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MAGNITOMODULYATSION O'ZGARMAS TOK O'ZGARTIRGICHI MAGNIT ZANJIRINING MATEMATIK MADELI.

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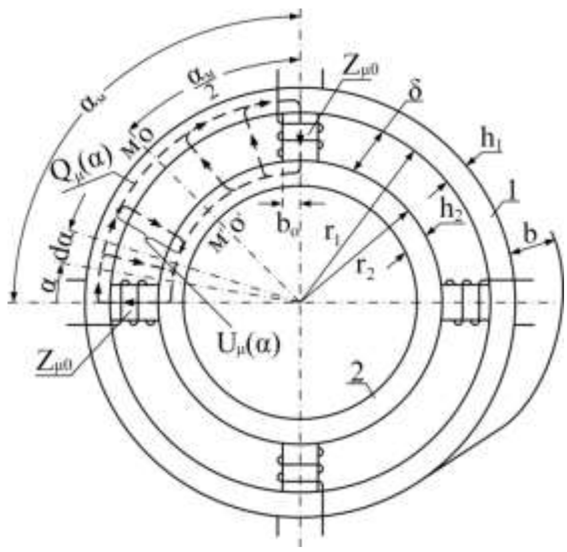
MO'TO'(magnitomodulyatsion o'zgarmas tok o'zgartirgichi) tomonidan ishlab chiqarilgan o'zgarmas tokning magnit zanjiri tasvirlangan. Tasvirlangan parametrlarga ferromagnit halqalarning magnit qarshiligining chiziqli qiymatlari $(Z_{\mu\text{п}})$ va ferromagnit halqalarning birlik burchagi bo'yicha kovaksimon ferromagnit halqalar orasidagi havo bo'shlig'ining magnit sig'imi$(C_{\mu\text{п}} = const)$ kiradi. Va undagi parametrlarda o'zgartirilgan tok I_x tomonidan amper kuchi (F_x) hosil bo'ladi.

Yangi MO'TO'larning asosiy xususiyatlarini nazariy o'rganish uchun ularning magnit maydoning matematik modellarini ishlab chiqish kerak, ya'ni. magnit oqimi va magnit kuchining magnit zanjir uzunligiga qarab analitik ifodalari topiladi.

Ushu bitiruv malakaviy ishida MO'TO' tomonidan ishlab chiqilgan magnit zanjirni o'rganish, uning magnit tizimi 1-rasm, differentsial tenglamalarni tuzish va yechish klassik usul bilan amalga oshiriladi.



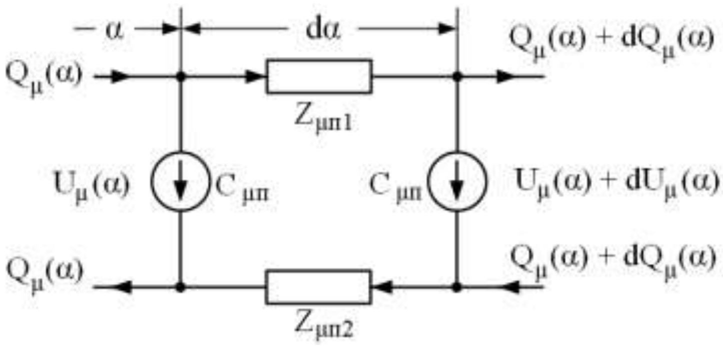
1-rasm. Yig'ilgan MO'TO'ni magnit tizimi

Bizga ma'lum bo'lgan magnit qarshilik $\rho_{\mu cp}$ning o'rtacha qiymatidan foydalanib, birinchi yaqinlashishda o'rtacha magnitlanish egri chizig'ining nochiziqligini hisoblaymiz.

$$\rho_{\mu cp} = \rho_{\mu min} - \frac{\rho_{\mu min} - \rho_{\mu max}}{2} = \frac{\rho_{\mu min} + \rho_{\mu max}}{2}, \quad (1)$$

Bu yerda $\rho_{\mu min}$ va $\rho_{\mu max}$- mos ravishda, konvertatsiya qilingan tokning o'zgarishi, magnit qarshilikning pastki va yuqori chegaralariga mos keladigan minimal va maksimal qiymatlari.

