Correction TD1 : Transformateur monophasé

Exercice 1

1°/ $m = \frac{U_{2V}}{U_{1V}} = \frac{225}{1500} = 0,15$

2°/ $I_a = I_{1V} \cos\varphi_V$ $\cos\varphi_V = \frac{P_{1V}}{U_{1V} I_{1V}}$

$\cos\varphi_V = \frac{300}{1500 \times 2} = 0,1$

$\rightarrow I_a = 2 \times 0,1 = 0,2A$

3°/ $p_{JV} = R_1 I_{1V}^2$ $R_1 = \frac{U_1}{I_1} = \frac{2,5}{10} = 0,25\Omega$ — essai en continu

$p_{JV} = 0,25 \times 2^2 = 1W$

$p_{JV} << P_{1V} = p_{Fer}$

4°/ $p_{Fer} = \alpha \times U_1^2$

Lors de l'essai en court-circuit : $p_{Fercc} = \alpha U_{1cc}^2$

" " à vide : $p_{FerV} = \alpha U_{1V}^2$

" $\Longrightarrow \alpha = \frac{p_{FerV}}{U_{1V}^2} = \frac{300}{1500^2} = 133.10^{-6}$ S

ce qui nous permet de calculer p_{Fercc}

$p_{Fercc} = \alpha U_{1cc}^2 = 133.10^{-6} \times 22,5^2 =$

$\boxed{p_{Fercc} = 0,0675W}$

autre méthode : À vide $p_{FerV} = \alpha \times U_{1V}^2$

en court-circuit $p_{Fercc} = \alpha U_{1cc}^2$

$$\Longrightarrow \frac{p_{Fercc}}{p_{FerV}} = \frac{\alpha U_{1cc}^2}{\alpha U_{1V}^2} = \left(\frac{U_{1cc}}{U_{1V}}\right)^2 \Longrightarrow$$

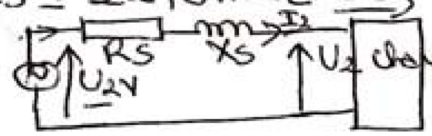
$$\boxed{p_{Fercc} = p_{FerV} \times \left(\frac{U_{1cc}}{U_{1V}}\right)^2}$$

AN : $p_{Fercc} = 300 \times \left(\frac{22,5}{1500}\right)^2 \simeq 0,0675W$

5°/ $R_S = \frac{P_{1cc}}{I_{2cc}^2}$ avec $I_{2cc} = \frac{I_{1cc}}{m} = \frac{22,5}{0,15} = 150A$

$R_S = \frac{225}{150^2} = 10 m\Omega$; $Z_S = \frac{m U_{1cc}}{I_{2cc}} = \frac{0,15 \times 22,5}{150}$

$Z_S = 22,5 m\Omega \Longrightarrow X_S = \sqrt{Z_S^2 - R_S^2} = 20,15 m\Omega$



6°) $U_1 = 1500V$;

$I_2 = 200A$

a) $\varphi_2 = (\vec{I_2}, \vec{U_2})$

$\Delta U_2 \simeq R_s I_2 \cos\varphi_2 + X_s I_2 \sin\varphi_2 = 0$

$\Longrightarrow R_s I_2 \cos\varphi_2 = - X_s I_2 \sin\varphi_2$

$\Longrightarrow R_s \cos\varphi_2 = - X_s \sin\varphi_2$

$\Longrightarrow \frac{R_s}{X_s} = -\frac{\sin\varphi_2}{\cos\varphi_2} = -\tan\varphi_2 \Longrightarrow \boxed{\tan\varphi_2 = -\frac{R_s}{X_s}}$

AN: $\tan\varphi_2 = -\frac{10}{20,15} = -0,496$

$\varphi_2 = \tan^{-1}(-0,496) = -26,38°$

il faut une charge capacitive de facteur de puissance

$\cos\varphi_2 = \cos(-26,38) = 0,895$

b) $\Delta U_2 \%$?

