Ashok Narayan Dwivedi

Roll no:- 19041404049002

Thermodynamics

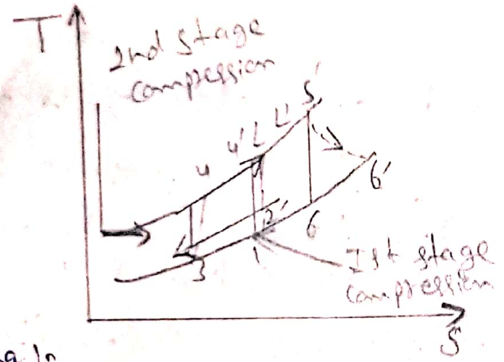
Section 1.

Ans (1)(A) Gas turbine:- thermal efficiency or specific out put of an open cycle gas turbine can be improved by following three methods:-

i) Intercooling:-

(1) this is required to reduce the compressor work and to increase the work ratio

(2) the compression of air to be done in two compressor. firstly in low pressure compressor then in high pressure compressor, compression process is to be done as shown in fig.



(b) Reheating:-

(1) this process uses two turbines a high pressure turbine and a low pressure turbine.

(2) there is a reheater present in between these two turbines.

(3) Here high pressure turbine is used to drive the compressure and the low pressure turbine provids useful work output.

(4) Actual process is shown by 1-2'-3-4'-5-6' (with reheating) and ideal process is shown by 1-2-3-4-5-6 (with reheating)

(5) Actual process without reheating is shown by 1-2'-3-L' and the ideal process without reheating is shown by 1-2-3-4-L.

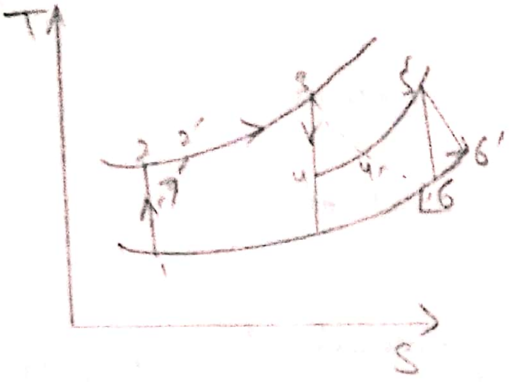
(6) the work output with reheating

$= C_p (T_5 - T_{6'})$

(7) The work output without reheating

$= C_p (T_4 - T_{L'})$

2) Brayton Cycle:-



(8) From T-S diagram it is clear that,

$$T_5 - T_{6'} > T_{4'} - T_{2'}$$

Hence the work output increase with reheating. This will also increase the work input and it may be result reduction in thermal efficiency.

(C) Regeneration:-

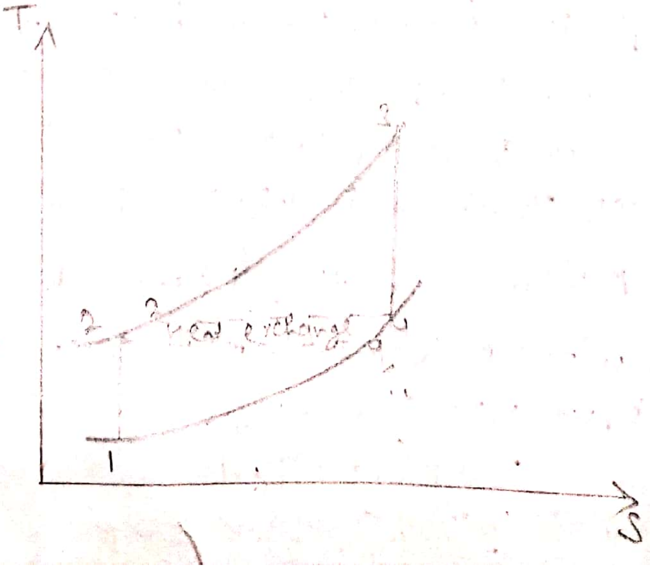
(1) Regeneration is a heat exchanger which is used to preheat the air leaving compressor before entering the combustion chamber, thereby reducing the amount of fuel to be burnt inside combustion chamber combustor.

(2) Regeneration air standard gas turbine cycle is shown in dig.

(3) Under ideal condition no frictional pressure drop occurs in neither fluid stream while turbine exhaust gas gets cooled from 4 to 4' while compressed air is heated from 2 to 2'.

(4) Assuming regenerator effectiveness as 100%. the temperature rise from 2 to 2' and drop from 4 to 4' is shown on T-S diagram

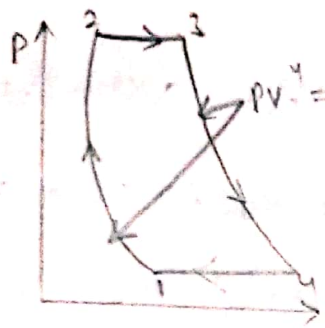
(5) Regenerator effectiveness = $\epsilon = \frac{h_{2'} - h_2}{h_4 - h_2}$



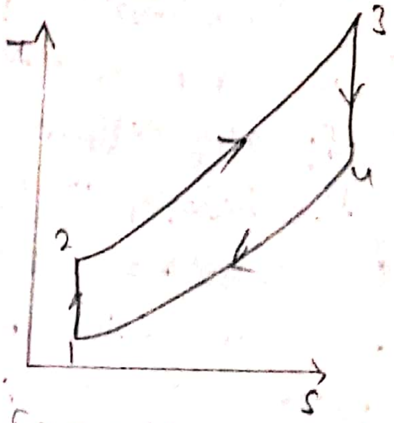
2) Brayton Cycle :-

① It is a theoretical cycle for gas turbine and also known as constant pressure cycle for a perfect gas.

(a) Brayton cycle on PV and T-S diagram :—



(a) P-V diagram



(b) T-S diagram

A = ⇒ Brayton cycle processes :-

1-2 :- adiabatic compression
2-3 :- Constant pressure heat addition.
3-4 :- adiabatic expansion
4-1 :- Constant pressure heat rejection.

⇒ Now workdone/cycle = Heat added/cycle − Heat rejection/cycle

Heat added in process = 2-3 = $mc_p(T_3-T_2)$

" rejected " " 4-1 = $mc_p(T_4-T_1)$

workdone /cycle = $mc_p(T_3-T_2) - mc_p(T_4-T_1)$

B = Efficiency of Brayton cycle :-

① Efficiency, $\eta_{air\ standard}$ = $\dfrac{\text{workdone/cycle}}{\text{Heat addition/cycle}}$

$$\Rightarrow \frac{mc_p(T_3-T_2) - mc_p(T_4-T_1)}{mc_p(T_3-T_2)}$$

$$\eta_{air\ standard} = 1 - \frac{T_4-T_1}{T_3-T_2} \quad \text{--- eq ①}$$

② from process 1-2

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

$$T_2 = T_1 (r_p)^{\frac{\gamma-1}{\gamma}}$$

③ Similarly, from process 3-4

$$T_3 = T_4 (r_p)^{\frac{\gamma-1}{\gamma}}$$

④ putting the value of T_2 and T_3 in eq. (①) we get

$$\eta_{air\ standard} = 1 - \frac{T_4 - T_1}{T_4(r_p)^{\frac{\gamma-1}{\gamma}} - T_1(r_p)^{\frac{\gamma-1}{\gamma}}}$$

$$\Rightarrow 1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}}$$