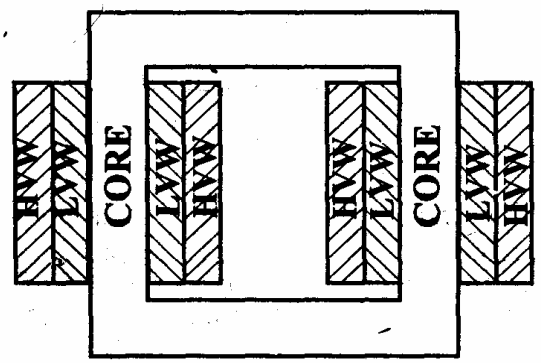
2.2 OUTPUT EQUATION OF SINGLE PHASE TRANSFORMER

- The equation which relates the rated kVA output of a transformer to the area of core and window is called output equation.
- In transformers the output kVA depends on flux density and ampere-turns.
- The flux density is related to core area and the ampere-turns is related to window area.
- The simplified cross-section of core type and shell type single phase transformers are shown in figures (4-1) and (4-2).
- The low voltage winding is placed nearer to the core in order to reduce the insulation requirement.
- The space inside the core is called window and it is the space available for accommodating the primary and secondary winding.
- The window area is shared between the winding and their insulations.



LVW - Low Voltage winding

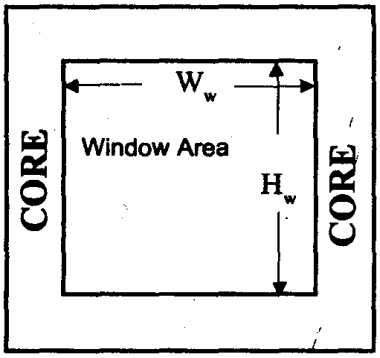
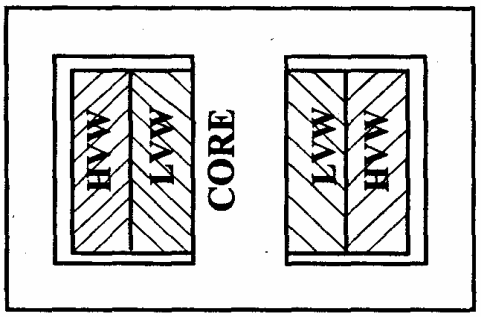


Fig 4.1: Cross-section of core type single phase transformer



HVW - High Voltage winding.

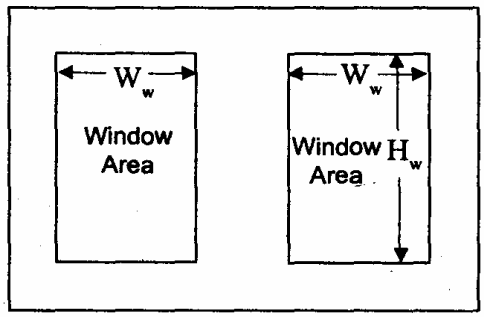


Fig 4.2: Cross-section of shell type single phase transformer

Figure 2.2.1 Core and shell type transformer

[Source: "A Course in Electrical Machine Design" by A.K.Sawhney, page-5.4]

- The induced emf in a transformer,

$$E = 4 \cdot 44 f \phi_m T \quad \text{Volts}$$

- Emf per turn,

$$E/T = 4 \cdot 44 f \phi_m \quad \text{Volts}$$

- The window in single phase transformer contains one primary and one secondary winding.
- The window space factor K_w is the ratio of conductor area in window to total area of window.

$$k_w = \frac{conductor\ area\ in\ window}{Total\ Area\ of\ window}$$

$$k_w = \frac{A_C}{A_w}$$

- Conductor area in window,

$$A_C = k_W A_W$$

- The current density is same in both the windings. Therefore Current density,

$$\delta = \frac{I_p}{Ap} = \frac{I_S}{As}$$

- Area of cross - section of primary conductor,

$$A_P = \frac{I_P}{\delta}$$

- Area of cross - section of secondary conductor,

$$A_S = \frac{I_S}{\delta}$$

- If we neglect magnetizing mmf then primary ampere turns is equal to secondary ampere turns. Therefore, ampere turns,

$$AT = I_p T_p = I_S T_S$$

- Total copper area in window,

Ac = Copper area of primary winding + Copper area of secondary winding

= (Number of primary turns x area of cross-section of primary conductor) + (Number of secondary turns x area of cross - section of secondary conductor)

$$A_C = \frac{2AT}{\delta}$$

- On equating the above equations, we get,

$$K_W A_W = \frac{2AT}{\delta}$$

- Therefore, Ampere turns,

$$AT = \frac{1}{2} k_W A_w$$

- The kVA rating of single phase transformer is given by,

$$Q = v_p I_p * 1O^{-3}$$

$$Q = 2.22 f \phi_m k_w A_v \delta x 1O^{-3}$$

The above equation is the output equation of single phase transformer.