$\Delta U_2 \% = 100 \frac{U_{2V} - U_2}{U_{2V}} = \frac{\Delta U_2}{U_{2V}} \times 100$

$\Delta U_2 = R_s I_2 \cos\varphi_2 + X_s I_2 \sin\varphi_2$

$\varphi_2 = \cos^{-1}(0,8) = 36,86° \Longrightarrow \sin\varphi_2 = 0,6$

$\Delta U_2 = 10 \cdot 10^{-3} \times 200 \times 0,8 + 20,15 \cdot 10^{-3} \times 200 \times 0,6$

$\Delta U_2 = 4V \Longrightarrow \Delta U_2 \% = \frac{\Delta U_2}{U_{2V}} \times 100 = \frac{4}{225} \times 100$

$\boxed{\Delta U_2 \% = 1,77\%}$

$\eta = \frac{P_2}{P_1}$ avec $P_1 = P_2 + p_F + p_J$

$P_2 = U_2 I_2 \cos\varphi_2$

$U_2 = U_{2V} - \Delta U_2 = 225 - 4 = 221V$

$P_2 = 221 \times 200 \times 0,8 = 35360W$

$P_1 = 35360 + 300 + 225 = 35885W$

$\eta = \frac{35360}{35885} = \underline{98,54\%}$

Exercice 2:

1°/ $\cos\varphi = \cos 36° = 0{,}809$

2°/ La tension nominale d'un enroulement du stator est 400V, cette tension correspond à la tension composée du réseau ⟹ on couple le stator du moteur en TRIANGLE.

3°/ $J = \frac{U}{Z} = \frac{400}{46{,}5} = 8{,}6A$

4°/ $I = J \times \sqrt{3} = 8{,}6 \times \sqrt{3} = 14{,}9A$

5°/ $S = UI\sqrt{3} = 400 \times 14{,}9 \times \sqrt{3} = 10322W$

6°/ $P = UI\sqrt{3}\cos\varphi = 400 \times 14{,}9 \times \sqrt{3} \times 0{,}809$

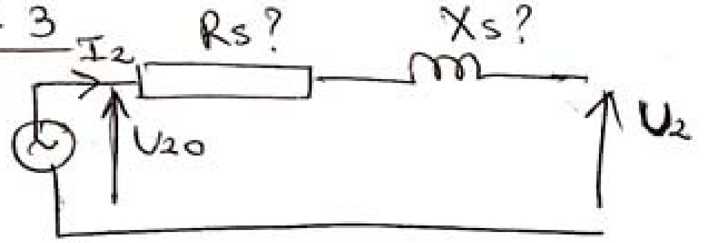
$P = 8350W$

7°/ $Q = P \times \tan\varphi = 8350 \times \tan 36 = 6066Var$

$\left(Q = \sqrt{S^2 - P^2} = \sqrt{10322^2 - 8350^2} = 6066Var\right)$

exercice 3

1°/



$$R_s = \frac{P_{1cc}}{I_{2cc}^2} = \frac{1000}{200^2} = 25\,m\Omega$$

$$Z_s = \frac{m\,U_{1cc}}{I_{2cc}} = 0{,}045 \times \frac{250}{200} = 56{,}25\,m\Omega$$

$$m = \frac{U_{20}}{U_1} = \frac{225}{5000} = 0{,}045$$

$$X_s = \sqrt{Z_s^2 - R_s^2} = \sqrt{56{,}25^2 - 25^2} = 50{,}39\,m\Omega$$

2°/ U_2 ? $\Delta U_2 = R_s I_2 \cos\varphi_2 + X_s I_2 \sin\varphi_2$

$\cos\varphi_2 = 0{,}8 \Rightarrow \varphi_2 = +\cos^{-1}(0{,}8) = 36{,}86°$

$\sin\varphi_2 = \sin 36{,}86 = 0{,}6$.

