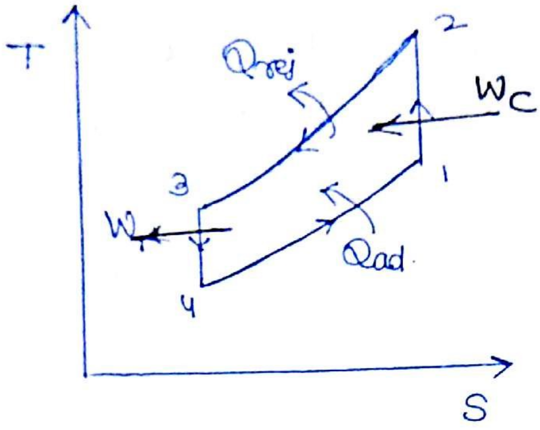
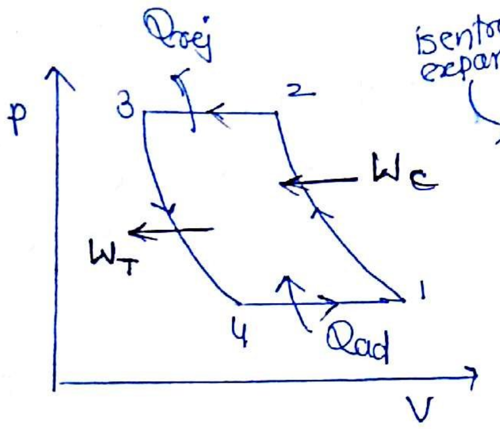
* Gas Refrigeration Cycle (Reversed brayton)

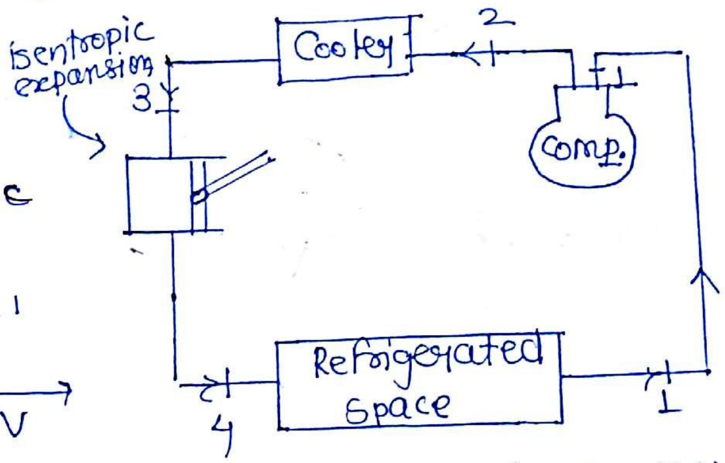
→ (Air craft - air Conditioning Cycle)

- Gas liquification cycle
- Bell Colemann cycle.



- 1 → 2 isentropic comp.
- 2 → 3 isobaric heat rej
- 3 → 4 isentropic exp.
- 4 − 1 isobaric heat addition





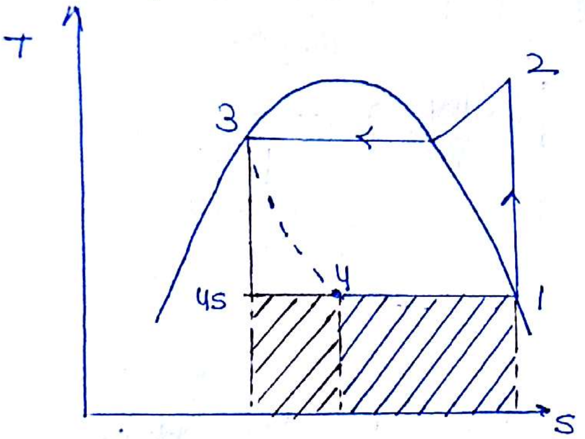
→ This cycle is used for air craft air Conditioning because of it's low weight per ton of refrigeration.

→ Air Conditioning is done for the cooling of the air-craft because since the air craft moves at high velocity due to skin friction a lot of heat is generated.

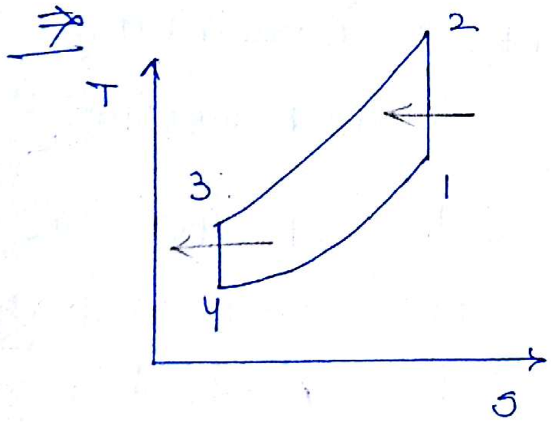
→ Isentropic expander v/s throttling :-

→ In gas refrigeration cycle since air is used as refrigerent which behaves as ideal gas hence throttling doesnot result in any temp. drop. More over use of isentropic expander gives some work output which reduces the work input from outside.

→ In VCRS we don't use isentropic expander because the refrigerent remain liquid during most of it's expansion hence the work obtain is very less this does not justify the cost of the isentropic expander. Hence throttling is used since it is very cheap device.



