Ασύγχρονος τριφασικός κινητήρας

$$\mathbf{V}_1 = \mathbf{I}_1(R_1 + jX_1) + \mathbf{E}_1$$

$$P_{\text{int}} = P_{w,c} + P_m \;,\; P_g = P_{\text{int}} + P_{Cu,r} \;,\; P_{in} = P_g + P_{Cu,r} \;,\; P_{Cu,s} = 3I_1^2 R_1 \;,\; P_{Cu,r} = 3I_2^2 R_2$$

$$P_g = P_{in} - P_{Cu,s} = 3I_2^2\left(\frac{R_2}{s}\right) \;,\; P_{int} = P_{em} = P_g - P_{Cu,r} = (1-s)P_g \;,\; P_{Cu,r} = 3I_2^2 R_2 = sP_g$$

$$\omega_r = (1-s)\omega_s \;,\; P_{\text{int}} = 3I_2^2\left(\frac{R_2}{s}\right) - 3I_2^2 R_2 = 3I_2^2 R_2\frac{(1-s)}{s} \;,\; T_{\text{int}} = \frac{P_{\text{int}}}{\omega_r} = \frac{(1-s)P_g}{\omega_r} \;,$$

$$T_{\text{int}} = \frac{P_{\text{int}}}{\omega_r} = \frac{P_g}{\omega_s} \;,\; T_{\text{int}} = \frac{3}{\omega_r} I_2^2 R_2\left(\frac{1-s}{s}\right) = \frac{3}{\omega_s} I_2^2 \frac{R_2}{s},$$

$$\mathbf{V_{TH}} = jX_m\mathbf{I}_1 = jX_m\frac{\mathbf{V}_1}{R_1 + j(X_1 + X_m)} = \mathbf{V}_1\frac{jX_m}{R_1 + jX_{11}} \;,\; X_{11} = X_1 + X_m, \; I_2 = \frac{V_{TH}}{\sqrt{\left(R_{TH} + \frac{R_2}{s}\right)^2 + \left(X_{TH} + X_2\right)^2}}$$

$$R_{TH} = \frac{X_m^2 R_1}{R_1^2 + X_{11}^2} \;,\; X_{TH} = \frac{X_m(R_1^2 + X_1 X_{11})}{R_1^2 + X_{11}^2} \;,\; s_{\max T} = \pm\frac{R_2}{\sqrt{R_{TH}^2 + \left(X_{TH} + X_2\right)^2}}$$

$$T_{\text{int}} = \frac{3}{\omega_s}\frac{V_{TH}^2\left(\frac{R_2}{s}\right)}{\left(R_{TH} + \frac{R_2}{s}\right)^2 + \left(X_{TH} + X_2\right)^2} \;,\; T_{\max} = \frac{3}{2\omega_s}\frac{V_{TH}^2}{R_{TH} + \sqrt{R_{TH}^2 + (X_{TH} + X_2)^2}}$$

$$P_{nl} = P_{W_1} + P_{W_2} \;,\; X_{nl} = X_1 + X_m \;,\; X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2} \;,\; Z_{nl} = \frac{V_{nl}}{\sqrt{3}\,I_{nl}} \;,\; R_{nl} = \frac{P_{nl}}{3I_{nl}^2}$$

$$X_{br} = X_1 + X_2 \;,\; X_{br} = \sqrt{Z_{br}^2 - R_{br}^2} \;,\; Z_{br} = \frac{V_{br}}{\sqrt{3}\,I_{br}} \;,\; R_{br} = \frac{P_{br}}{3I_{br}^2} \;,\; X_1 = X_2 = \frac{X_{br}}{2} \;,\; R_2 = R_{br} - R_1 \;,\; Q = \frac{X_1 + X_2}{R_1}$$

Ασύγχρονος μονοφασικός κινητήρας

$$s_f = \frac{n_s - n_r}{n_s} \;,\; s_b = \frac{n_s - (-n_r)}{n_s} = 1 + \frac{n_r}{n_s} = 1 + (1 - s_f) = 2 - s_f$$

$$\mathbf{Z}_f = R_f + jX_f = \left(\frac{jX_m}{2}\right)//\left(\frac{R_2}{2s} + \frac{jX_2}{2}\right) \;,\; \mathbf{Z}_b = R_b + jX_b = \left(\frac{jX_m}{2}\right)//\left(\frac{R_2}{2(2-s)} + \frac{jX_2}{2}\right)$$

