Ejercicio MAs 151214

Una máquina asíncrona de 400 V, 50 Hz, 1.450 rpm, con el estator en estrella, se somete a ensayos y se obtienen los siguientes resultados:

E. VACIO: 400 V, 7 A, 800 W. E. A ROTOR BLOQUEADO: 62 V, 18 A, 1.300 W.

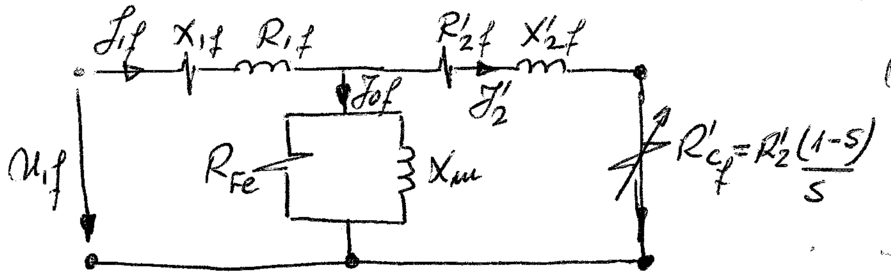
Considerando las pérdidas mecánicas despreciables y la resistencia del estator de 0,7 Ω. Determinar:

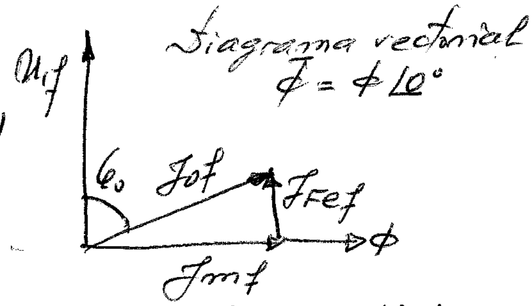
a) Los parámetros del circuito equivalente aproximado.

b) Par de arranque, par máximo y par nominal.

c) Velocidad del motor cuando consume una corriente mitad de la de arranque y par interno desarrollado por la máquina en esa situación.

d) Si la máquina se acciona mediante una turbina hidráulica a 1.580 rpm, determinar las potencias activa y reactiva enviada a la red de 400 V y el par suministrado por la turbina.





a) $P_{Fe} = P_0 - perd_{mec} - 3 R_{1f} I_{0f}^2 = 800 - 0 - 3 \cdot 0{,}7 \cdot 7^2 = 697{,}1 \text{ W}$

$P_{Fe} = \sqrt{3} \cdot U_0 I_0 \cos\varphi_0 \Rightarrow \cos\varphi_0 = \dfrac{P_{Fe}}{\sqrt{3} \cdot I_0 U_0} = \dfrac{697{,}1}{\sqrt{3} \cdot 7 \cdot 400} = 0{,}1437 \quad \varphi_0 = 81{,}736°$

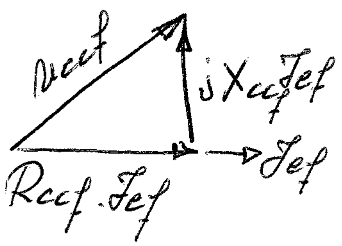
$\operatorname{sen}\varphi_0 = 0{,}9896$

$I_{Fef} = I_{0f} \cdot \cos\varphi_0 = 7 \cdot 0{,}1437 = 1 \text{ A}, \quad I_{mf} = I_{0f} \operatorname{sen}\varphi_0 = 7 \cdot 0{,}9896 = 6{,}93 \text{ A}$

$R_{Fef} = \dfrac{U_{0f}}{I_{Fef}} = \dfrac{\frac{400}{\sqrt{3}}}{1} = \underline{230{,}94\ \Omega} \qquad X_{mf} = \dfrac{U_{0f}}{I_{mf}} = \dfrac{\frac{400}{\sqrt{3}}}{6{,}93} = \underline{33{,}32\ \Omega}$

$P_{cc} = \sqrt{3} \cdot U_{cc} \cdot I_e \cdot \cos\varphi_{cc} \Rightarrow \cos\varphi_{cc} = \dfrac{P_{cc}}{\sqrt{3} \cdot U_{cc} I_e} = \dfrac{1300}{\sqrt{3} \cdot 62 \cdot 18} = 0{,}672 \Rightarrow \varphi_{cc} = 47{,}78°$

$\Rightarrow \operatorname{sen}\varphi_{cc} = 0{,}74$



$R_{ccf} = \dfrac{U_{ccf} \cdot \cos\varphi_{cc}}{I_{ef}} = \dfrac{\frac{62}{\sqrt{3}} \cdot 0{,}672}{18} = \underline{1{,}34\ \Omega}$

$R_{ccf} = R_{1f} + R'_{2f} \Rightarrow R'_{2f} = 1{,}34 - 0{,}7 = \underline{0{,}64\ \Omega}$

$X_{ccf} = \dfrac{U_{ccf} \cdot \operatorname{sen}\varphi_{cc}}{I_{ef}} = \dfrac{\frac{62}{\sqrt{3}} \cdot 0{,}74}{18} = \underline{1{,}47\ \Omega}$

b) $M_i = \dfrac{3 \cdot \frac{R'_{2f}}{s} U_f^2}{\frac{2\pi n_s}{60}\left[\left(R_{1f} + \frac{R'_{2f}}{s}\right)^2 + X_{cc}^2\right]} \Rightarrow$ ARRANQUE $(s=1)$ $\Rightarrow M_a = \dfrac{3 \cdot \frac{0{,}64}{1} \left(\frac{400}{\sqrt{3}}\right)^2}{\frac{2\pi \cdot 1500}{60}\left[\left(0{,}7 + \frac{0{,}64}{1}\right)^2 + 1{,}47^2\right]} =$

