EEE 206 Machine Lab Term Project

Group: 05

Projects: DESIGN A 200VA 230/180V TRANSFORMER

Submission date: 10.09.14

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Windings turns calculations:

$v = N(\frac{d\phi}{dt})$

$For\ a\ sinusoidal\ flux\ \phi = \phi_m sin\omega t$

$Then\ RMS\ value\ V = 4.44f\phi_m N$

$\frac{Volt}{turn} = E_t = \frac{V}{N} = 4.44.f.\phi_m = 4.44.f.B_m.A$

- Here we choose $B_m = 1.2\ tesla$
- f= 50 defined by Bangladesh Power grid system
- $A = wt$ where w=limb width and t=thickness . Market available $w = 1.5\ inch.$ For minimum copper wire we choose $t = w = 1.5\ inch.$

$$A = wt = 1.5x1.5x2.54^2x10^{-4} = 1.452x10^{-3}\ m^2$$

$$E_t = 4.44x50x1.2x1.452x10^{-3} = .3867\ volt/turn$$

- $N_p = \frac{V_p}{E_t} = 595\ turns$
- $N_s = \frac{V_s}{E_t} = 465\ turns$

Copper wire diameter calculation:

- $I_p = \frac{Q}{V_p} = \frac{200}{240} = .8333A \approx 1A$.

  So For 1A current American wire gauge (AWG) No =23 and diameter= .57mm
- $I_s = \frac{Q}{V_s} = 1.11A \approx 1.2A$.

  So for 1.2A Current AWG No=22 and diameter=.65m.

Core Loss:

Empirical equation for core loss:

$$W_c\ loss\ = W_c\ density\ x\ L\ x\ Ax10^{-3}\ watts\ .$$

- $W_c density\ in\ mW/cm^3 = 193xB_m^{2.01}x(fx10^{-3})^{1.29}\ = 5.8396.$
- $L = Magnetic\ Path\ length = 4.5 + 4.5 + (3 - 2x0.75)x2$
  $= 12inch = 30.48\ cm$
- $A = 1.452x10^{-3}m^2 = 14.52\ cm^2$

$$W_c\ \boldsymbol{loss = 2.5844\ watt}$$

Copper Loss:

$$Core\ loss = I_p^2 x R_p + I_s^2 x R_s$$

- $R_p = \frac{\rho_c L_p}{A_p}$
  - $\rho_c = specific\ resistance\ for\ copper = 1.68x10^{-8}\ \ \Omega - m$
  - $L_p = Primary\ winding\ copper\ wire\ length$
    $= 2(1.5 + 1.5)inch/turn\ x595\ turns$

$= 3570\ inch = 90.678m$

- $A_p = Cross\ section\ Area\ of\ primary\ coil = 3.1416x\left(\frac{0.57}{2}\right)^2$
  $= .255mm^2\ = 2.55x10^{-7}m^2$

$$So\ Now\ R_p = 5.974\ \Omega$$

- $R_s = \frac{\rho_c L_s}{A_s}$
  - $L_s = 2(1.5 + 1.5)\frac{inch}{turn}x465\ turn = 2790\ inch = 70.866m$
  - $A_s = 3.1416x\left(\frac{.65}{2}\right)^2 = 3.3x10^{-7}\ m^2$

$$So\ Now\ R_s = 3.61\ \Omega$$

- $\boldsymbol{Copper\ loss = I_p^2 xR_p + I_s^2 xR_s = 8.596\ watt.}$

Voltage Regulation Calculation :

$$Volatge\ regulation = \frac{\frac{V_p}{a} - V_s}{V_s}x100\%$$

- $a = turns\ ratio = rated\ \left(\frac{V_p}{V_s}\right) = 1.278$
- $\frac{V_p}{a} = V_s\angle 0^\circ + \{I_s\angle\cos^{-1}(rated\ lag\ pf)\ x\ (R_{e,s} + jX_{e,s})\}$
  - $R_{e,s} = \frac{R_p}{a^2} + R_s = 7.268\Omega$
  - $X_p = 2\pi f x N_p^2 x\ P_{air} =\ .661\ \Omega$
  - $X_s =\ 2\pi f x N_s^2 x\ P_{air} =\ .404\ \Omega$
  - $X_{e,s} = \frac{X_p}{a^2} + X_s = 0.8088\ \Omega$
  - $\mu_{air} = 4\pi x10^{-7}\ henry/m$
  - $P_{air} = \mu_{air} x\frac{A}{L} = 5.949x10^{-9}$
  - $Rated\ load\ pf\ =\ .98$

$$So\ Now\frac{V_p}{a} = 188.11\ volt$$

$$\boldsymbol{And\ Volatge\ regulation = 4.5\%}$$

Efficiency Calculation:

$Total\ loss\ W_{loss} = W_{core\ loss} + W_{copper\ loss}$ = 11.184 watt

$$\boldsymbol{so\ efficiency = \left(100 - \frac{11.184}{200}x100\right)\% = 94.4\%}$$