Land Based Gas Turbines

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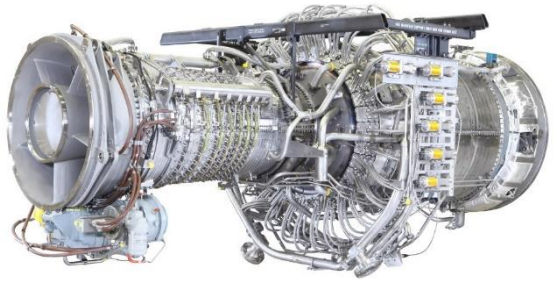
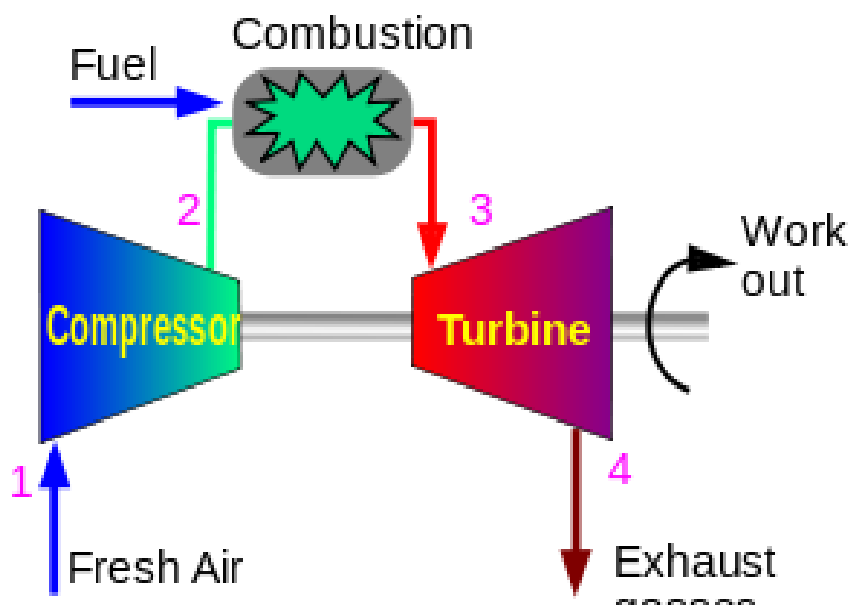
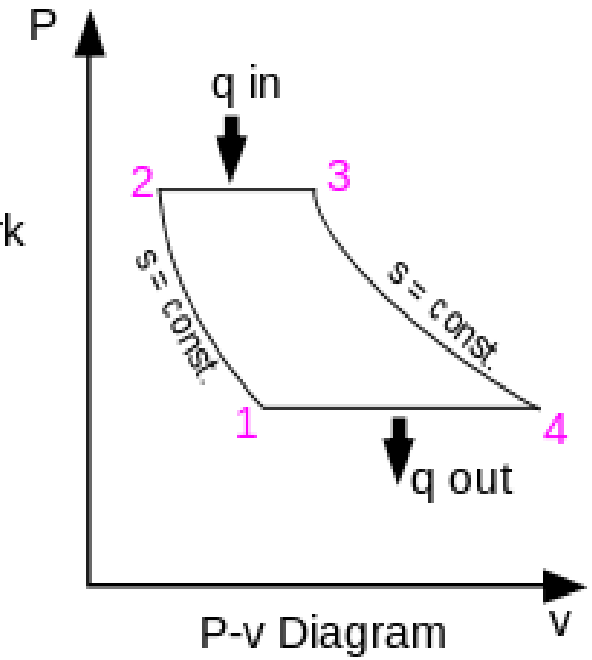
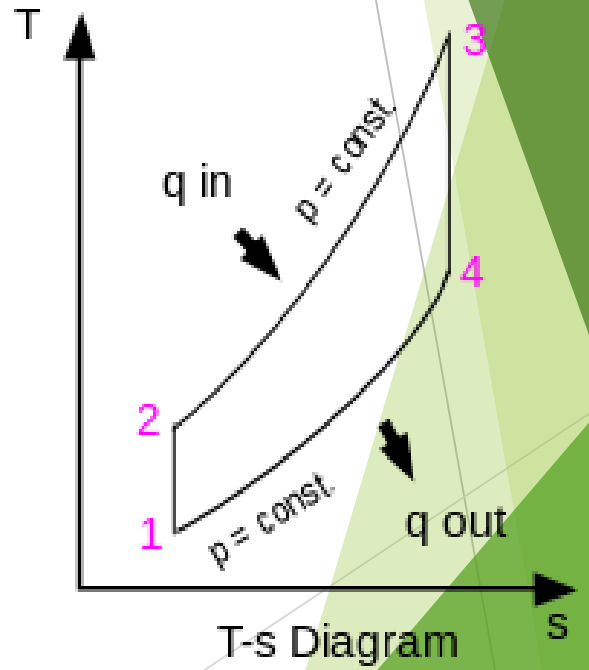


