Una máquina asíncrona de 380 V, 50 Hz, 1425 rpm, con el estator en estrella, se somete a ensayos en fábrica y se obtienen los siguientes resultados:

ENSAYO DE VACIO: 380 V, 5 A, 900 W

E. ROTOR BLOQUEADO: 60 V, 16 A, 1000 W

Medida de la resistencia por fase del estator en caliente= 0,50 Ω

Pérdidas mecánicas consideradas constantes a las diferentes velocidades = 450 W.

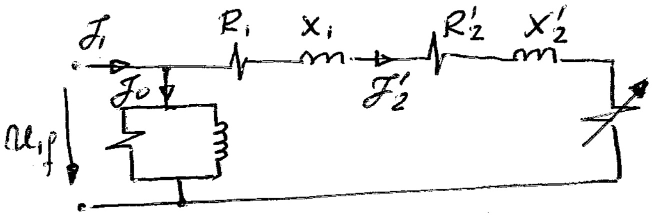
Determinar:

a) Parámetros del circuito equivalente aproximado

b) Corriente nominal, factor de potencia, par máximo, par de arranque, par nominal y par útil

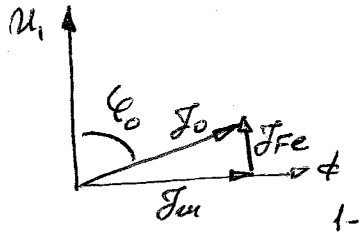
Si la máquina se acciona mediante una turbina hidráulica a la velocidad de 1560 rpm. Determinar:

c) Las potencias activa y reactiva enviadas a la red de 380 V y el par que suministra la turbina



$$R'_c = R'_2 \frac{(1-s)}{s}$$

a) $P_{Fe} = P_0 - P_{mec} - 3 R_1 I_0^2 = 900 - 450 - 3 \cdot 0{,}5 \cdot 5^2 = 412{,}50\ W$



$P_{Fe} = \sqrt{3}\, U_1 I_0 \cos\varphi_0$

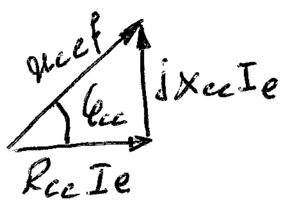
$\cos\varphi_0 = \dfrac{P_{Fe}}{\sqrt{3}\, U_1 I_0} = \dfrac{412{,}5}{\sqrt{3} \cdot 380 \cdot 5} = 0{,}1253$ $\left\{ \begin{array}{l} \varphi_0 = 82{,}80^\circ \\ \operatorname{sen}\varphi_0 = 0{,}992 \end{array} \right.$

1-λ

$I_m = I_0 \operatorname{sen}\varphi_0 = 5 \cdot 0{,}992 = 4{,}96 A$

$I_{Fe} = I_0 \cos\varphi_0 = 5 \cdot 0{,}1253 = 0{,}6265 A$

$R_{Fe} = \dfrac{U_{1f}}{I_{Fe}} = \dfrac{\frac{380}{\sqrt{3}}}{0{,}6265} = \underline{351{,}16\ \Omega}$ (1-λ) $\quad X_\mu = \dfrac{U_{1f}}{I_\mu} = \dfrac{220}{4{,}96} = \underline{44{,}35\ \Omega}$



$P_{cc} = \sqrt{3}\, U_{cc} I_e \cos\varphi_{cc}$

$\cos\varphi_{cc} = \dfrac{P_{cc}}{\sqrt{3}\, U_{cc} I_e} = \dfrac{1000}{\sqrt{3} \cdot 60 \cdot 16} = 0{,}6014$ $\left\{ \begin{array}{l} \varphi_{cc} = 53{,}03^\circ \\ \operatorname{sen}\varphi_{cc} = 0{,}7989 \end{array} \right.$

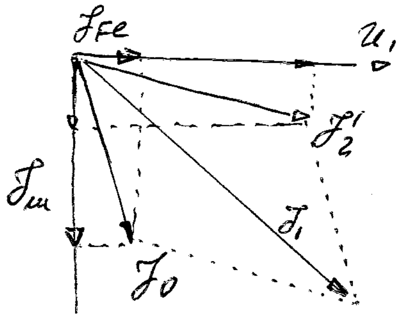
$U_{ccf} \cos\varphi_{cc} = R_{cc} I_e \Rightarrow \underline{R_{cc}} = \dfrac{U_{ccf} \cos\varphi_{cc}}{I_e} = \dfrac{\frac{60}{\sqrt{3}} \cdot 0{,}6014}{16} = \underline{1{,}30\ \Omega}$

$R_{cc} = R_1 + R'_2 \Rightarrow \underline{R'_2} = R_{cc} - R_1 = 1{,}30 - 0{,}5 = \underline{0{,}80\ \Omega}$

