Let $\frac{T_3}{T_1} = t$ and $(r)^{\gamma-1/\gamma} = C$

Then $W = C_p T_1 \left[t\left(1 - \frac{1}{C}\right) - (C-1) \right]$

at $\left.\begin{matrix} C = 1, & W = 0 \\ C = t, & W = 0 \end{matrix}\right\} C = t$ means $\frac{T_3}{T_1} = (r)^{\frac{\gamma-1}{\gamma}} = \frac{T_2}{T_1}$ or $T_3 = T_2$ i.e., no heat addition

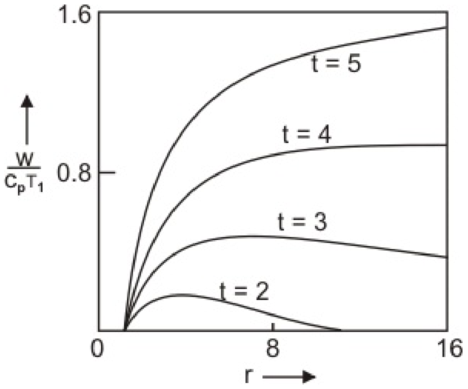


Figure 4.5 Specific work output of a simple gas turbine

To get the maximum work output for a fixed temperature ratio t and inlet temperature T_1,

$$\frac{dW}{dC} = 0 = C_p T_1 \left(\frac{t}{C^2} - 1 \right)$$

or, $$C^2 = t$$

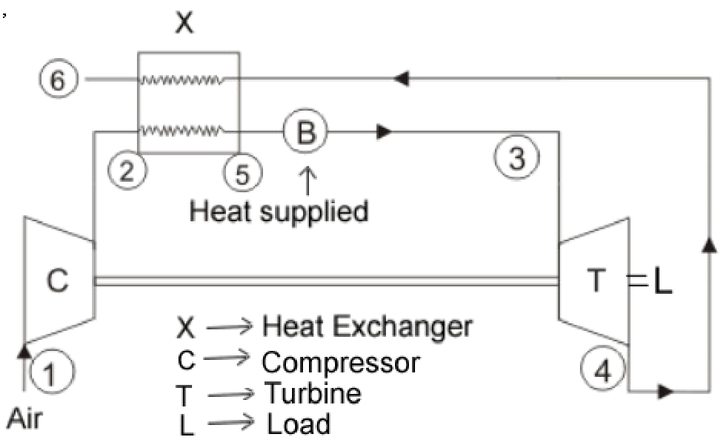
or, $$\frac{T_3}{T_1} = \frac{T_2}{T_1} \cdot \frac{T_3}{T_4}$$

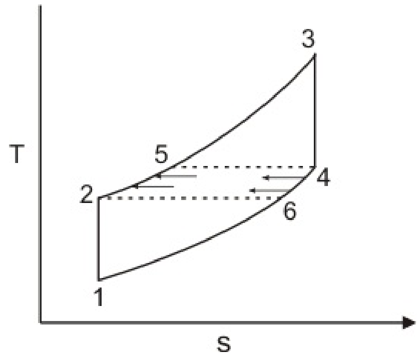
or, $$T_2 = T_4$$

Thus, the work output will be maximum when the compressor outlet temperature is equal to that of turbine. Figure 4.5 illustrates the variation of specific work output with pressure ratio for different values of temperature ratio. The work output increases with increase of T_3 for a constant value of inlet temperature T_1. However for a given temperature ratio i.e constant values of T_1 and T_3, the output becomes maximum for a particular pressure ratio.

Simple Cycle with Exhaust Heat Exchange CBTX Cycle (Regenerative cycle)

In most cases the turbine exhaust temperature is higher than the outlet temperature from the compressor. Thus the exhaust heat can be utilised by providing a heat exchanger that reduces heat input in the combustion chamber. This saving of energy increases the efficiency of the regeneration cycle keeping the specific output unchanged. A regenerative cycle is illustrated in Figure 2.6





$T_4 > T_2$ for heat exchange to take place

We assume ideal exchange $T_4 = T_5$ and $T_6 = T_2$

Figure 4.6 Simple gas turbine cycle with heat exchange

With ideal heat exchange, the cycle efficiency can be expressed as,

$\eta = \dfrac{C_p(T_3 - T_4) - C_p(T_2 - T_1)}{C_p(T_3 - T_5)}$	$\dfrac{T_2}{T_1} = \left(\dfrac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = \dfrac{T_3}{T_4}$
$= \dfrac{C_p(T_3 - T_4) - C_p(T_2 - T_1)}{C_p(T_3 - T_4)}$	or, $\dfrac{T_2}{T} = \dfrac{T_3}{T_4}$
$= 1 - \dfrac{T_2 - T_1}{T_3 - T_4} = 1 - \dfrac{T_2}{T_3}$	or, $\dfrac{T_2}{T_3} = \dfrac{T_1}{T_4}$
or, $\eta = 1 - \dfrac{T_2}{T_1} \cdot \dfrac{T_1}{T_3} = 1 - \dfrac{C}{t}$	we can write $\dfrac{T_2 - T_1}{T_3 - T_4} = \dfrac{T_2}{T_3}$

- Efficiency is more than that of simple cycle
- With heat exchange (ideal) the specific output does not change but the efficiency is increased