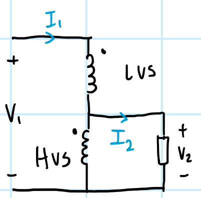
ASN5

Thursday, February 1, 2024 11:01 AM

1)



$V_S = 2410V$

$\overset{S_T}{2.5\text{ kVA}}$ $\overset{V_H}{2250}/\overset{V_L}{160V}$ transformer

Max Power: $P = S_T\left(\frac{V_H + V_L}{V_L}\right) = \underline{37.656\text{ k VA}}$

Max Primary Current: $I_1 = \frac{S_T}{V_L} = \underline{15.625\text{ A}}$

$I_H = \frac{S_T}{V_H} = 1.111\text{ A}$

Max Secondary Current: $I_2 = I_1 + I_H = \underline{16.736\text{ A}}$

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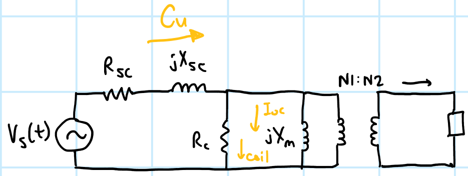
2)



$V_{sec}(t) = 204 \sin(377t)$ V

N1 = 84

N2 = 204

$I_{sec}(t) = 10 \sin(377t + 4°)$

$10\angle 4°$

$R_{sc} = 0.2\Omega$

$X_{sc} = 0.75\Omega$

$R_c = 300\Omega$

$X_m = 70\Omega$

a) $I_{prim\_Rms} = ?$ b) $V_{reg} = ?\%$ c) Efficiency $= ?\%$

a) $V_2 = \frac{V_{sec}}{\sqrt{2}} = 144.2498$

$\dot{i}_2 = \frac{I_{sec}}{\sqrt{2}} = 7.0538 + j0.4933$

$V_1 = V_2 \frac{N_1}{N_2} = 59.3970\text{ V}$

$\dot{i}_{oc} = \frac{V_1}{R_c \| jX_m} = 0.1980 - j3.5822$

$\dot{i}_1 = \dot{i}_2 \frac{N_2}{N_1} = 17.1308 + j1.1979$

$\dot{i}_{prim} = \dot{i}_1 + \dot{i}_{oc} = 17.3288 + j0.3494$

$I_{prim} = I_1 + I_{oc} = 17.3280 + j0.3494$

$|i_{prim}| = \underline{17.3323 \text{ A}}$

b) $V_{reg} = \frac{|V_{NL}| - |V_{FL}|}{|V_{FL}|}$ ignore $\underline{i_{oc}}$ $V_{FL} = V_1$

$V_{NL} = V_1 + I_1 (R_{sc} + jX_{sc}) = 61.9247 + j13.0877$

$\rightarrow V_{reg} = \underline{6.5587} \ \%$

c) $P_{out} = \frac{V_{sec}}{\sqrt{2}} \frac{I_{sec}}{\sqrt{2}} \angle -4°$

$P_{Cu} = |i_{prim}|^2 R_{sc} = 60.0815$

$P_{coil} = \frac{V_1}{R_c} = 11.76$

$\eta = \frac{P_{out}}{P_{source}}$

$P_{source} = P_{Cu} + P_{coil} + P_{out} = 1089.3569$

$\eta = \frac{P_{out}}{P_{in}} \times 100\% = \underline{93.4051} \%$

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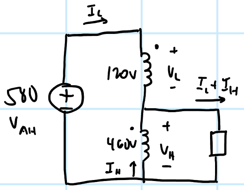
3)



116 kVA, 460/120V, 60 Hz

$\eta_1 = 95\% \rightarrow$ FL @ 0.44 pf

PF2 : 0.9

$S_{max} = \frac{V_H + V_L}{V_L} S_T = \underline{560.67 \text{ kVA}}$

$\eta_1 = \frac{S_T \cdot PF1}{S_T \cdot PF1 + P_{loss}} \rightarrow P_{loss} = 2686.3158 \text{ VA}$

$\eta_{new} = \frac{S_{max} \cdot PF2}{S_{max} \cdot PF2 + P_{loss}} \times 100\% = \underline{99.47\%}$

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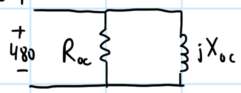
4) 30 kVA 20k/480V 60Hz