Gas Turbines and Brayton Cycle





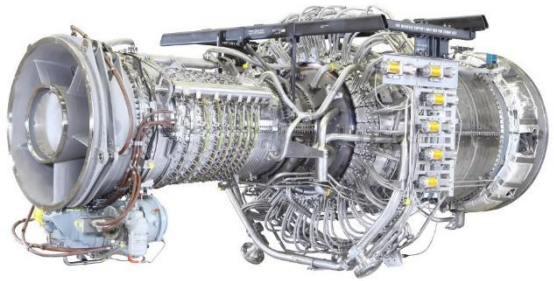


Difference between aviation and land based turbine

Difference	Aviation GT	Land GT
Aim	Produce thrust	Produce mechanical power
End component	Nozzle in the end	Power generator
Weight and size	Constrained	No constrains
Modularity	Very modular	Initially Not modular- increasing
Cycle	Open simple cycle	Closed and combined cycle
Attachments	No attachments	Regenerator, Intercooler, Reheater
Fuel	Single fuel	Various fuels

Aero derivative VS Industrial gas turbines

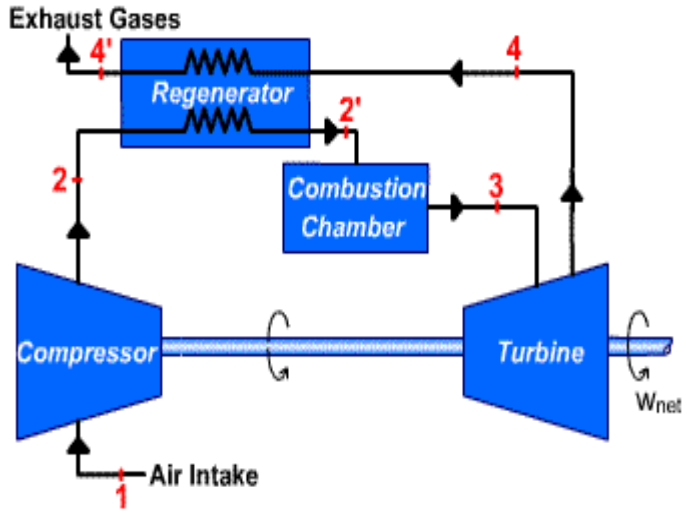
- Aero derivative turbines are those which draw their design from an aerospace jet engine while industrial gas turbines are designed specifically for land use.
- Aero derivative land turbine produce smaller power but are more compact, run at higher efficiency and pressure ratios.
- The GE LM6000 engine is a derivative of the CF6-80C2 and produces 40 MW at 40% simple cycle efficiently and weighs 6 tons.
- The Frame 9F an industrial gas turbine of GE produces 200MW at 34% simple cycle efficiently and weighs 400 tons.

