Q#9

Ans The volumetric efficiency of a single stage reciprocating compressor is defined as the volume of gas entering the compressor or per min. divide by the piston displacement of the compressor per dis minute. Therefor a single stage compressor.

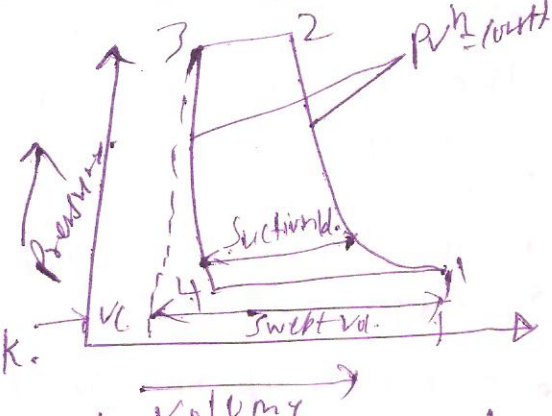
$$\text{Volumetric efficiency} = \frac{\text{Vol. of gas entring compressor per minute}}{\text{Piston displacement per minute.}}$$

The volumetric eff. of multistage compressor or is defined in the same way except that the piston displacement taken is that of the low pre. cylinder only. Therefor for a single stage compressor.

$$\text{Volumetric compressor} = \frac{\text{Vol. of gas entering compressor per minute}}{\text{Piston disp. of the low pre. cylinder per minute}}$$

As by the fig.

$$\text{Volumetric } \eta = \frac{V_1 - V_4}{V_1 - V_3}$$



from the Process 3-4

$$\left(\frac{P_3}{P_4}\right)^{1/n} = \frac{V_4}{V_3} = \left(\frac{P_2}{P_1}\right)^{1/n} \text{ or } V_4 = V_3 \times \left(\frac{P_2}{P_1}\right)^{1/n}.$$

Since $P_3 = P_2$ & $P_4 = P_1$

Let the clearance ratio $= \frac{\text{clearance vol.}}{\text{swept vol.}} = \frac{V_3}{V_1 - V_3} = k.$

then volumetric efficiency $= \frac{V_1 - V_4}{V_1 - V_3} = \frac{V_1 - V_3\left(\frac{P_2}{P_1}\right)^{1/n}}{V_1 - V_3} = \frac{V_1 - V_3\left(\frac{P_2}{P_1}\right)^{1/n}}{V_3/K}$

$$= \frac{kV_1}{V_3} - K\cdot\left(\frac{P_2}{P_1}\right)^{1/n}$$

Since $K = \frac{V_3}{V_1 - V_3}$ so $V_1 = \frac{KV_3}{K} + V_3 = V_3\left(\frac{1}{K} + 1\right)$

$$\therefore \text{Volumetric efficiency} = K\,\frac{V_3\left(\frac{1}{K}+1\right)}{V_3} - K\left(\frac{P_2}{P_1}\right)^{1/n}$$

$$= 1 + K - K\left(\frac{P_2}{P_1}\right)^{1/n} = 1 + K - K\left(\frac{V_1}{V_2}\right)$$

Hence if $P_2 = P_1$ the volumetric eff. will be 100% whereas if $V_1 = V_4$ the volumetric η will be Zero.

$$= 1 + K - K\left(\frac{P_2}{P_1}\right)^{1/n} \times \frac{P_i T_a}{P_a T_i}$$

$$= 1 + K - K\left(\frac{V_1}{V_2}\right) \times \frac{P_i T_a}{P_a T_i}$$

Where suffix (i) & (a) stand for inside & atm. conditions.

Q#10

Ans As we know

mass of steam (Kg) discharged through the nozzle per second

$$m = \frac{A}{v_1} \times \sqrt{\left[2\left(\frac{n}{n-1}\right)P_1 v_1 \left\{\left(\frac{P_2}{P_1}\right)^{2/n} - \left(\frac{P_2}{P}\right)^{\frac{n+1}{n}}\right\}\right]}$$