Gas Turbine Cycle

Lecture 6
Enhancements of gas cycle

Tikrit university\ engineering college\ mechanical dept.

Brayton cycle with intercooling, reheat & regeneration:

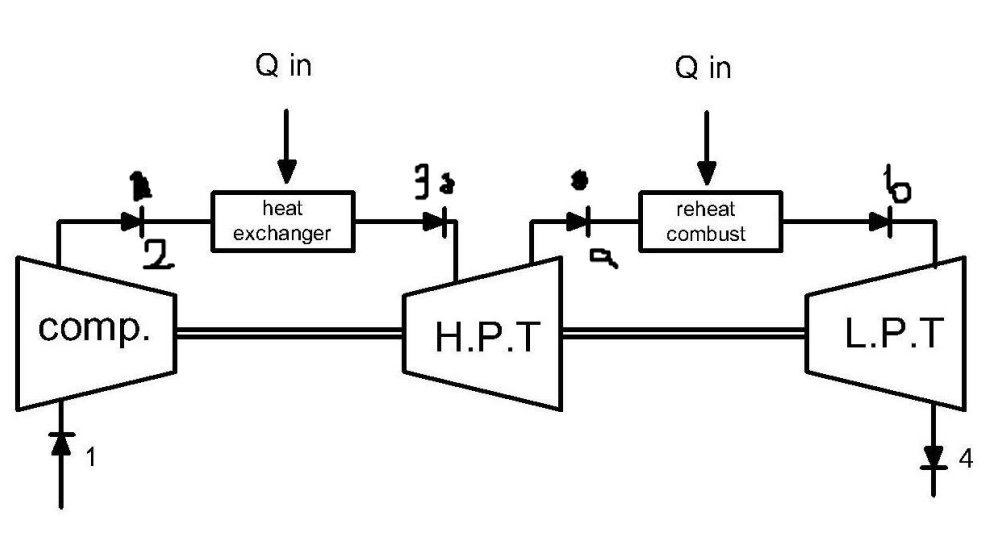
- The net work increases by either decreasing the compressor work, or increasing the turbine work, or both
- Thermodynamic principles:
  The steady flow compression or expansion is proportional to the specific volume of the fluid, therefore the specific volume of the working fluid should be as low as possible during a compression process & as high as possible during an expansion process.
- The work required to compress a gas between two specific pressures can be decreased by carrying out the compression process in stages and cooling the gas in between, that is using multistage compression with intercooling.
- Likewise, the work output of the turbine operating between two pressure levels can be increased by expanding the gas in stages and reheating it in between. That is, utilizing multistage expansion with reheating.
- This is accomplished without raising the max temp of the cycle.
- The working fluid leaves the compressor at lower temp, and the turbine at high temp, when intercooling and reheating are utilized. This makes regeneration more attractive since greater potential for regeneration exists.

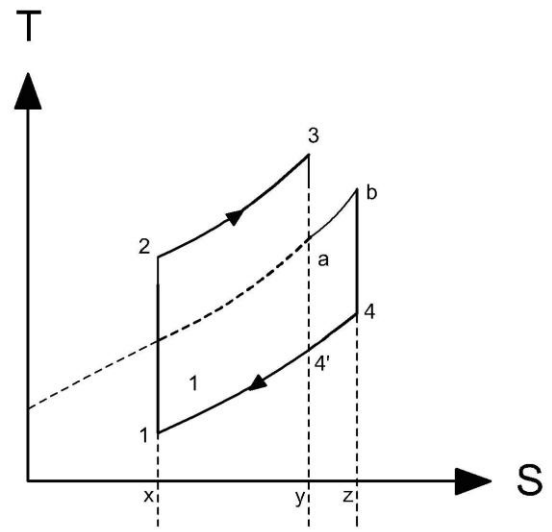
Gas turbine with reheat

For metallurgical reasons, the temp of the gases entering the turbine must be limited. This temp can be contorted by providing air in excess of the amount required to burn fuel in the combustor. So the gasses exiting the combustor contain sufficient air to support the combustion of additional fuel.

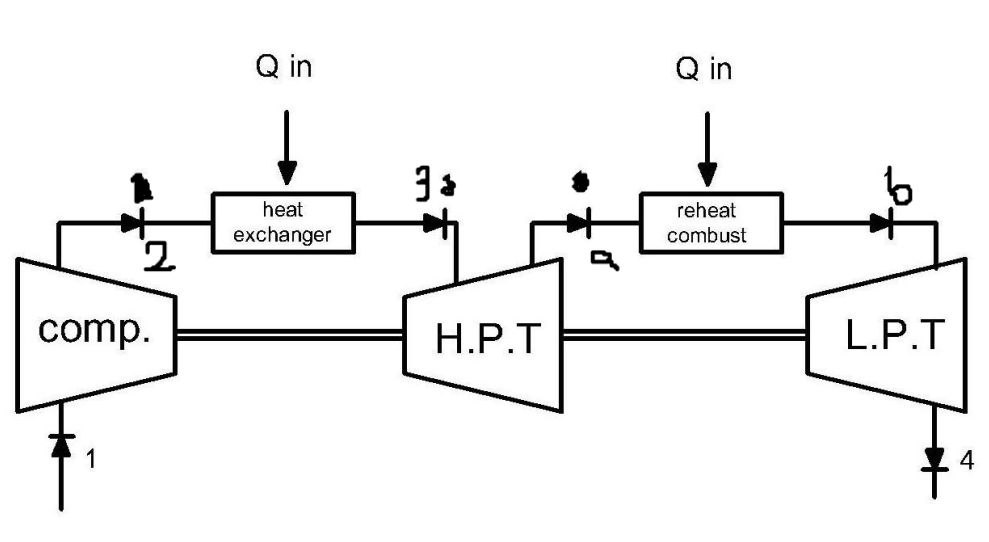
A reheat combustor installed in multistage turbine as show in figure.

