Službeni podsjetnik – Projektiranje u elektrostrojarstvu (ak. god. 2015./2016.)

Magnetski ekvivalentni krugovi

$$R_m = \frac{1}{\mu}\frac{l}{S} \qquad \Lambda = \frac{1}{R_m} = \mu\frac{S}{l}$$

$$\phi = \frac{\theta}{R_m} = \theta\Lambda$$

$$\Theta = NI \qquad \Psi = N\phi$$

$$E = \frac{1}{2}\,\theta\phi = \frac{1}{2}\,\phi^2 R_m = \frac{1}{2}\,\frac{\theta^2}{R_m} = \frac{1}{2}\,LI^2$$

$$L = \frac{\Psi}{I} = \frac{N^2}{R_m} = N^2\Lambda = \mu N^2\frac{S}{l}$$

Inducirani napon

$$U = 4 f_0 f f_n \alpha_i B_\delta l_i \tau_p w$$

w - broj u seriju spojenih zavoja po fazi

-za jednoslojni namot

$$w = \frac{N}{2ma} w_{sv}$$

-za dvoslojni namot

$$w = \frac{N}{ma} w_{sv}$$

Faktori namota

Zonski faktor namota:

$$f_{z,\nu} = \frac{\sin\left(q\,\frac{\nu\alpha}{2}\right)}{qb\sin\left(\frac{\nu\alpha}{2b}\right)}$$

$q = \frac{N}{2pm} = \frac{a}{b}$ - broj utora po polu i fazi

$\alpha = \frac{2\pi p}{N}$ - el. kut među naponima u susjednim utorima

Tetivni faktor namota:

$$f_{t,\nu} = \sin\left(\frac{\pi}{2}\frac{\nu Y}{\mathrm{T}_p}\right)$$

Faktor namota zbog skošenja:

$$f_{\beta,\nu} = \frac{\sin\left(\frac{\nu\beta}{2}\right)}{\frac{\nu\beta}{2}}$$

Ukupni faktor namota:

$$f_{n,\nu} = f_{z,\nu} f_{t,\nu} f_{\beta,\nu}$$

Poništavanje v-tog harmonika:

$$Y = \frac{\nu - 1}{\nu} T_p$$

Idealna duljina stroja

Duljina paketa:

$$L = L_{Fe} + n_k b_k$$

Idealna duljina paketa:

$$l_i = L - n_k b_k'$$

$$b_k' = \kappa b_k \quad \kappa = \frac{\frac{b_k}{\delta}}{5 + \frac{b_k}{\delta}}$$

Neto duljina željeza:

$$L_{netto} = k_{Fe} L_{Fe}$$

Idealna duljina zračnog raspora

Carterov faktor:

$$k_c = \frac{\tau_u}{\tau_u - \kappa o}$$

$$\kappa = \frac{\frac{o}{\delta}}{5 + \frac{o}{\delta}}$$

Idealna duljina zračnog raspora:

$$\delta_i = k_c \delta$$

$$\delta_{i,uk} = \delta_{i,stator}\delta_{i,rotor}$$

Magnetski krug električnog stroja

Zračni raspor:

$$V_\delta = \frac{B_\delta}{\mu_0}\delta_i$$

Zubi (*h* - proizvoljna visina):

$$B_z(h) = \frac{\tau_u l_i B_\delta}{b_z(h) k_{Fe} L_{Fe}}$$

$$b_z(h) = \tau_u(h) - o(h)$$

$$\tau_u(h) = \frac{(D \pm 2h)\pi}{N}$$

$$k_z(h) = \frac{\tau_u(h) - k_{Fe} b_z(h)}{k_{Fe} b_z(h)}$$

$$V_z = H_z' h_z$$

Jaram statora i rotora:

$$B_j = \frac{\phi_j}{h_{js} k_{Fe} L_{Fe}}$$

$$V_j = k_j H_j l_j$$

Ukupni pad napona:

$$V_{uk} = 2V_\delta + 2V_z + V_{js} + V_{jr} = 2\theta_1$$

$$\theta_1 = \frac{3}{2}\frac{4}{\pi}\frac{I\sqrt{2}}{2p}\frac{w}{a} f_{n1}$$

$k_{zas} = \frac{V_{uk}}{V_\delta}$ (za asinkrone strojeve)

