EJERCICIO-3 DE TRANSFORMADORES (ej3Tr)

Un transformador trifásico D-y de 100 kVA, 15.000/380 V, 50 Hz, se ha sometido a los ensayos de vacío y cortocircuito obteniéndose los siguientes resultados:

Ensayo de vacio: Io=16 A, Po = 1.000 W, Uo=380 V.
E. de cortocircuito: I = 8 A, Pcc= 1.200 W, Ucc= 380 V.

Determinar:

1.- Las impedancias del circuito equivalente referido al devanado de AT.
2.- Las impedancias del circuito equivalente referido al devanado de BT.
3.- El porcentaje de regulación de tensión a plena carga con cosφ=0,8 inductivo (considerar el circuito equivalente aproximado).
4.-Los rendimientos a plena carga y a media carga para factores de potencia 0,8 inductivo y 0,6 capacitivo

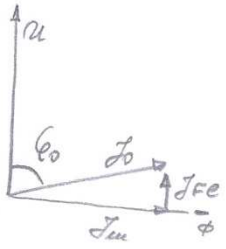
1.-

BT - λ $\Rightarrow$ $U_{fo} = \frac{U_{Lo}}{\sqrt{3}} = \frac{380}{\sqrt{3}} = 219,39\ V$

$P_{fo} = \frac{1000}{3} = 333,33\ W$

$I_{fo} = I_{oL} = 16\ A$

$P_{fFe} = P_{fo} = R_p I_p^2 = R_p \left(\frac{U_{fo}}{R_p}\right)^2 = \frac{U_{fo}^2}{R_p} \Rightarrow \boxed{R_{p_{BT}} = \frac{U_{fo}^2}{P_{fo}} = \frac{219,39^2}{333,33} = 144,40\ \Omega}$



$P_o = \sqrt{3}\, U_o I_o \cos\varphi_o \Rightarrow \cos\varphi_o = \frac{P_o}{\sqrt{3}\, U_o I_o} = \frac{1000}{\sqrt{3}\, 380.16} = 0,0949$

$\varphi_o = 84,55° \Rightarrow \operatorname{sen}\varphi_o = 0,9955$

$I_\mu = I_{fo} \cdot \operatorname{sen}\varphi_o = 16 \times 0,9955 = 15,93$

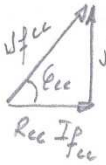
$\boxed{X_{m_{BT}} = \frac{U_{fo}}{I_\mu} = \frac{219,39}{15,93} = 13,77\ \Omega}$

AT - Δ

$P_{fcc} = \frac{P_{cc}}{3} = \frac{1.200}{3} = 400\ W$; $I_{fcc} = \frac{I}{\sqrt{3}} = \frac{8}{\sqrt{3}} = 4,62\ A$; $U_{fcc} = U_{cc} = 380\ V$

$P_{cc} = \sqrt{3}\, U_{cc} I \cos\varphi_{cc} \Rightarrow \cos\varphi_{cc} = \frac{P_{cc}}{\sqrt{3}\, U_{cc} I} = \frac{1200}{\sqrt{3}\, 380.8} = 0,2279 \Rightarrow \varphi_{cc} = 76,83°$

$\operatorname{sen}\varphi_{cc} = 0,9737$



$R_{cc} I_{fcc} = U_{fcc} \cdot \cos\varphi_{cc} \Rightarrow \boxed{R_{cc_{AT}} = \frac{U_{fcc}\cos\varphi_{cc}}{I_{fcc}} = \frac{380 \cdot 0,2279}{4,62} = 18,74\ \Omega}$

$X_{cc} I_{fcc} = U_{fcc} \operatorname{sen}\varphi_{cc} \Rightarrow \boxed{X_{cc_{AT}} = \frac{U_{fcc}\operatorname{sen}\varphi_{cc}}{I_{fcc}} = \frac{380 \cdot 0,9737}{4,62} = 80,09\ \Omega}$

$r_t = \frac{N_1}{N_2} = \frac{U_{fAT}}{U_{fBT}} = \frac{15.000}{\frac{380}{\sqrt{3}}} \simeq 68,37$

$\boxed{R_{pAT} = r_t^2 \cdot R_{pBT} = 68,37^2 \times 144,40 = 675\ k\Omega}$

$\boxed{X_{m_{AT}} = r_t^2 \cdot X_{m_{BT}} = 68,37^2 \times 13,77 = 64,368\ k\Omega}$

