P1

$$I_2 = \frac{150 \times 10^3}{240} = 625 \text{ A}$$

$$\frac{I_2}{a} = 62.5 \angle -36.8° = 50 - j37.5 \text{ A}$$

$$aV_2 = 2400 \angle 0° = 2400 + j0 \text{ V}$$

$$a^2R_2 = 0.2\ \Omega \quad \text{and} \quad a^2X_2 = 0.45\ \Omega$$

Hence

$$E_1 = (2400 + j0) + (50 - j37.5)(0.2 + j0.45)$$

$$= 2427 + j15 = 2427 \angle 0.35° \text{ V}$$

$$I_m = \frac{2427 \angle 0.35°}{1550 \angle 90°} = 1.56 \angle -89.65 = 0.0095 - j1.56 \text{ A}$$

$$I_c = \frac{2427 + j15}{10{,}000} \approx 0.2427 + j0 \text{ A}$$

$$I_0 = I_c + I_m = 0.25 - j1.56 \text{ A}$$

$$I_1 = I_0 + \frac{I_2}{a} = 50.25 - j39.06 = 63.65 \angle -37.850° \text{ A}$$

Thus, the primary voltage is

$$V_1 = (2427 + j15) + (50.25 - j39.06)(0.2 + j0.45)$$

$$= 2455 + j30 = 2455 \angle 0.7° \text{ V}$$

$$VR = \frac{2455 - 2400}{2400} * 100 = 2.3\%$$

$$P_i = I_c^2 R_c, \quad P_{Cu} = I_1^2 R_1 + I_2^2 R_2$$

$$P_i + P_{Cu} = 2.18 \text{ KW}, \quad P_{o/p} = 150 * 0.8 = 120 \text{ KW}$$

$$\eta = \frac{120}{120 + 2.18} * 100 = 98.2\%$$

P2

$$aV_2 = 2400 \angle 0^0 \text{ V}$$

$$\frac{I_2}{a} = 50 - j37.5 \text{ A}$$

$$R_1 + a^2R_2 = 0.4 \ \Omega$$

$$X_1 + a^2X_2 = 0.9 \ \Omega$$

$$V_1 = (2400 + j0) + (50 - j37.5)(0.4 + j0.9)$$

$$= 2453 + j30 = 2453 \angle 0.7° \text{ A}$$

$$I_c = \frac{2453 \angle 0.7°}{10 \times 10^3} = 0.2453 \angle 0.7° \text{ A}$$

$$I_m = \frac{2453 \angle 0.7°}{1550 \angle 90°} = 1.58 \angle -89.3° \text{ A}$$

$$I_0 = 0.2453 - j1.58 \text{ A}$$

$$I_1 = 50.25 - j39.08 = 63.66 \angle -37.9° \text{ A}$$

$$\text{percent regulation} = \frac{2453 - 2400}{2400} \times 100 = 2.2\%$$

$$\text{efficiency} = \frac{120 \times 10^3}{120 \times 10^3 + (63.66)^2(0.4) + (0.2453)^2(10 \times 10^3)}$$

$$= 0.982 = 98.2\%$$

Notice that the approximate circuit yields results that are sufficiently accurate.

P3

O.C

$$R_c' = \frac{(120)^2}{80} = 180\,\Omega \quad , \; a = \frac{450}{120} = 3.75$$

$$R_c = a^2 R_c' = \underline{\underline{2530\,\Omega}}$$

$$I_c' = \frac{120}{R_c'} = 0.667\,A \; , \; I_m' = \sqrt{I_o^2 - I_c'} = 4.15\,A$$

$$X_m' = \frac{120}{I_m'} = 28.94\,\Omega$$

$$X_m = a^2 X_m' = \underline{\underline{407}}\,\Omega$$

S.C

$$Z_{e_1} = \frac{9.65}{22.2} = 0.435\,\Omega$$

$$R_{e_1} = \frac{120}{(22.2)^2} = \underline{\underline{0.243}}\,\Omega$$

$$X_{e_1} = \sqrt{Z_{e_1}^2 - R_{e_1}^2} = \underline{\underline{0.361}}\,\Omega$$