(Area)$_{4s-4}$ → extra R.E. due to isentropic expande



expression for COP = ?

$$COP = \frac{R.E.}{W_c - W_T}$$

$$R.E. = h_1 - h_4$$

$$= C_p(T_1 - T_4)$$

$$W_c = h_2 - h_1 = C_p(T_2 - T_1)$$

$$W_T = h_3 - h_4 = C_p(T_3 - T_4)$$

$$COP = \frac{(T_1 - T_4)}{(T_2 - T_1) - (T_3 - T_4)}$$

$$COP = \frac{T_1 - T_4}{(T_2 - T_3) - (T_1 - T_4)}$$

$$COP = \frac{1}{\frac{T_2 - T_3}{T_1 - T_4} - 1} = \frac{1}{\frac{T_2\left(1 - \frac{T_3}{T_2}\right)}{T_1\left(1 - \frac{T_4}{T_1}\right)} - 1} \quad (1)$$

$\because$ comp & exp. are isentropic.

$$\therefore \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = r_p^{x} \qquad \text{let } \frac{\gamma-1}{\gamma} = x$$

$$\rightarrow \quad \frac{T_3}{T_4} = r_p^{x}$$

Since $\quad T_2/T_1 = T_3/T_4 \Rightarrow \frac{T_4}{T_1} = \frac{T_3}{T_2}$

$$1 - \frac{T_4}{T_2} = 1 - \frac{T_3}{T_2}$$

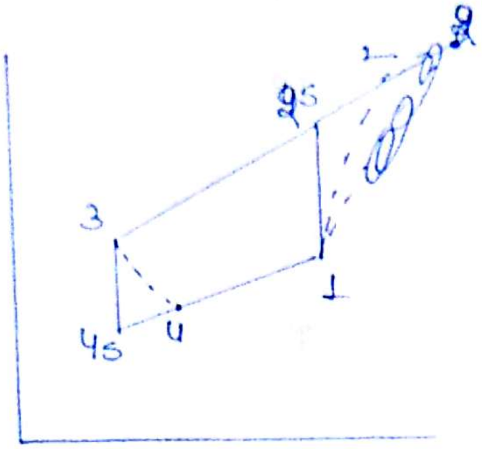
from (1)

$$COP = \frac{1}{T_2/T_1 - 1}$$

$$COP = \frac{1}{r_p^{x} - 1}$$

$$COP = \frac{1}{r_p^{x} - 1}$$

$$\boxed{COP = \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}} - 1}}$$



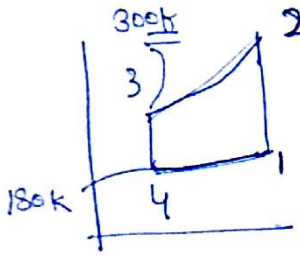
$$\eta_{isc,C} = \frac{T_{2s} - T_1}{T_2 - T_1}$$

$$\eta_{isc,T} = \frac{T_3 - T_4}{T_3 - T_{4s}}.$$

Q. 3

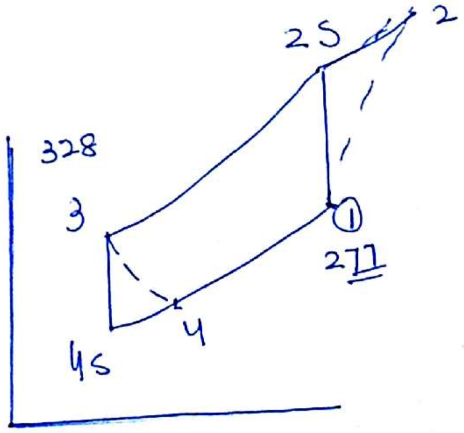
$$COP = \frac{1}{(\gamma_p)^{\frac{\gamma-1}{\gamma}} - 1} = \frac{1}{\frac{T_2}{T_1} - 1}$$

$$COP = \frac{1}{\frac{300}{180} - 1} = 1.5$$



$$\left(\frac{P_3}{P_4}\right)^{x} = \frac{T_3}{T_4} = \left(\frac{P_2}{P_1}\right)^{x} = \frac{T_2}{T_1} = \frac{300}{180}$$

Q.20



$P_1 = 0.1$ MPa

$P_2 = 0.3$ MPa.

$W_{ise,C} = 72\%$, $W_{ise,T} = 78\%$

$T_1 = 277 K$

$T_3 = 328$

$$\frac{T_3}{T_{4s}} = \frac{T_{2s}}{T_1}$$

$T_{2s} = 379.14$

$$0.72 = \frac{T_{2s} - T_1}{T_2 - T_1}$$

$$0.72 = \frac{379.14 - 277}{T_2 - 277} \Rightarrow T_2 = 418.86 K$$

$$W_{isc,T} = 0.78 = \frac{T_3 - T_4}{T_3 - T_{4s}} \qquad \frac{T_3}{T_{4s}} = (3)^{2/7}$$

$T_{4s} = 239.63$

$$0.78 = \frac{328 - T_4}{328 - 239.63}$$

$$T_4 = \sout{141.08}\ 259.07\ K$$

$$COP = \frac{T_1 - T_4}{(T_2 - T_1) - (T_3 - T_4)}$$

$$= \frac{277 - 259.07}{(418.86 - 277) - (328 - 259.07)}$$

$$COP = 0.245 \text{ Ans}$$

$$RC = 3\ TR = \dot{m} \times R.E.$$

$$3 \times 3.51 = \dot{m} \times (1.005\ (T_1 - T_4))$$

$$3 \times 3.51 = \dot{m}\ (1.005\ (277 - 259.071))$$

$$\dot{m} = 0.584\ kg/s.$$

$$COP = \frac{RC}{W_{input}}$$

$$W_{i/p} = \frac{3 \times 3.51}{0.245} = 42.97\ kW$$