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17 EEB 409

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GROUP - 14

ELECTRICAL MACHINE DESIGN

CALCULATION OF MAIN DIMENSIONS

Design Given →

KVA Rating = 1600 KVA = S

Voltage Ratio = 33/6.6 KV

Phase = 3

Type = core/Power

Connection = Y/A

Tap = ±5%.

Design

(1) Calculate volts/turn

$$E_t = k\sqrt{S}$$

for 3 phase core type Power t/f

$k = 0.6$ to 0.7

$S = 1600$ KVA

$$E_t = k\sqrt{S} = \quad (k = 0.65)$$

$$0.65\sqrt{1600} = 26$$

$$\boxed{E_t = 26}$$

(2) No. of turns in LV & HV winding

$$T_{LV/ph} = \frac{V_{LV/ph}}{E_t}$$

$$T_{LV_{ph}} = \frac{6.6 \times 10^3}{E_t} = \frac{6.6 \times 10^3}{26}$$

$253.846 \simeq 254$ turns [integer value]

$$T_{LV_{PH}} = 254 \text{ turns}$$

So, $E_t' = E_t = \frac{6.6 \times 10^3}{254} = 26$ turns/volt

for HV having star connection

$$V_P = \frac{V_L}{\sqrt{3}} = \frac{33}{\sqrt{3}}$$

$$T_{HV_{PH}} = \frac{33 \times 10^3}{\sqrt{3}\ 26} = 732.65$$

$$T_{HV_{PH}} = 733 \text{ turns}$$

(3) Calculate area of core section

for power t/f, $B_m = 1.25$ to 1.45 Wb/m^2

Assume value of $B_m = 1.35$ Wb/m^2

$$E_t = 4.44 f B_m A_i$$

$$26 = 4.44 \times 50 \times 1.35 \times A_i$$

$$A_i = 0.08675 \text{ m}^2$$

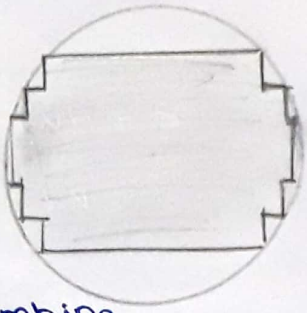
(4) Select core selection & calculate diameter of circum circle.

for 3 stepped Ai core section

$$A_i = 0.60 d^2$$

$$0.08675 = 0.60 d^2$$

$$\therefore \boxed{d = 0.3802}$$



width of the largest stamping

$$a = 0.9d = 0.9 \times 0.3802 = 0.34218$$

width of the middle stamping

$$b = 0.7d = 0.9 \times 0.3802$$

$$b = 0.2661$$

Width of the smallest stamping

$$c = 0.42d = 0.42 \times 0.3802$$

$$c = 0.1596$$

(5) Assume current density & calculate window dimension.

δ = 2.2 to 3.2 amp/mm² ... large power

transformer, oil cooled or air blast

$$\boxed{\delta = 2.7 \times 10^{-3}}$$

window space factor k_w =

$$k_w = \frac{12}{30 + kV}$$ ... for 1000 kVA rating where kV is voltage of HV wdg in kilo volt

$$K_w = \frac{12}{30 + 19.05}$$

$$\boxed{K_w = 0.2446}$$

window area A_w:

$$S = K_f B_m \delta A_w K_w \delta \times 10^{-3}$$

where $K = 3.3$ for 3 phase core type

$$1600 = S = 3.3 \times 50 \times 1.35 \times 10^6 \times 0.0867 \times A_w \times 0.2446 \times 2.7 \times 10^{-3}$$

$$1600 = 12.754 \times 10^3 \times A_w$$

$$\boxed{A_w = 0.12545}$$

window height & width

Assume $\frac{H_w}{W_w} = 2 \text{ to } 4$

$$\frac{H_w}{W_w} = 3$$

$$H_w = 3 W_w$$

$$A_w = H_w \times W_w$$

$$A_w = 3 W_w^2$$

$$0.1254 = 3 W_w^2$$

$$\boxed{W_w = 0.2044}$$

$H_w = 3 \times 0.2044$

$$\boxed{H_w = 0.613}$$

(6) Calculate dimension of yoke

for Rectangular yoke sections, depth of yoke is equal to the core, = to the width of the largest stamping a