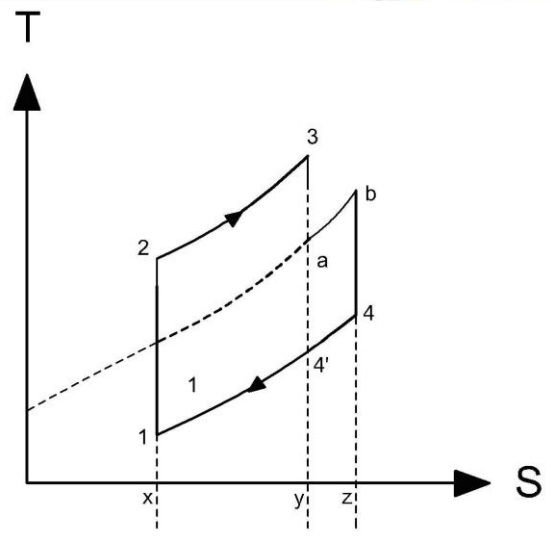
In the arrangement, the net work per unit mass flow can be increased.





Gas turbine with reheat



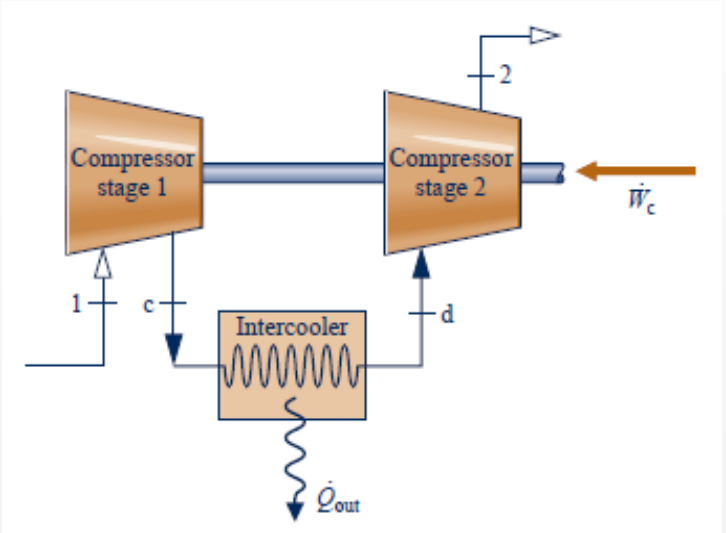


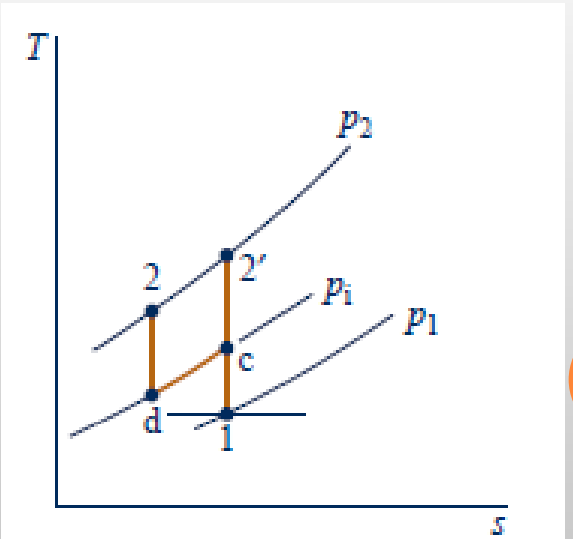
- in reheat cycle the net work for the cycle (1,2,3,a,b,4,1) is greater than the net work for the one without reheat (1,2,3,4́,1).
- The cycle thermal efficiency would not necessarily increase because a greater total heat addition would be required.
- However, the temp at the exit of the turbine is higher with reheat than without reheat, so the potential for regeneration is enhanced .
- When reheat & regeneration are used together, the thermal efficiency can increase significantly.

Compression with intercooling

It is heat exchanger installed between two stages of compressor to reduce the temp of compressed air entering the second stage compressor, so it decreases the total compressor work.

- process 1 – C is isentropic compression from state 1 to state C where the pressure is P_i.
- process C – d is constant pressure cooling from temp T_c to temp T_d.
- process d – 2 is an isentropic compression to state 2.





Compression with intercooling

- The work input per unit mass flow is represented on the P–V diagram by shaded area 1 – c – d – 2 – a – b – 1.

- Without intercooling, the gas would be compressed isentropically in a single stage from state 1 to state ź and the work would be represented by enclosed area 1 – ź – a – b – 1.

- The crosshatched area on P-V diagram represents the reduction in the work that would be achieved with intercooling.