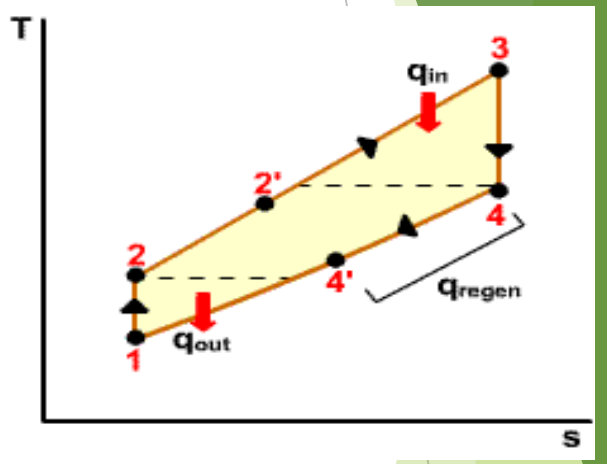


Regeneration

$$\epsilon_{regen} = \frac{T_{2'} - T_2}{T_4 - T_{4'}}$$

$$\eta = 1 - \left(\frac{T_3}{T_1}\right) r_p^{\gamma-1/\gamma}$$





Regeneration involves using a heat exchanger to transfer the residual heat from turbine exhaust to the air from the compressor exit before it enters the combustion chamber,

Regeneration can produce 5-6% increase in efficiency in a simple cycle.

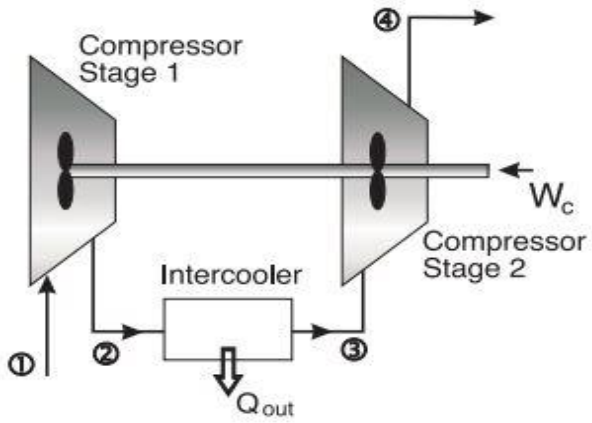
The disadvantage of the regenerator is that it is heavy and costly, but those are negated as weight is not a constraint and the effect of fuel cost savings.

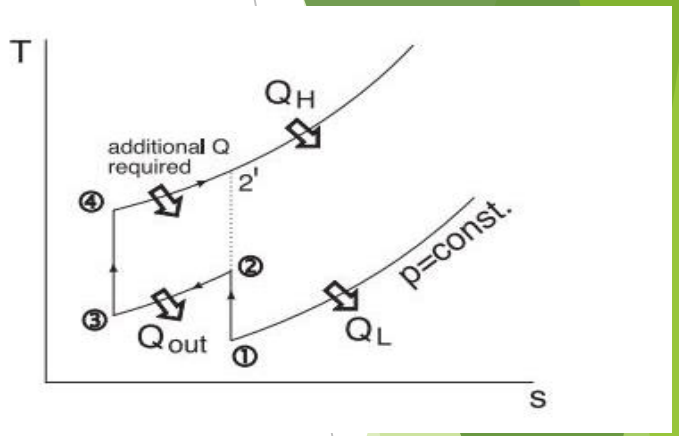
Intercooling

$$W_C = c_p T_{start}\left(\frac{r_c^{\gamma-1/\gamma}-1}{\eta_c}\right)$$

$$P_{intercool} = \sqrt{P_{HPC\ exit} * P_{LPC\ inlet}}$$

$$\in_{intercool} = \frac{T_2 - T_3}{T_2 - T_{coolant}}$$





Intercooling is the process in which a heat exchanger is installed in-between the high and low pressure compressors so as to reduce the work performed for compression.

