

Q19
 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 minute. Therefore for a single stage compressor.

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

The volumetric eff. of multistage compressor or is defined in the same way except that the piston displacement taken by that of the low pre. cylinder only. therefore 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 $P_3 = P_2$ & $P_4 = P_1$

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

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

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

$$\text{Since } k = \frac{V_3}{V_1 - V_3} \text{ so } V_1 = \frac{kV_3}{1 - k} + V_3 = V_3 \left(\frac{1}{1 - k} + 1\right)$$

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

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

hence if $P_2 = P_1$ the volumetric eff. will be 100% whereas if $V_1 = V_2$ the volumetric η will be zero.

$$= 1 + k - k \left(\frac{P_2}{P_1}\right)^{1/n} \times \frac{P_1 T_1}{P_2 T_2}$$

$$= 1 + k - k \left(\frac{V_1}{V_2}\right) \times \frac{P_1 T_1}{P_2 T_2}$$

where suffix 1 & 2 stand for inside & atm. conditions.

Q20

Ans. As we know mass of steam (kg) discharged through the nozzle per second

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