Yopiq halqa ferromagnitda magnit zanjirlarini magnit tokini va ular orasidagi magnit kuchlanishni hisoblashda Kirixgof qonunlari asosida differentsial tenglamalardan foydalanamiz. (1 va 2-rasm);



2-rasm. Magnit zanjir elementar kesimining ekvivalent zanjiri $d\alpha$.

$$Q_\mu(\alpha) - U_\mu(\alpha) C_{\mu п} d\alpha - Q_\mu(\alpha) - dQ_\mu(\alpha) = 0$$

yoki

$$\frac{dQ_\mu(\alpha)}{d\alpha} = -U_\mu(\alpha) C_{\mu п}, \quad (2)$$

$$-U_\mu(\alpha) + Z_{\mu п1} Q_\mu(\alpha) d\alpha + U_\mu(\alpha) + dU_\mu(\alpha) + Z_{\mu п2} Q_\mu(\alpha) d\alpha = 0$$

yoki

$$\frac{dQ_\mu(\alpha)}{d\alpha} = -(Z_{\mu п1} + Z_{\mu п2}) Q_\mu(\alpha), \quad (3)$$

Bu yerda $Q_\mu(\alpha)$, $U_\mu(\alpha)$ – mos ravishda halqa zanjirlaridagi magnit tok va ular orasidagi magnit kuchlanish; $Z_{\mu п1} = \frac{1}{\mu \mu_0 b h_1} = Z_{\mu п2} == \frac{1}{\mu \mu_0 b h_2}$ - magnit zanjirning birlik burchagi uchun halqa ferromagnit o'zaklari 1 va 2 magnit qarshiligining chiziqli qiymatlari; $C_{\mu п} = \mu_0 \frac{b}{\delta}$ - kovaksimon joylashtirilgan ferromagnit o'zaklari 1 va 2 orasidagi bo'shliqni magnit sig'imining chiziqli qiymati. 1-rasmda ko'rsatilgan 1 va 2 o'zakning geometrik o'lchami.

Unga (3) ni (2) qo'yib, quyidagi differentsial tenglamani hosil qilamiz;

$$\frac{d^2 U_\mu(\alpha)}{d\alpha^2} = (Z_{\mu п1} + Z_{\mu п2}) C_{\mu п} Q_\mu(\alpha) \ . \quad (4)$$

Differentsial tenglamaning umumiy yechimi (4) ga binoan, quyidagi ko'rinishga keltirib olamiz;

$$U_\mu(\alpha) = A_1 e^{\gamma \alpha} + A_2 e^{-\gamma \alpha}, \quad (5)$$

Bu yerda $\gamma = \sqrt{2Z_{\mu п}C_{\mu п}}$ - magnit oqimning magnit zanjir uzunligi bo'ylab tarqalish koeffitsienti, 1/м ; A_1 va A_2- integratsiya konstantalari.

(5) ni (3) ga almashtirib olamiz:

$$Q_\mu(\alpha) = -\frac{\gamma}{2Z_{\mu п}}A_1e^{\gamma\alpha} + \frac{\gamma}{2Z_{\mu п}}A_2e^{-\gamma\alpha} \qquad (6)$$

A_1 va A_2 integratsiyalashgan konstantalari quyidagi chegara shartlaridan aniqlanadi:

$$\left.\begin{aligned} U_\mu(\alpha)|_{\alpha=0} &= F_x - Q_\mu(\alpha)|_{\alpha=0}Z_{\mu 0} \\ U_\mu(\alpha)|_{\alpha=\alpha_M} &= -[\,F_x - Q_\mu(\alpha)|_{\alpha=\alpha_M}Z_{\mu 0}] \end{aligned}\right\} \qquad (7)$$

Bu yerda $Z_{\mu 0}$ – ma'lum diametrdagi o'trkazgichning magnit qarshiligi.

Shuni ta'kidlash kerakki, magnit neytral $M - M'$ning ikkala tomonidagi halqasimon o'zaklari 1 va 2 orasidagi magnit kuchlanish qiymatlari belgilariga qarama-qarshi ($Z_{\mu 01} = Z_{\mu 02} = Z_{\mu 0}$ uchun magnit neytral geometrik neytral $0 - 0'$ ga to'g'ri keladi) (1-rasmga qarang). Shuning uchun 7) tizimning ikkinchi tenglamasining o'ng tomonida magnit kuchlanish $U_\mu(\alpha)$ « - » belgisi bilan kiritilgan.