Gross yoke area $A_y = D_y \times H_y$

where $D_y = a = 0.90d$ for 3-stepped core section

$A_y = 0.90 \times 0.3802 = 0.34218$

$A_y = (1.15 \text{ to } 1.25) \times A_i$

$= 1.2 \times 0.08675$

$$\boxed{A_y = 0.1041 m}$$

$\therefore$ Gross yoke area $= \frac{A_y}{0.9} = \frac{0.1091}{0.9}$

$= 0.1157$

$\therefore$ Height of yoke $(H_y) = \frac{\text{Gross yoke area}}{D_y}$

$= \frac{0.1157}{0.34218}$

$$\therefore \boxed{H_y = 0.3382}$$

Step-7 Overall Dimension of Transformer frame

Height of frame

$H = H_w + 2H_y$

$= 0.613 + 2(0.3381)$

$\boxed{H = 1.2892\ m}$

width of frame $W = 2D + a$ for 3Phase core type

where, D = centre to centre distance b/n adjacent limbs

$D = W_w + d$

$D = 0.62064$

∴ width of frame

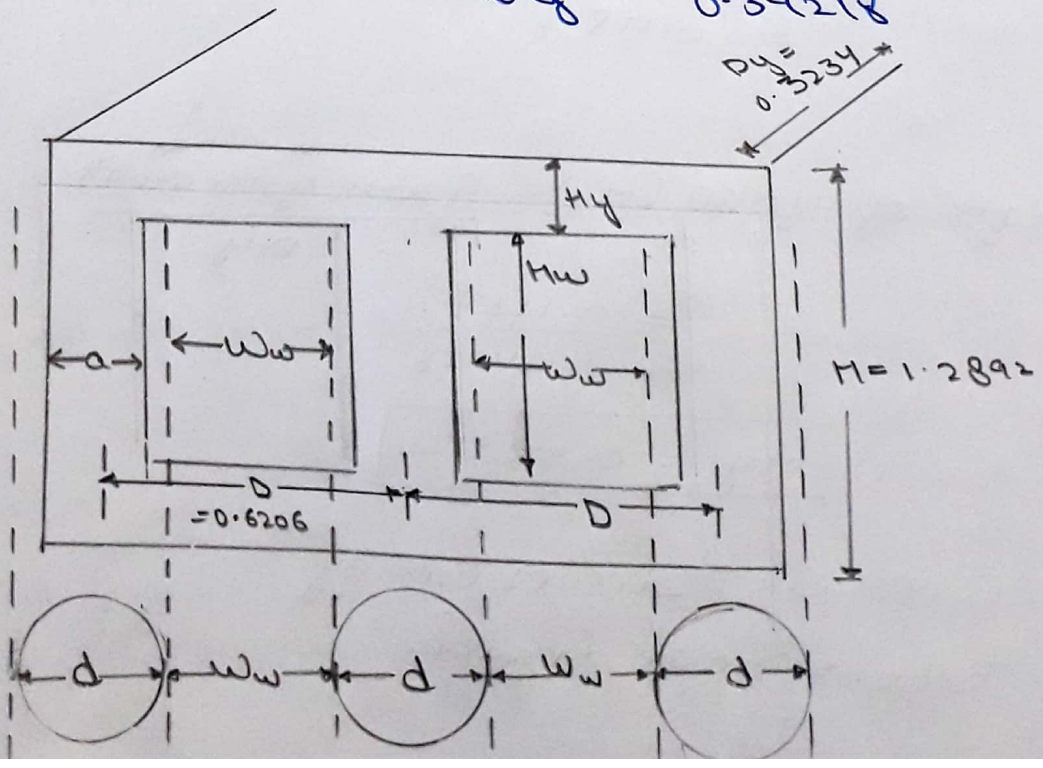
$W = 2(W_w + d) + a$

$= 2[0.2044 + 0.3802] + 0.3239$

$\boxed{W = 1.4926}$

Depth of frame $D_y = a$

$D_y = 0.34218$



(8) No. of turns /ph

$$T_{ph} = \frac{V_{ph}}{E_t} + 5\%. \text{ turns on HV for tapping}$$

$$= 733 + 733 \text{ of } 5\%. = 733 + 36.65$$

$$= 769.65$$

$T_{ph\ HV} = 770$ turns

$T_{ph\ LV} = 254$ turns