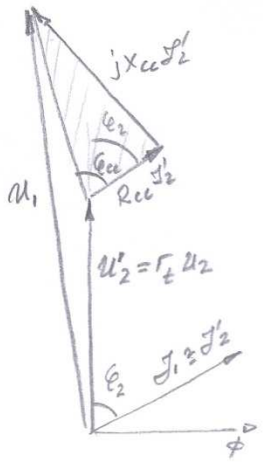
$\boxed{R_{cc_{BT}} = \frac{R_{cc_{AT}}}{r_t^2} = \frac{18,74}{68,37^2} = 4 \times 10^{-3}\ \Omega}$

$\boxed{X_{cc_{BT}} = \frac{X_{cc_{AT}}}{r_t^2} = \frac{80,09}{68,37^2} = 17,13 \times 10^{-3}\ \Omega}$

1.) AT $\Rightarrow$ $R_{cc_{AT}} = 18,74\ \Omega$ $X_{cc_{AT}} = 80,09\ \Omega$ $R_{p_{AT}} = 675\ k\Omega$ $X_{m_{AT}} = 64,368\ k\Omega$

2) BT $\Rightarrow$ $R_{cc_{BT}} = 4 \times 10^{-3}\ \Omega$ $X_{cc_{BT}} = 17,13 \times 10^{-3}\ \Omega$ $R_{p_{BT}} = 144,40\ \Omega$ $X_{m_{BT}} = 13,77\ \Omega$

3)



$$U_1 = U'_2 + R_{cc} I'_2 \cos\varphi_2 + X_{cc} I'_2 \operatorname{sen}\varphi_2 \qquad \begin{cases} \cos\varphi_2 = 0{,}8 \\ \operatorname{sen}\varphi_2 = 0{,}6 \end{cases}$$

$$15.000 = U'_2 + 18{,}74 \times 2{,}22 \times 0{,}8 + 80{,}09 \times 2{,}22 \times 0{,}6 \quad (*)$$

$$\left(S_n = \sqrt{3}\, U_n \cdot I_n \Rightarrow I_n = \frac{100.000}{\sqrt{3} \cdot 15.000} = 3{,}85\ A. \quad \Delta\, I_{nf} = \frac{I_n}{\sqrt{3}} = \underline{\underline{2{,}22\ A}} \right)$$

$$(*) \Rightarrow 15.000 = U'_2 + 139{,}96 \Rightarrow U'_2 = 14860\ V$$

$$Reg\,\% = \frac{(U_1 - U'_2) \times 100}{U_1} = \frac{15.000 - 14860}{15.000} \times 100 = 0{,}93\,\%$$

4) $$\eta_c\,\% = \frac{P_2 \cdot 100}{P_2 + P_o + c^2 P_c} = \frac{100 \times c\, S_n \cos\varphi}{c\, S_n \cos\varphi + P_o + c^2 P_{cc}} \leftarrow (*)$$

PC ($c = 1$)

$$\eta_{0,8} = \frac{1 \times 100.000 \times 0{,}8 \times 100}{1 \times 100.000 \times 0{,}8 + 1000 + 1^2 \cdot 277{,}8} = 98{,}43\,\%$$

$$\eta_{0,6} = \frac{1 \times 100.000 \times 0{,}6 \times 100}{1 \times 100.000 \times 0{,}6 + 1000 + 1^2 \cdot 277{,}8} = 97{,}91\,\%$$

MC ($c = 0{,}5$)

$$\eta_{0,8} = \frac{0{,}5 \times 100.000 \times 0{,}8 \times 100}{0{,}5 \times 100.000 \times 0{,}8 + 1000 + 0{,}5^2 \cdot 277{,}8} = 97{,}40\,\%$$

$$\eta_{0,6} = \frac{0{,}5 \times 100.000 \times 0{,}6 \times 100}{0{,}5 \times 100.000 \times 0{,}6 + 1000 + 0{,}5^2 \times 277{,}8} = 96{,}56\,\%$$

(*)
$$\begin{cases} AT \rightarrow R_{cc_{AT_f}} = 18{,}74\,\Omega \qquad I_{n_{AT}} = \dfrac{100.000}{\sqrt{3} \cdot 15.000} = 3{,}85\,\Omega \qquad AT \rightarrow \Delta \Rightarrow I_{n_{AT_f}} = \dfrac{I_{n_{AT}}}{\sqrt{3}} = \dfrac{3{,}85}{\sqrt{3}} = \underline{2{,}22\ A} \\ P_{cc_{n_f}} = R_{cc_{AT_f}} \cdot I^2_{n_{AT_f}} = 18{,}74 \times 2{,}22^2 = 92{,}59\ w \rightarrow \boxed{P_{cc_n}} = 3 \times 92{,}59 = \underline{\underline{277{,}8\ w}} \end{cases}$$