Rasipni induktivitet statora

Specifična rasipna magnetska vodljivost utora:

- za jednoslojni namot:

$$\lambda_u = \frac{h_4}{3b_4} + \frac{h_3}{b_3} + \frac{h_1}{b_1} + \frac{h_2}{b_4 - b_1}\ln\left(\frac{b_4}{b_1}\right)$$

- za dvoslojni namot:

$$\lambda_u = k_1\lambda_{Cu} + k_2\lambda_{zrak} + \frac{h'}{4b}$$

$$k_1 = 1 - \frac{9}{16}\varepsilon \qquad k_2 = 1 - \frac{3}{4}\varepsilon \qquad \varepsilon = 1 - \frac{Y}{T_p}$$

Rasipni idnuktivitet (utorska kompona)

$$L_{u\sigma} = \frac{4m}{N}\mu_0 l_i w^2 \lambda_u = \mu_0 l_i \frac{N}{m}\left(\frac{z_u}{a}\right)^2$$

Specifična rasipna magnetska vodljivost vrhova zubiju

$$\lambda_z = \frac{5\frac{\delta}{o}}{5 + 4\frac{\delta}{o}}$$

Rasipni idnuktivitet (zbog rasipanja vrhova zubiju)

$$L_{z\sigma} = \frac{4m}{N}\mu_0 l_i w^2 \lambda_z$$

Rasipni idnuktivitet (zbog rasipanja glava namota)

$$L_{g\sigma} = \frac{2}{p}\,w^2 \mu_0 l_g \lambda_g$$

Prigušni kavez

$$k_p = 2\sin\left(\frac{\pi p}{N_r}\right) \qquad I_p = \frac{I_š}{k_p}$$

$$R = r_š + \frac{2r_p}{k_p^2} \qquad X_\sigma = x_{š\sigma} + \frac{2x_{p\sigma}}{k_p^2}$$

Rasipni induktivitet štapa:

$$L_{š\sigma} = \mu_0 l_i \lambda_š$$

Rasipni induktivitet segmenta prstena:

$$\lambda_p = 0{,}46\log_{10}\frac{2{,}35 D_{psr}}{2a + b} \qquad L_{p\sigma} = \mu_0 l_p \lambda_p$$

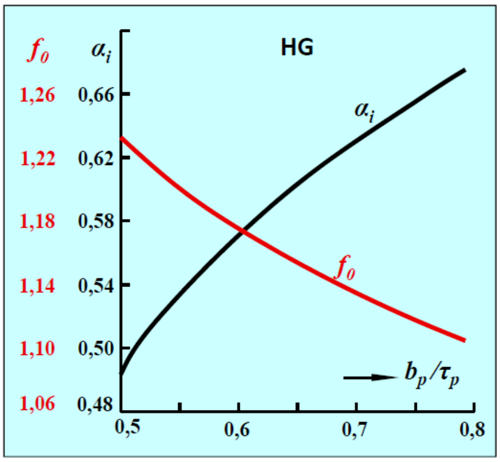
Preračunavaje rotorskih veličina na statorsku stranu

$$k_{12} = \frac{w_1 f_{n1}}{w_2 f_{n2}} = 2w_1 f_{n1} = z_f f_{n1}$$

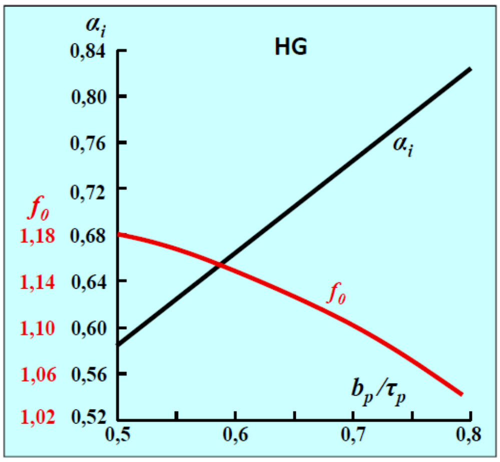
$$Z_2' = Z_2\left(\frac{k_{12}}{f_\beta}\right)^2 \frac{m_1}{N_2}$$