OCT from LVS : $V_{oc} = 480V$, $I_{oc} = 1.6A$, $P_{oc} = 268.8W$

SCT from HVS: $V_{sc} = 1130V$, $I_{sc} = 1A$, $P_{sc} = 113W$

OCT



At LVS:

$$R_{oc} = \frac{V_{oc}^2}{P_{oc}} = 857.14$$

$$I_{R_{oc}} = \frac{V_{oc}}{R_{oc}} = 0.56$$

$$I_X = \sqrt{I_{oc}^2 - I_{Roc}^2} = 1.4988$$

$$X_{oc} = \frac{V_{oc}}{I_x} = 320.256$$

Going to HVS:

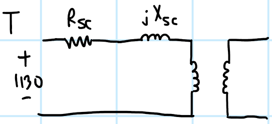
$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\rightarrow \frac{480}{20k} = \frac{N_1}{N_2} = 0.024$$

$$\rightarrow R_C = R_{oc} \times \left(\frac{N_2}{N_1}\right)^2 = \underline{1.4881\ M\Omega}$$

$$\rightarrow X_M = X_{oc} \times \left(\frac{N_2}{N_1}\right)^2 = \underline{0.5560\ M\Omega}$$

SCT



$$R_{SC} = \frac{P_{sc}}{I_{sc}^2} = \underline{113}\ \Omega$$

$$Z_{SC} = \frac{V_{sc}}{I_{sc}} = 1130$$

$$X_{SC} = \sqrt{Z_{sc}^2 - R_{sc}^2} = \underline{1124.3358\ \Omega}$$

$$I_{base} = \frac{S}{V_H} = \frac{30kVA}{20kV} = 1.5A$$

$$Z_{base} = \frac{V_H}{I_{base}} = 13333.33\ \Omega$$

$$R_C \rightarrow \frac{R_C}{Z_{base}} = \underline{111.607\ p.u.}$$

$$X_M \rightarrow \frac{X_m}{Z_{base}} = \underline{41.700\ p.u.}$$

$$R_{SC} \rightarrow \frac{R_{sc}}{Z_{base}} = 0.008475\ p.u.$$

$X_M \rightarrow Z_{base}$ p.u.

$R_{sc} \rightarrow \frac{R_{sc}}{Z_{base}} = \underline{0.008475\ p.u.}$

$X_{sc} \rightarrow \frac{X_{sc}}{Z_{base}} \simeq \underline{0.08433\ p.u.}$

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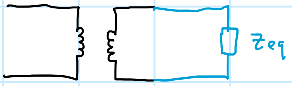
5) $Z_{\overset{SC}{eq},\overset{HVS}{H}} = 3.8 + j3\,\Omega$

$\underset{S}{\uparrow}$61kVA, $\underset{V_H}{\uparrow}$2300/$\underset{V_L}{\uparrow}$230V, $\underset{f}{\uparrow}$60 Hz

$Reg = \frac{|V_{NL}| - |V_{FL}|}{|V_{FL}|} \times 100\%$ / Worst case: V_{FL} is maximum $\rightarrow V_{FL} = V_H$

$V_{FL} = 2300$ V

$V_{NL} = \frac{S}{V_H} |Z_{eq,H}| + V_{FL} = 2428.40$



$Reg = \underline{5.5828\%}$

$pf: Re\left(\frac{R_{eq}}{Z_{eq}}\right) = Re\left(\frac{3.8}{Z_{eq}}\right) = \underline{0.7849}$

Zero-regulation:

$Reg = 0 = \frac{|V_{NL}| - |V_{FL}|}{|V_{FL}|} \rightarrow V_{NL} = V_{FL} = 2300$ V

$I_{FL} = \frac{S}{V_H} = 26.5217$A

$PF = a\cos\left(-\frac{I_{FL} \cdot |Z_{eq}|}{2 V_H}\right) - arg(Z_{eq})$

$= \underline{53.3094°}$

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6) $\phi(t) = -\frac{V_m}{\omega \cdot N_{120}} \cos(\omega t)$