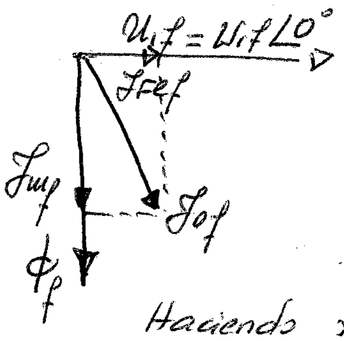
$\underline{M_a = 164{,}77 \text{ Nm}}$

$s_m = \dfrac{R'_2}{\sqrt{R_1^2 + X_{cc}^2}} = \dfrac{0{,}64}{\sqrt{0{,}7^2 + 1{,}47^2}} = 0{,}393 \Rightarrow M_{max} = \dfrac{3 \cdot \frac{0{,}64}{0{,}393} \left(\frac{400}{\sqrt{3}}\right)^2}{\frac{2\pi \cdot 1500}{60}\left[\left(0{,}7 + \frac{0{,}64}{0{,}393}\right)^2 + 1{,}47^2\right]} = \underline{218{,}75 \text{ Nm}}$

$$s_n = \frac{1500-1450}{1500} = 0{,}033 \Rightarrow M_n = \frac{3\cdot\frac{0{,}64}{0{,}033}\cdot\left(\frac{400}{\sqrt{3}}\right)^2}{\frac{2\pi\cdot1500}{60}\left[\left(0{,}7+\frac{0{,}64}{0{,}033}\right)^2+1{,}47^2\right]} = \underline{48{,}66\ Nm}$$

c) $$Z_{12af} = \left(0{,}7+\frac{0{,}64}{1}\right)+j1{,}47 = 1{,}34+j1{,}47 = 1{,}99\,\underline{/47{,}65^\circ}$$

$$I'_{2af} = \frac{U_{1f}}{Z_{12af}} = \frac{\frac{400}{\sqrt{3}}\underline{/0^\circ}}{1{,}99\,\underline{/47{,}65}} = 116{,}05\,\underline{/-47{,}65} = 78{,}18-j85{,}77$$



$$I_{1af} = I_{0f}+I'_{2af} = (78{,}18+1)-j(85{,}77+6{,}93)$$
$$= 79{,}18-j92{,}67 = 121{,}91\,\underline{/-49{,}50^\circ}\ A.$$

$$\frac{121{,}91}{2} = \frac{\frac{400}{\sqrt{3}}}{\sqrt{\left(0{,}7+\frac{0{,}64}{s}\right)^2+1{,}47^2}} \Rightarrow (0{,}7+x)^2+1{,}47^2 = \left(\frac{\frac{400}{\sqrt{3}}}{\frac{121{,}91}{2}}\right)^2 = 14{,}35$$

Haciendo $x = \frac{0{,}64}{s}$

$$x^2+1{,}4x+0{,}7^2+1{,}47^2-14{,}35=0 \Rightarrow x^2+1{,}4x-12{,}19=0$$

$$x = \frac{-1{,}4\pm\sqrt{1{,}4^2+4\cdot12{,}19}}{2} = \frac{-1{,}4\pm7{,}12}{2} = \begin{cases}2{,}86\\-4{,}26\end{cases} \rightarrow s = \frac{0{,}64}{x} = \begin{cases}\underline{0{,}22}\ \text{MOTOR}\\-0{,}15\ \text{GEN.}\end{cases}$$

$$s = 0{,}22 = \frac{1.500-n_r}{1.500} \Rightarrow n_r = 1500(1-0{,}22) = \underline{1.170}\ rpm$$

$$M_i = \frac{3\cdot\frac{0{,}64}{0{,}22}\left(\frac{400}{\sqrt{3}}\right)^2}{\frac{2\pi\cdot1500}{60}\left[\left(0{,}7+\frac{0{,}64}{0{,}22}\right)^2+1{,}47^2\right]} = \underline{195{,}12\ Nm}$$

d) $$s = \frac{1500-1580}{1500} = -0{,}053 \Rightarrow R'_{cf} = 0{,}64\frac{(1+0{,}053)}{-0{,}053} = -12{,}72\ \Omega$$

$$Z_{12f} = (0{,}7+0{,}64-12{,}72)+j1{,}47 = -11{,}38+j1{,}47 = 11{,}47\,\underline{/172{,}64^\circ}$$

$$I'_{2f} = \frac{U_{1f}}{Z_{12f}} = \frac{\left(\frac{400}{\sqrt{3}}\right)\underline{/0^\circ}}{11{,}47\,\underline{/172{,}64}} = 20{,}13\,\underline{/-172{,}64} = -19{,}96-j2{,}58$$

$$I_{1f} = I_{0f}+I'_{2f} = (-19{,}96+1)-j(2{,}58+6{,}93) = -18{,}96-j9{,}51$$

$$S = 3\cdot U_{1f}\cdot I_{1f}^{*} = 3\cdot\left(\frac{400}{\sqrt{3}}\right)(-18{,}96+j9{,}51) = -13.136+j6.589 = P+jQ$$

$$\left.\begin{aligned}P &= -13.136\ W\\ Q &= 6.589\ VAr\end{aligned}\right\} \qquad P_{mec} = 3R'_{cf}I'^{2}_{2f} = 3(-12{,}72)\cdot20{,}13^2 = -15.463\ W$$

$$M_T = \frac{|P_{mec}|+perd_{mec}}{\frac{2\pi n_r}{60}} = \frac{15463}{\frac{2\pi\cdot1580}{60}} = \underline{93{,}46\ Nm}$$