After the gas expands in the first turbine, we reheat it in order to be used in a second turbine. As a consequence, the output and net work increases but also extra heat is needed in the reheater.Explanation for B - During intercooling processes, we use at least two compressors and an intercooler in between. After the gas is compressed by the first compressor, the gas is cooled down in the intercooler before entering the second compressor. As a consequence, the input work decreases. This leads to an overall increase of the net work ($w_{net} = w_{out} - w_{in}$). Explanation for D - During regeneration or recuperation processes, part of the heat carried out by the gas at the outlet of the turbine is used to pre-heat the gas that is leaving the compressor and before it enters the combustion chamber. Therefore, less heat needs to be input in the cycle.

11.5 Which of the following statements is NOT true:
a) A jet propulsion cycle does not produce power.
b) Intercooling decreases the compressor work as the average specific volume of the gases that are compressed is reduced.
c) Reheating increases the compressor work as the average specific volume of the gases that are expanded is higher.
d) Intercooling as well as reheating reduces the thermal efficiency.
e) The outlet temperature of an ideal regenerator is equal to the outlet temperature of the compressor.
f) The effectiveness of a regenerator is defined as the ratio of the theoretically maximum heat that can be regenerated over the actual heat that is regenerated.

Ans: F. The effectiveness of a regenerator is defined as the ratio of the actual heat that is regenerated over the theoretically maximum heat that can be regenerated =q_regen,actual / q_regen,max. That means that this statement is false.

The other statements are all true:

- There is no net work output in a jet propulsion cycle. The system is designed in such a way that the gases are not expanded to the ambient pressure but to a higher pressure such that the power produced by the turbine is just sufficient to drive the compressor.
- Steady flow compression or expansion work is proportional to the specific volume of the working fluid. Therefore, the specific volume of the working fluid should be as low as possible during a compression process and as high as possible during an expansion process.
- Intercooling reduces the thermal efficiency as the average temperature at which heat is added reduces
- Reheating reduces the thermal efficiency as the average temperature at which heat is rejected increases
- In an ideal regenerator the outlet temperature of the regenerator is equal to the outlet temperature of the compressor and the inlet temperature of the regenerator is equal to the outlet temperature of the turbine.