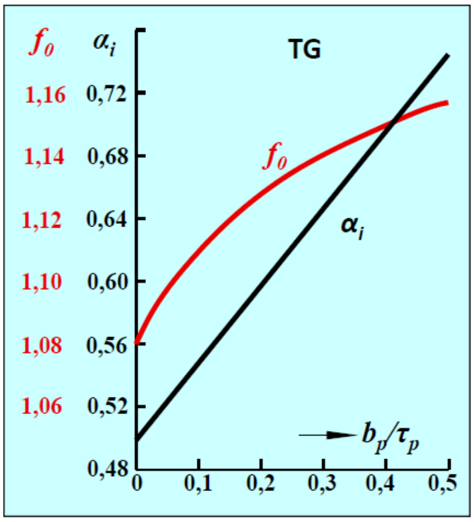
Faktori oblika f_0 i α_i za dvije izvedbe polnih stopala kod izraženih polova

sinusna raspodjela polja u rasporu



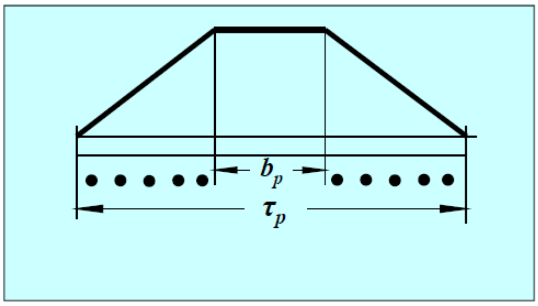
konstantan raspor

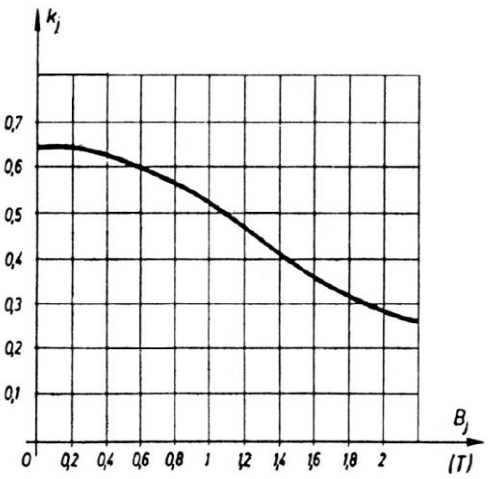




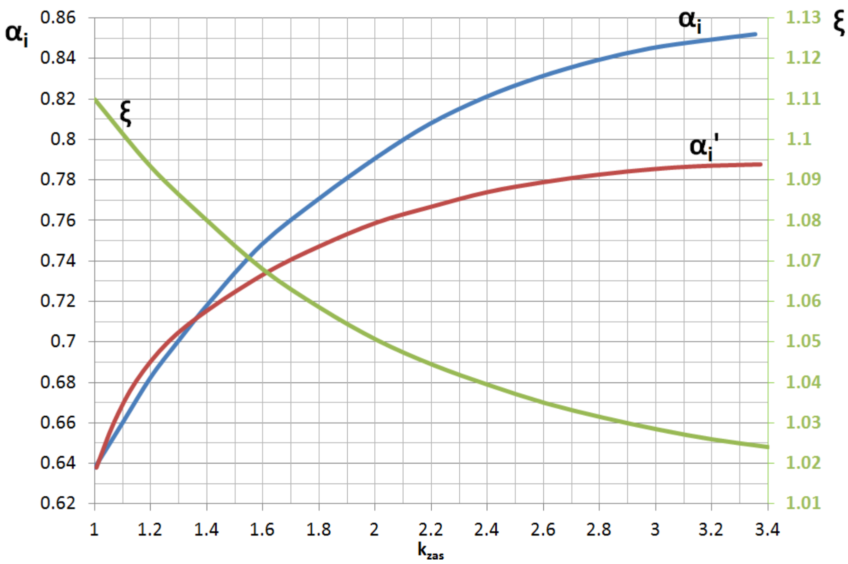
Faktori f_0 i α_i za turbogenerator gdje se za odnos uzima odnos nenamotanog prema namotanom dijelu rotora.

Kod turbogeneratora taj je odnos obično 0,33.





Sl. 19.33. Korekcijski faktor k_j za jaram



Krivulja magnetiziranja dinamo lima M330-50A