$$I_{1FL} = \frac{10000}{450} = 22.2\,A$$

Voltage Drop $\simeq I_1 (R_{e_1} \cos\phi + X_{e_1} \sin\phi) \simeq 9.2\,V$

$$VR = \frac{9.2}{450} * 100 = 2.04\,\%$$

$$\eta_{FL} = \frac{10000 * 0.8}{10000 * 0.8 + 80 + 120} * 100 = 97.57\%$$

at half load

$$\eta = \frac{\frac{1}{2} * 10000 * 0.8}{\frac{1}{2} * 10000 * 0.8 + 80 + (\frac{1}{2})^2 * 120} * 100 = 97.34\%$$

P4

The rated current in the 110-V winding

$$I_1 = \frac{10{,}000}{110} = 90.91 \text{ A}$$

The current in the 440-V winding

$$I_3 = I_2 - I_1 = \frac{10{,}000}{440} = 22.73 \text{ A}$$

Thus the load current is

$$I_2 = I_1 + I_3 = 90.91 + 22.73 = 113.64 \text{ A}$$

Check: For the autotransformer

$$a = \frac{550}{440} = 1.25$$

and

$$I_2 = aI_1 = 1.25 \times \frac{10{,}000}{110} = 113.64 \text{ A}$$

which agrees with I_2 calculated above. Hence the rating of the autotransformer is

$$P_{\text{auto}} = V_2 I_2 = V_2 a I_1 = 440 \times 113.64 = 50 \text{ kVA}$$

Thus the inductively supplied apparent power is

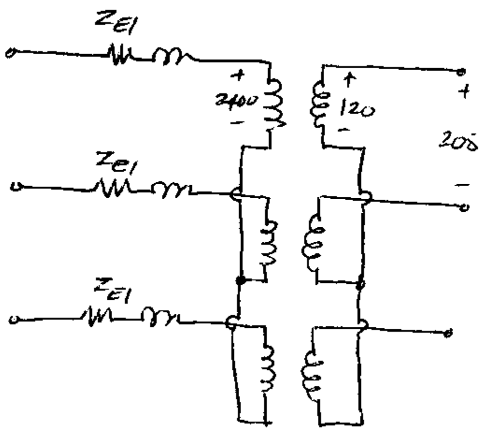
$$P_i = V_2(I_2 - I_1) = \frac{a-1}{a} P = \frac{1.25 - 1}{1.25} \times 50 = 10 \text{ kVA}$$

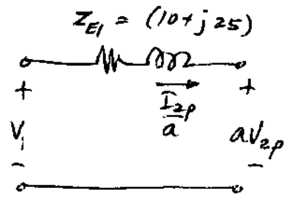
which is the volt-ampere rating of the two-winding transformer.

The conductively supplied power is

$$P_c = \frac{P}{a} = \frac{50}{1.25} = 40 \text{ kVA}$$

P5





$$a = \frac{2400}{120} = 20$$

$$I_{2p} = I_{2L} = \frac{27{,}000}{\sqrt{3}(208)(0.9)} \angle -\cos^{-1} 0.9 = 83.27 \angle +25.8^\circ \ A$$

$$I_{1L} = I_{1p} = \frac{I_{2p}}{a} = 4.16 \angle 25.8^\circ \ A$$

$$V_{1p} = aV_{2p} + \frac{I_{2p}}{a} Z_{E1} = 20(120 \angle 0) + (4.16 \angle 25.8^\circ)(10+j25)$$

$$= 2394.8 \angle 2.67^\circ \ V$$

$$V_{1L} = \sqrt{3}\, V_{1p} \angle 30^\circ = 4148 \angle 32.67^\circ \ V$$

$$PF = \cos(2.67^\circ - 25.8^\circ) = 0.92 \text{ leading}$$

$$V.R. = \frac{V_{1p} - aV_{2p}}{aV_{2p}} 100\% = \frac{2394.8 - 2400}{2400} 100\% = -0.2\%$$