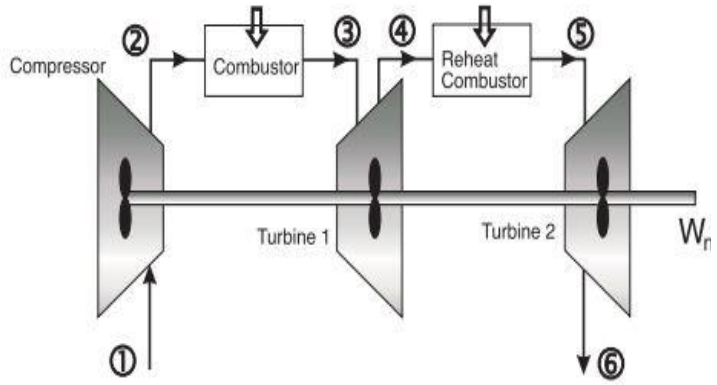
This pressure gives minimum compressor work the highest overall cycle efficiency is obtained at an intercool pressure much lower than the one given by the above equation. This is because lowering the intercooling pressure increases the compressor exit temperature, lowers the Fuel/Air ratio, lowers the heat loss in the intercooler, but increases the cooling air temperature and so the needed cooling flow rate. But net work output is still the highest as per the above equation and hence a compromise must be found between the two.

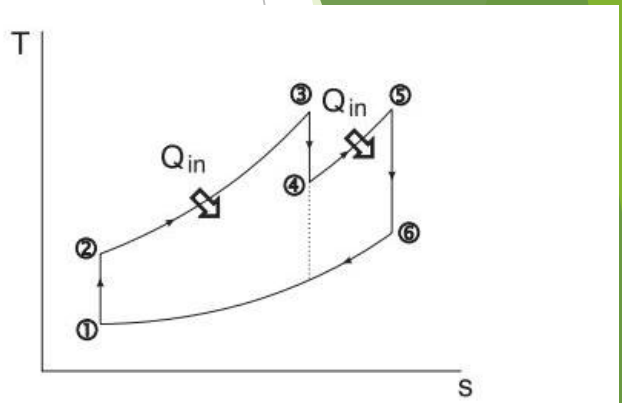
Comparatively an intercooled gas turbine power plant can offer a fuel consumption of 8% better than that of a simple cycle gas turbine, with a 5-9 % increase in net power.