$U_{ccf} \operatorname{sen}\varphi_{cc} = X_{cc} I_e \Rightarrow \underline{X_{cc}} = \dfrac{U_{ccf} \operatorname{sen}\varphi_{cc}}{I_e} = \dfrac{\frac{60}{\sqrt{3}} \cdot 0{,}7989}{16} = \underline{1{,}73\ \Omega}$

b) R_c' $\quad s_n = \dfrac{1500-1425}{1500} = 0{,}05 \quad R_c' = R_2' \dfrac{(1-s)}{s} = 0{,}80\, \dfrac{1-0{,}05}{0{,}05} = \underline{15{,}2\ \Omega}$

$$Z_1 = (0{,}50 + 0{,}80 + 15{,}2) + j1{,}73 = 16{,}50 + j1{,}73 = 16{,}59\ \angle 5{,}99°$$



$$I_{2n}' = \frac{U_{1f}}{Z_1} = \frac{220\angle 0}{16{,}59\angle 5{,}99} = 13{,}26\ \angle -5{,}99$$
$$= 13{,}19 - j1{,}38$$

$$I_{1fn} = (13{,}19 + 0{,}6265) - j(1{,}38 + 4{,}96)$$
$$= 13{,}8165 - j6{,}34 = \underline{15{,}20}\ \angle -24{,}65°$$

$$I_{1n} = I_{1fn} = 15{,}20\,A \qquad \cos\varphi_1 = \cos(-24{,}65°) = \underline{0{,}909}$$

$$s_m = \frac{R_2'}{\sqrt{R_1^2 + X_{cc}^2}} = \frac{0{,}80}{\sqrt{0{,}50^2 + 1{,}73^2}} = 0{,}444$$

$$M_{max} = \frac{3\, \frac{R_2'}{s_m} \cdot U_{1f}^2}{\frac{2\pi n_s}{60}\left[\left(R_1 + \frac{R_2'}{s_m}\right)^2 + X_{cc}^2\right]} = \frac{3 \cdot \frac{0{,}80}{0{,}444} \cdot \left(\frac{380}{\sqrt{3}}\right)^2}{\frac{2\pi \cdot 1500}{60}\left[\left(0{,}50 + \frac{0{,}80}{0{,}444}\right)^2 + 1{,}73^2\right]} = \underline{199{,}80\,Nm}$$

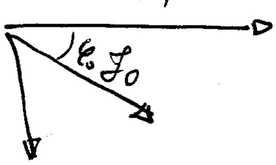
$$s = 1 \Rightarrow M_a = \frac{3 \cdot \frac{0{,}80}{1} \cdot 220^2}{\frac{2\pi \cdot 1500}{60}\left[\left(0{,}50 + \frac{0{,}80}{1}\right)^2 + 1{,}73^2\right]} = \underline{157{,}91\,Nm}$$

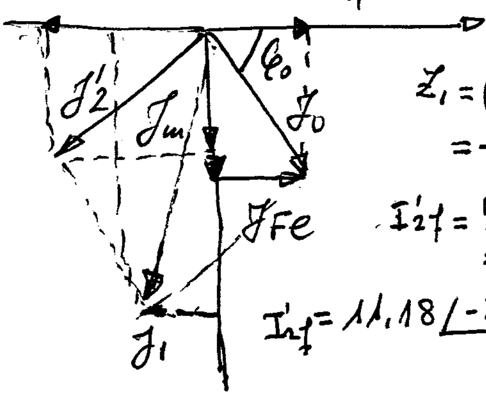
$$M_{i\,nom} = \frac{3\, \frac{R_2'}{s_n} \cdot I_n'^2}{\frac{2\pi n_s}{60}} = \frac{3 \cdot \frac{0{,}8}{0{,}05} \cdot 13{,}26^2}{\frac{2\pi \cdot 1500}{60}} = \underline{53{,}73\,Nm}$$

$$M_{perd} = \frac{perd_{mec}}{\Omega_r} = \frac{450}{\frac{2\pi \cdot 1425}{60}} = 3{,}02\,Nm.$$

$$\underline{M_u} = M_{i\,nom} - M_{perd} = 53{,}73 - 3{,}02 = \underline{50{,}71\,Nm}$$

3) c)





$$Z_1 = (0{,}50 + 0{,}80 - 20{,}8) + j1{,}73$$
$$= -19{,}5 + j1{,}73 = 19{,}58\angle 174{,}93°$$

$$s_g = \frac{1500-1560}{1500} = -0{,}04$$

$$R_c' = \frac{0{,}80\,[1-(-0{,}04)]}{-0{,}04} = -20{,}8\ \Omega$$

$$I_{2f}' = \frac{U_{1f}}{Z_1} = \frac{220\angle 0}{19{,}67\angle 174{,}93} =$$

$$I_{2f}' = 11{,}18\angle -174{,}93 = -11{,}14 - j0{,}99$$

$$I_1 = (-11{,}14 + 0{,}6265) - j(0{,}99 + 4{,}96) = -10{,}51 - j5{,}95 = ?$$

$$S = 3U_1 I_1^* = 3 \cdot 220(-10{,}51 + j5{,}95) = \underline{-6.937} + j\,\underline{3927} = P + jQ$$

$$P_{IM} = 3 \cdot R_c' I_2' = 3 \cdot (-20{,}8) \cdot 11{,}18^2 = -7799\ W$$

$$P_{J1} = 3 R_1 I_2'^2 = 3 \cdot 05 \cdot 11{,}18^2 = 187{,}5\ W$$

$$P_{J2} = 3 R_2' I_2'^2 = 3 \cdot 0{,}8 \cdot 11{,}18^2 = 300\ W$$

$$P_{Fe} = 3 \cdot 351{,}16 \cdot 0{,}6265^2 = 412{,}5\ W$$

$$P_u = 7799 - 187{,}5 - 300 - 412{,}5 = 6.899\ W$$

Diferencia: $\underline{38\ W}$

$$M_T = \frac{-(7799 + 450)}{\frac{2\pi \cdot 1560}{60}} = -\underline{\underline{50{,}5\ Nm}}$$