Magnit kuchlanish va magnit oqimini qabul qiladigan chegaralariga mos keladigan qiymatlarini (5) va (6) ga almashtirib, quyidagi algebraik tenglamalarni hosilqilamiz:

$$\left.\begin{aligned} \left(1 - \frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}\right)A_1 + \left(1 + \frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}\right)A_2 &= F_х, \\ \left(1 + \frac{\gamma Z_{\mu 0}}{2Z_{\mu \tau}}\right)e^{\gamma\alpha_M}A_1 + \left(1 - \frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}\right)e^{-\gamma\alpha_M}A_2 &= -F_х. \end{aligned}\right\} \qquad (8)$$

A_1 va A_2 uchun(2.15) tenglamalar sistemasini yechib quyidagilarni hosil qilamiz:

$$A_1 = -\frac{F_х}{2\Delta}e^{-\gamma\alpha_M} + \frac{F_х}{2\Delta}\frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}e^{-\gamma\alpha_M} - \frac{F_х}{2\Delta} - \frac{F_х}{2\Delta}\frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}, \qquad (9)$$

$$A_2 = \frac{F_х}{2\Delta} - \frac{F_х}{2\Delta}\frac{\gamma Z_{\mu 0}}{2Z_{\mu П}} + \frac{F_х}{2\Delta}e^{\gamma\alpha_M} + \frac{F_х}{2\Delta}\frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}e^{\gamma\alpha_M}, \qquad (10)$$

Bu yerda $\Delta = \left(1 + \frac{\gamma^2 Z_{\mu 0}^2}{4Z_{\mu П}^2}sh(\gamma\alpha_M)\right) + \frac{\gamma Z_{\mu 0}}{Z_{\mu П}}ch(\gamma\alpha_M).$

Topilgan A_1 va A_2 qiymatlarini (5) va (6) ifodalarga almashtirib quyidagilarni hosil qilamiz:

$$U_\mu(\alpha) = \frac{F_х}{\Delta}\{sh[\gamma(\alpha_M - \alpha)] - sh(\gamma\alpha)\} + \frac{F_х}{\Delta}\frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}\{ch[\gamma(\alpha_M - \alpha)] - ch(\gamma\alpha)\}, \qquad (11)$$

$$Q_\mu(\alpha) = \frac{\gamma F_х}{2Z_{\mu П}\Delta}\left\{\{ch[\gamma(\alpha_M - \alpha)] + ch(\gamma\alpha)\} + \frac{\gamma Z_{\mu 0}}{2Z_{\mu П}}\{sh[\gamma(\alpha_M - \alpha)] + sh(\gamma\alpha)\}\right\}.$$

(12)

Giperbolik trigonometriya formulalaridan foydalanib (7) va (12) ni o'zgartiramiz va ba'zi bir yozuvlarni kiritib, quyidagilarni olamiz:

$$U_\mu(\alpha^*) = \frac{F_х}{2\Delta}[ch(1/2\,\beta_3) + \beta_3 K\_0\, sh(1/2\beta_3)]sh\left[\beta_3\left(\frac{1}{2} - \alpha^*\right)\right] \qquad (13)$$

$$Q_\mu(\alpha^*) = \frac{\beta_3 F_х}{Z_{\mu П}\alpha_M\Delta}\left[ch\left(\frac{1}{2}\beta_3\right) + \beta_3 K_0 sh\left(\frac{1}{2}\beta_3\right)\right]ch\left[\beta_3\left(\frac{1}{2} - \alpha^*\right)\right] \qquad (14)$$

Bu yerda $\lambda\alpha_M = \beta_3$, $K_0 = \frac{Z_{\mu 0}}{2Z_{\mu\Pi}\alpha_M}$, $\alpha^* = \frac{\alpha}{\alpha_M}$; β_3 – magnit zanjir bo'ylab magnit oqimning kamayib borish koeffitsienti.