Reheating

$$W_T = \eta_T c_p T_{start} \left(r_p^{\gamma-1/\gamma} - 1 \right)$$

$$P_{reheat} = \sqrt{P_{HPT\ inlet} * P_{LPT\ exit}}$$

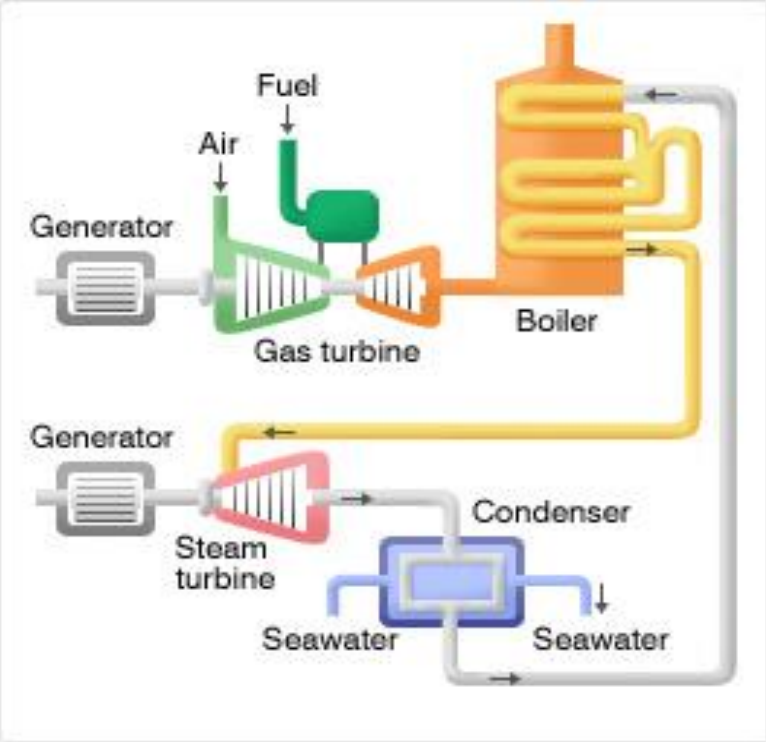


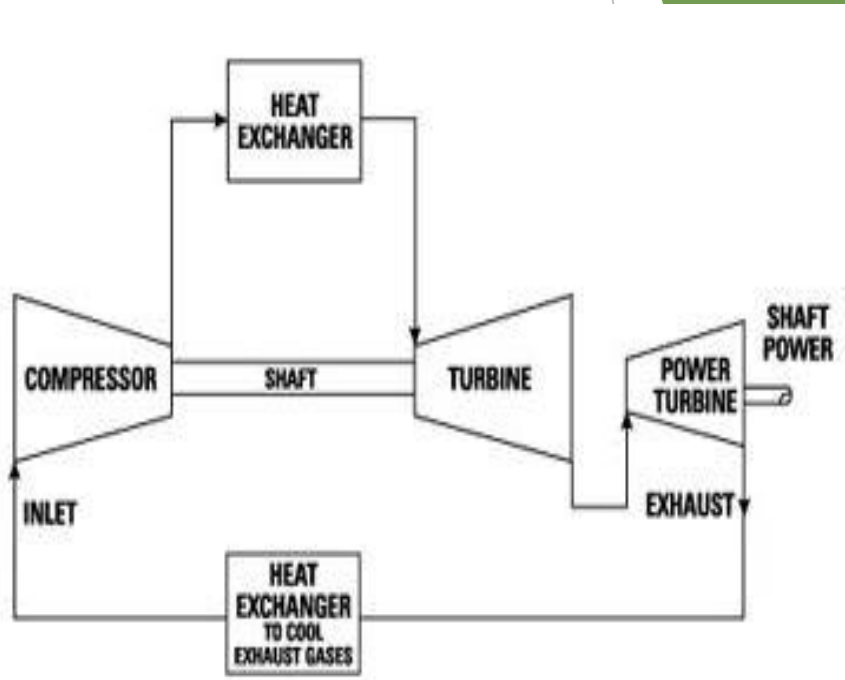


Reheating is the process of adding heating via a heat secondary combustor in-between the high and low pressure turbine stages.

Reheat alone can give a boost of about 2-3% to the efficiency. As with intercooling, the reheating pressure for maximum work output is a root of the ratio of turbine inlet and exit pressures.

Combined cycle gas turbines





The term combined cycle refers to a system that incorporates a gas turbine, a steam turbine, a heat recovery steam generator, where the heat of the exhaust gases is used to produce steam and a generator. The shaft power from the gas turbine and that developed by the steam turbine both run the generator that produces electric power.

Combined cycle power plants can be used to produce up to 50% more power than simple gas turbine

Facts!!!

- The first jet powered flight was accomplished by a German, H.P. Von Ohain with his HeS313 engine in 1939.
- The same year, the Brown Boveri Company, commissioned the world's first utility gas turbine power plant at Neuchatel, Swiss. It produced 1.6 MW power and had 23 stage axial compressor, one single-can combustor, 7 stage axial turbine and a generator coupled to same shaft.
- The largest gas turbine built is the GE 9HA which provides 550 MW, weighing 400 tons at a 61% efficiency. Two of these are being installed in Pakistan and will run on re-liquefied LNG.
- Combined cycle plants are cheaper to build that steam power plants and also 50% less polluting that coal plants.

Questions?