$$P_{gf} = I_s^2 R_f \;,\; P_{gb} = I_s^2 R_b \;,\; P_g = P_{gf} - P_{gb} \;,\; P_{\text{m}} = P_{\text{int}} - P_{\text{w,c}} \;,\; P_{\text{int}} = (1-s)P_g = (1-s)I_s^2(R_f - R_b) \;,$$

$$T_{em} = T_f - T_b \;,\; T_{\text{int}} = \frac{1}{\omega_s} I_s^2(R_f - R_b)$$

$$\mathbf{Z_f}(s \to 0) = R_f + jX_f = \frac{jX_m}{2}//\left[\frac{R_2}{2s} + j\frac{X_2}{2}\right] \approx \frac{jX_m}{2} = jX_f \;,\; \mathbf{Z_b}(s \to 0) = \frac{jX_m}{2}//\left[\frac{R_2}{4} + j\frac{X_2}{2}\right] \approx \frac{R_2}{4} + j\frac{X_2}{2}$$

$$X_{nl} = X_1 + \frac{X_m}{2} + \frac{X_2}{2} \;,\; Z_{nl} = \frac{V_{s,nl}}{\sqrt{3}\,I_{s,nl}} \;,\; R_{nl} = \frac{P_{nl}}{3I_{s,nl}^2} \;,\; X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2} \;,\; X_1 = X_2 = \frac{X_L}{2}$$

$$X_L = X_1 + X_2 \quad , \quad X_m = 2X_{nl} - 3X_1 \quad , \quad R_{br} = \frac{P_{br}}{I_{s,br}^2}$$

<u>Σύγχρονες Μηχανές</u>

$$\mathbf{E_f} = \mathbf{E_R} + jx_a\mathbf{I_a} = \mathbf{V_a} + j\mathbf{I_a}(r_a + jx_s) \quad , \quad \mathbf{E_f} = \mathbf{E_R} - jx_a\mathbf{I_a} = \mathbf{V_a} - j\mathbf{I_a}(r_a + jx_s) \quad , \quad x_s = x_a + x_{al}$$

$$P_{\text{int}} = 3\,\text{Re}\left\{\mathbf{E_f}\mathbf{I_a^*}\right\} \quad , \quad \mathbf{I_a} = \frac{\mathbf{E_f} - \mathbf{V_a}}{r_a + jx_s} = \frac{\mathbf{E_f} - \mathbf{V_a}}{\mathbf{z_s}} \quad , \quad P_{int} = 3\left(\frac{E_f^2}{z_s}\cos\varphi - \frac{E_f V_a}{z_s}\cos(\delta + \varphi)\right),$$

$$Q_{\text{int}} = \text{Im}\left\{\mathbf{S_{int}}\right\} = 3\left(\frac{E_f^2}{z_s}\sin\phi - \frac{E_f V_a}{z_s}\sin(\delta + \phi)\right)$$

$$P_{\text{int}} = P_L + I_a^2 r_a \quad , \quad Q_{\text{int}} = Q_L + I_a^2 x_s \quad , \quad P_{\text{int}} = P_L = 3\,\frac{V_a E_f}{x_s}\sin\delta = P_{\max}\sin\delta$$

$$Q_{\text{int}} = 3\left(\frac{E_f^2}{z_s} - \frac{E_f V_a}{z_s}\cos\delta\right) \quad , \quad Q_L = 3\left(\frac{V_a E_f}{z_s}\cos\delta - \frac{V_a^2}{z_s}\right) \quad , \quad P_{\max} = \frac{3E_f V_a}{x_s}$$

$$T = \frac{P_{\text{int}}}{\omega_s} = \frac{3}{\omega_s}\,\frac{V_a E_f}{x_s}\sin\delta = T_{\max}\sin\delta \quad , \quad T_{\max} = \frac{3}{\omega_s}\frac{E_f V_a}{x_s} \quad , \quad \delta = \tan^{-1}\left(\frac{I_a X_q\cos\phi}{V_a + I_a X_q\sin\phi}\right)$$

$$r_{in} = 2r_a \quad , \quad r_a = \frac{r_{in}}{2} = \frac{V_{dc}}{2I_{dc}} \quad , \quad r_{in} = r_a \,//\, 2r_a = \frac{2r_a}{3} \quad , \quad r_a = \frac{3r_{in}}{3} = \frac{2V_{dc}}{3I_{dc}}$$

$$\mathbf{I_a} = \frac{\mathbf{V_a} - \mathbf{E_a}}{jx_s} \quad , \quad \mathbf{S} = P + jQ = 3\,\frac{V_a E_f}{x_s}\sin\delta + j\left(\frac{3V_a E_f}{x_s}\cos\delta - \frac{3V_a^2}{x_s}\right)$$