

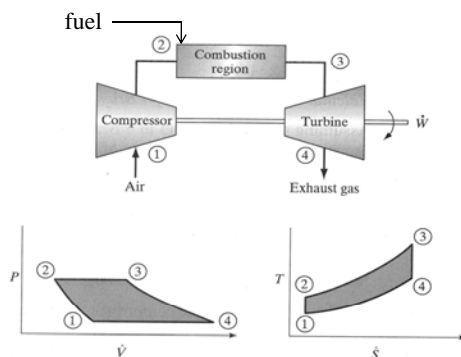
Gas Turbine Power Plants

In certain situations it is desirable to have a more portable power generator (e.g. on aircraft, boats, building sites). This can be accomplished through the use of internal combustion.

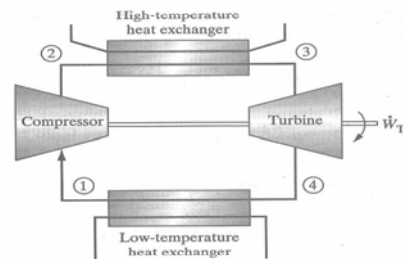
A gas turbine is a power systems which uses only a gas as the working fluid. The gas is typically the product of high pressure combustion upstream of a turbine.

Ideal Brayton Cycle

open Brayton cycle (gas turbine)



closed Brayton cycle (used in nuclear plants)

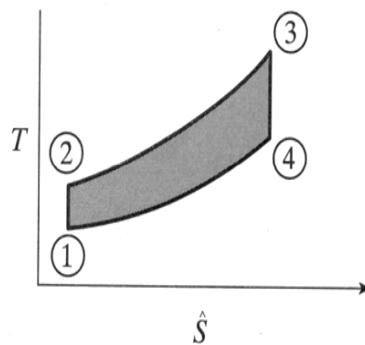
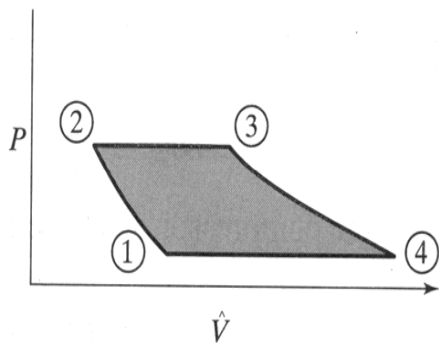
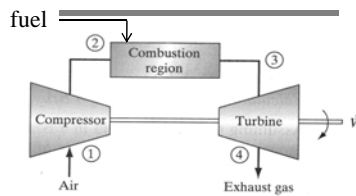


$$\eta = 1 - \frac{Q_c}{Q_H} = 1 - \frac{T_1}{T_2} = 1 - \left(\frac{P_2}{P_1} \right)^{\frac{1-\gamma}{\gamma}}$$

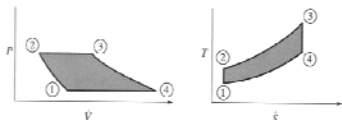
Ideal Brayton Cycle

open Brayton cycle (gas turbine)

$$\eta = 1 - \frac{Q_c}{Q_H} = 1 - \frac{T_1}{T_2} = 1 - \left(\frac{P_2}{P_1}\right)^{\frac{1-\gamma}{\gamma}}$$



Ideal Brayton Cycle

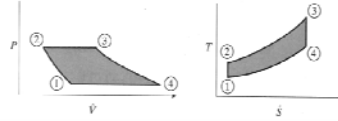


Ideal Brayton Cycle

$$\eta = 1 - \frac{Q_c}{Q_H} = 1 - \frac{T_1}{T_2} = 1 - \left(\frac{P_2}{P_1}\right)^{\frac{1-\gamma}{\gamma}}$$

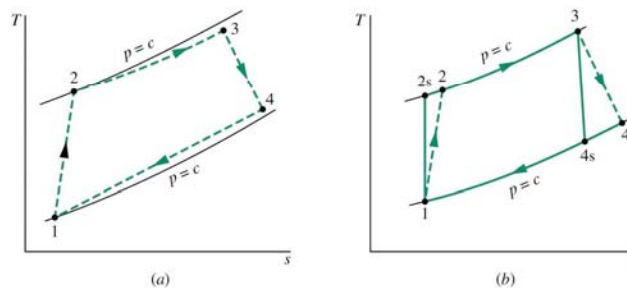
The compression ratio P_2 / P_1 defines the efficiency. For $\gamma = 1.4$

| P_2 / P_1 | η |
|-------------|--------|
| 1 | 0 |
| 2 | 0.18 |
| 4 | 0.33 |
| 6 | 0.40 |



Diminishing incs as compression ratio increases. Limited by temperature that materials can endure. Upper limit 1700 K (Titanium combustor)

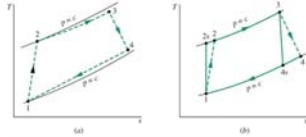
Influence of Irreversibilities



$$\eta = \frac{\eta_i \eta_c (T_3 / T_1) (1 - 1/\alpha) - (\alpha - 1)}{\eta_c (T_3 / T_1 - 1) - (\alpha - 1)}$$

$$\alpha = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

Influence of Irreversibilities



$$\eta = \frac{\eta_t \eta_c (T_3/T_1)(1-1/\alpha) - (\alpha-1)}{\eta_c (T_3/T_1 - 1) - (\alpha-1)}$$

$$\alpha = \left(\frac{P_2}{P_1} \right)^{\frac{\gamma-1}{\gamma}}$$

$P_2 / P_1 = 5$ (Ideal eff $\cong 0.22$)

$\alpha = 1.584$

For $\gamma = 1.4$

| T_3 / T_1 | η_{real} |
|-------------|----------------------|
| 2.5 | 0.01 |
| 4 | 0.2 |
| 6 | 0.24 |

Real efficiencies significantly less.

T_3 (temperature of combustion is critical)

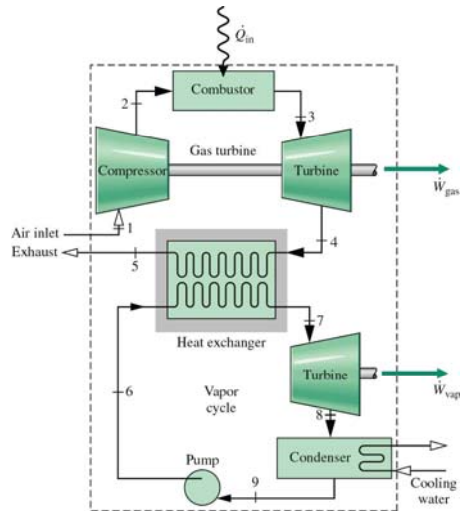
Note: $6 \times 298 = 1788 \text{ K}$ (too hot)

The key opportunity is the very hot exhaust gas for combined cycle.

EXAMPLE

For a gas turbine operating at a compression ratio of 6, taking in air at room temperature (25 °C), and having a temperature in the combustion chamber of 760 °C, determine the efficiency of the reversible case and the irreversible operation case if the turbine efficiency is 86% and the compressor efficiency is 83%.

Combined Brayton/Rankine Power Cycle



http://www.youtube.com/watch?v=gPzC_li3_nc&feature=related