$\Delta U_2 = 25.10^{-3} \times 180 \times 0{,}8 + 56{,}25.10^{-3} \times 180 \times 0{,}6$

$\Delta U_2 = 9{,}675\,V$

$U_2 = U_{20} - \Delta U_2 = 225 - 9{,}675 = 215{,}325\,V$

Pertes Joule: p_J ?

$$\left.\begin{array}{l} P_{1cc} = R_s I_{2cc}^2 \\ P_J = R_s I_2^2 \end{array}\right\} \quad \frac{P_J}{P_{1cc}} = \frac{R_s I_2^2}{R_s I_{2cc}^2} = \left(\frac{I_2}{I_{2cc}}\right)^2$$

$$P_J = P_{1cc} \times \left(\frac{I_2}{I_{2cc}}\right)^2 = 1000 \times \left(\frac{180}{200}\right)^2$$

$\boxed{P_J = 810\,W}$ ← Pertes Joule pour $I_2 = 180\,A$

2°/ $\eta = \frac{P_2}{P_1} = \frac{P_2}{P_2 + p_F + p_J}$ $\quad p_F = P_{10} = 790\,W$ car tension primaire identique que lors de l'essai à vide

$P_2 = U_2 I_2 \cos\varphi_2 = 215{,}325 \times 180 \times 0{,}8 = 31006\,W$

$P_1 = 31006 + 790 + 810 = 32606\,W$

$\eta = \frac{31006}{32606} = 95\,\%$

exercice 4

1°/ $N_1 = \frac{N_2}{m}$ $m = \frac{U_{20}}{U_{10}} = \frac{700}{10.000} = 0,07$

$N_1 = \frac{595}{0,07} = 8500$ spires

2°/ U_2 ? pour $I_2 = 400\,A$
avec $\cos\varphi_2 = 0,8$ quand $U_1 = 10\,kV$

$U_2 = U_{20} - \Delta U_2$ et $\Delta U_2 = R_S I_2 \cos\varphi_2 + X_S I_2 \sin\varphi_2$
il faut calculer les valeurs de R_S et de X_S :

$R_S = \frac{P_{1cc}}{I_{2cc}^2} = \frac{8000}{400^2} = 50\,m\Omega$

$Z_S = \frac{m\,U_{1cc}}{I_{2cc}} = \frac{0,07 \times 1000}{400} = 175\,m\Omega$

$X_S = \sqrt{Z_S^2 - R_S^2} = \sqrt{175^2 - 50^2} =$

Calcul de la chute de tension : $\sin\varphi = \sqrt{1-\cos^2\varphi} = \sqrt{1-0,8^2} = 0,6$

$\Delta U_2 = 50.10^{-3} \times 400 \times 0,8 + 167,7.10^{-3} \times 400 \times 0,6$

$\Delta U_2 = 56,25\,V \Longrightarrow U_2 = U_{20} - \Delta U_2 = 700 - 56,25$

$U_2 = 643,75\,V$

Pour $I_2 = 200\,A$ $\Delta U_2 = R_S I_2 \cos\varphi_2 + X_S I_2 \sin\varphi_2$

$\Delta U_2 = 50.10^{-3} \times 200 \times 0,8 + 167,7.10^{-3} \times 200 \times 0,6 = 28,12\,V$

$P_2 = U_2 I_2 \cos\varphi_2 = (U_{20} - \Delta U_2)\, I_2 \cos\varphi_2 = (700 - 28,12) \times 200 \times 0,8$

$P_2 = 107,5\,kW$

$P_1 = P_2 + P_F + P_J$ pour $I_2 = 200\,A \Rightarrow$ $P_J = P_{1cc} \times \left(\frac{I_2}{I_{2cc}}\right)^2$

$P_J = 8000 \times \left(\frac{200}{400}\right)^2 = 2000\,W$

$P_F = P_{10} = 6900\,W$, car on a la même tension primaire

$P_1 = 107,5 + 2 + 6,9 = 116,4\,kW$

$\eta = P_2/P_1 = \frac{107,5}{116,4} = 92,35\%$

Exercice 5 :