$V_{rms} = 120$

$f = 60Hz \rightarrow \omega = 2\pi f$

$N_{120} = 660$

$N_{240} = 2 \times 660$

$S = 3$ kVA

$V_H = 120V$

$V_L = 240V$

$V_m = V_{rms}\sqrt{2}$

a) $t = 0.014s$: $\phi(t) = \underline{-365.4649\ \mu Wb}$

$MMF(A) = 66.235\ A$

$I_{mag} = \frac{MMF}{N_{120}} = \underline{100.3560\ mA}$

$t = 0.038s$: $\phi(t) = \underline{127.8049\ \mu Wb}$

$MMF(A) = 21.9510\ A$

$I_{mag} = \frac{MMF}{N_{120}} = \underline{33.2591\ mA}$

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7) $\overset{S_T}{12\,kVA}$, $\overset{V_H}{2400}/\overset{V_\ell}{240\,V}$, $\overset{f}{60\,Hz}$ Core loss : $\underset{core}{\overset{rated}{290\,W}}$, Cu loss : $\underset{Cu}{\overset{half}{120\,W}}$

a) $\eta = ?$ @ pf = 0.56 lagging — pf1

b) % rated load where η is max.

c) η @ pf = 0.9 — pf2

d) Load cycle: No load for 6 hours, 70% full load 10 hrs @ $\underset{pf3}{0.8pf}$, 90% full load 8hrs @ $\underset{pf4}{0.9\,pf}$

a) $\overset{Cu}{loss}$ = 120 W at half rated

$$\rightarrow 120 = \left(\frac{1}{2}\right)^2 (\text{Cu loss at full load})$$

$$\underset{loss}{Cu} = 480\ W \rightarrow cu$$

$$\eta_1 = \frac{S_t \cdot pf1}{St \cdot pf_1 + Cu + core} \times 100\% = \underline{89.72\%}$$

b) $$load_{max} = \sqrt{\frac{\text{core loss}}{\text{FL Cu loss}}} \times 100\%$$

$$= \sqrt{\frac{core}{Cu}} \times 100\%$$

$$= \underline{77.73\%}$$

c) Max efficiency: Core loss = Cu loss

$$\eta_2 = \frac{load_{max} \cdot S_t \cdot pf2}{load \cdot St \cdot \quad + Cu + core} \rightarrow Cu_2 = core$$

$$\eta_2 = \frac{\text{load}_{max} \cdot S_t \cdot pf2}{\text{load}_{max} \cdot St \cdot pf_2 + Cu_2 + \text{core}} \rightarrow Cu_2 = \text{core}$$

$$= 93.54\%$$

d) 10 hours

$$\text{kWh o/p} = 0.7 \times \frac{S_T}{pf3} \times 10 \text{ hours} = 105 \text{kWh}$$

$$\text{kVA o/p} = 0.7 \times S_T = 8.4 \text{ kVA}$$

$$P_{Cu'} = \frac{P_{Cu\,FL}}{\left(\frac{S_T}{kVA}\right)^2} = 235.2 \text{ W}$$

$$P_{Cu'} \times 6\text{hrs} \rightarrow 1.4112 \text{ kWh} \rightarrow pcu6$$

$$\times 10\text{hrs} \rightarrow 2.352 \text{ kWh}$$

8 hours

$$\text{kWh o/p} = 0.9 \cdot \frac{S_T}{pf4} \cdot 8 \text{hours} = 96 \text{ kWh}$$

$$\text{kVA o/p} = 0.9 \cdot S_T = 10.8 \text{ kVA}$$

$$P_{Cu''} = \left(\frac{kVA}{S_T}\right)^2 \cdot Cu = 388.8 \text{ W} \xrightarrow{\times 8\text{hrs}} 3110.4$$

Total core loss: $\text{Core} * 24 = 6960 \text{ Wh} \rightarrow \text{core\_day}$

$$\eta_3 = \frac{\text{kWh for 24 hrs}}{\text{kWh for 24hrs} + \text{kWh } P_{core} + \text{kWh } P_{Cu}} = \frac{\text{kWh 8} + \text{kWh 10}}{\text{kWh8} + \text{kWh 10} + \text{core\_day} + \text{pcu6} +}$$

Core loss for entire day: $\overset{(290)}{\text{core}} \cdot 24 \text{ hours} = 6960 \text{ Wh} \rightarrow \text{core\_day}$

Cu loss: $(0.7)(480)(10) + (0.9)(480)(8) = 6816 \text{ Wh} \rightarrow \text{cu\_day}$

$$\eta_3 = \frac{\left[(0.7) S_t \, pf_3 \, (10 \text{ hours}) + (0.8) S_t \, pf_4 \, (8 \text{ hours})\right]}{\left[(0.7) S_t \, pf_3 \, (10 \text{ hours}) + (0.8) S_t \, pf_4 \, (8 \text{ hours})\right] + \text{core\_day} + \text{cu\_day}}$$