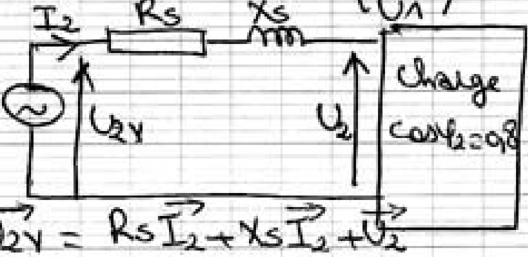
1°/

a) $\cos\varphi_v = \frac{P_{1v}}{S_{1v}} = \frac{P_{1v}}{U_{1v} I_{1v}} = \frac{36}{220 \times 0{,}3} = 0{,}545$

b) $N_2 = m \times N_1 = \left(\frac{U_{2v}}{U_1}\right) \times N_1 = \frac{110}{220} \times 500 = 250$ spires

2°/

a)



modèle équivalent de Thevenin du transformateur, vu du secondaire

$\vec{U_{2V}} = R_s\vec{I_2} + X_s\vec{I_2} + \vec{U_2}$

– calcul des éléments du modèle équivalent :

$R_s = \frac{P_{1cc}}{I_{2cc}^2} = \frac{30}{10^2} = 300\,m\Omega$

$Z_s = m\frac{U_{1cc}}{I_{2cc}} = 0{,}5 \times \frac{10}{10} = 500\,m\Omega$

$X_s = \sqrt{Z_s^2 - R_s^2} = 400\,m\Omega$

construction de Fresnel : $R_sI_2 = 0{,}3 \times 20 = 6V$

$X_sI_2 = 0{,}4 \times 20 = 8V$, $U_{2v} = 110V$

$\varphi_2 = (\vec{I_2}, \vec{U_2}) = \cos^{-1}(0{,}8) = 36{,}86°$

Echelle : 1cm ⟶ 10cm

R_sI_2 ⟶ 0,6cm

X_sI_2 ⟶ 0,8cm

U_{2V} ⟶ 11cm

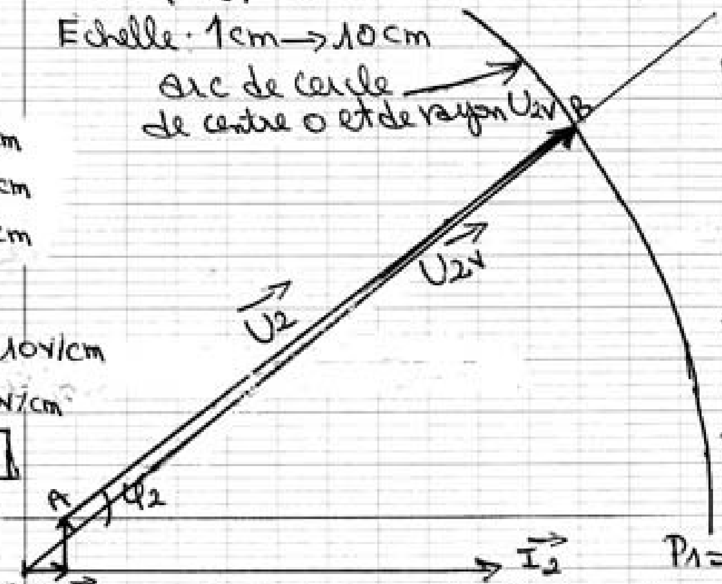


Diagramme de Kapp

$U_2 = AB_{cm} \times 10V/cm$

$U_2 = 10_{cm} \times 10V/cm$

$\boxed{U_2 = 100V}$

b/

$\Delta U_2 = U_{2V} - U_2$

$= 110 - 100$

$\boxed{\Delta U_2 = 10V}$

$\Delta U_2\% = \frac{\Delta U_2}{U_{2V}} \times 100$

$\Delta U_2\% = \frac{10}{110} \times 100 = 9\%$

3°/ $P_2 = U_2 I_2 \cos\varphi_2$

$P_2 = 100 \times 20 \times 0{,}8 = 1600W$

$P_1 = P_2 + P_F + P_J$

$P_J = P_{1cc} \times \left(\frac{I_2}{I_{2cc}}\right)^2 = 30 \times \left(\frac{20}{10}\right)^2$

$P_J = 120W$; $P_1 = 1600 + 36 + 120 = 1756W$

$\eta = \frac{P_2}{P_1} = \frac{1600}{1756} = 91{,}11\%$