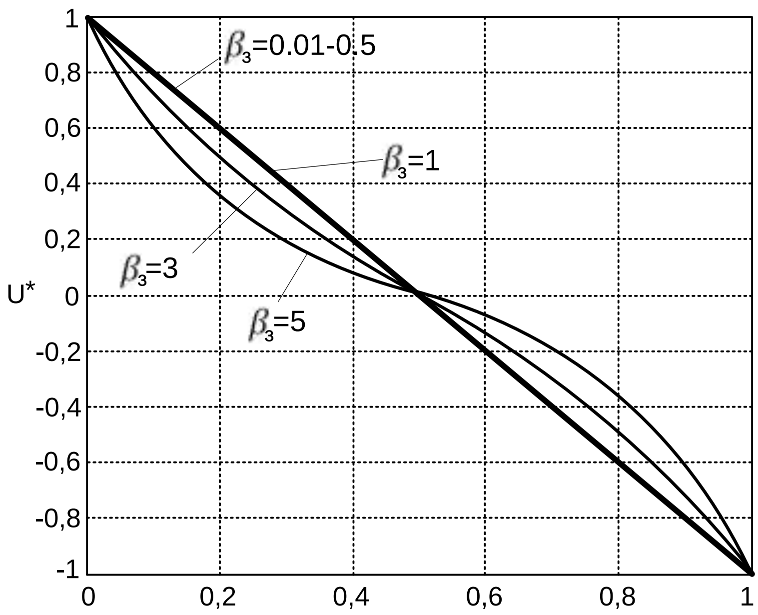
Ushbu masalalarni tahlil qilishni yengillashtirish uchun biz nisbiy birliklardan foydalanamiz:

$$U_\mu^*(\alpha^*) = \frac{U_\mu(\alpha^*)}{U_\mu(0)} = \frac{sh\left[\beta_3\left(\frac{1}{2}-\alpha^*\right)\right]}{sh\left(\frac{1}{2}\beta_3\right)}, Q_\mu^*(\alpha^*) = \frac{Q_\mu(\alpha^*)}{Q_\mu\left(\frac{1}{2}\right)} = \frac{ch\left[\beta_3\left(\frac{1}{2}-\alpha^*\right)\right]}{ch\left(\frac{1}{2}\beta_3\right)} \quad (15)$$

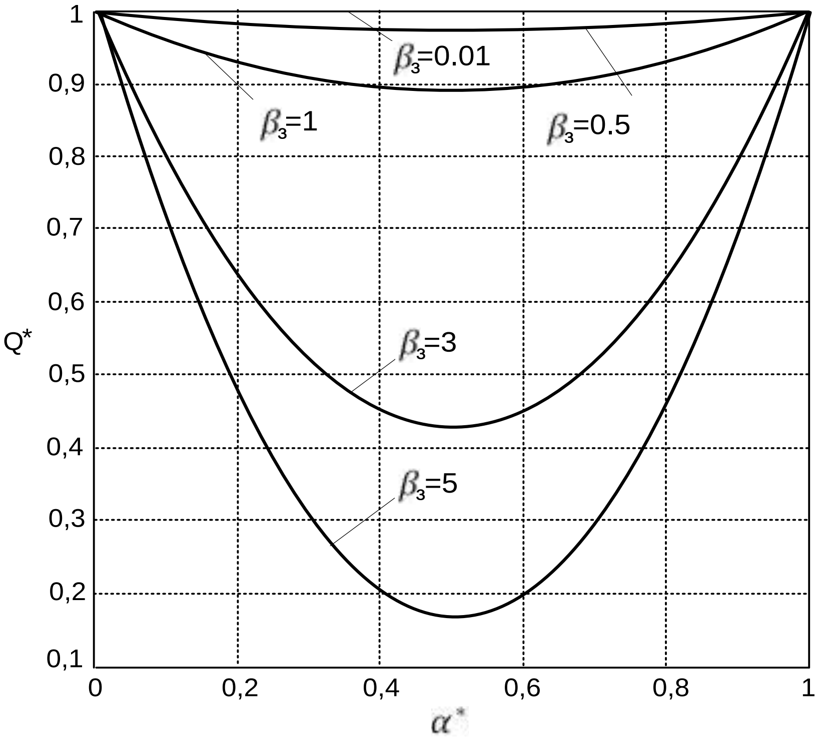
Bu yerda $U_\mu(0)$ va $Q_\mu\left(\frac{1}{2}\right)$ lar, $U_\mu(\alpha^*)$ va $Q_\mu(\alpha^*)$ning mos ravishda maksimal qiymatlari:

3 va 4 rasmda β_3 ning har xil qiymatlari uchun $U_\mu(\alpha^*) = f(\alpha^*)$ va $Q_\mu(\alpha^*) = f(\alpha^*)$ bog'liqlik egri chiziqlari ko'rsatilgan.

(15) ifodalarni va ularning asosida qurilgan egri chiziqlarni tahlil qilish shuni ko'rsatadiki, magnit oqimning kamayish koeffitsienti β_3 magnit zanjiri bo'ylab, magnit kuchlanish o'zgarishi va noaniqlik darajasi magnit oqimning magnit zanjir bo'ylab o'zgaruvchanligi oshadi.



3-rasm. β_3 ning turli xil qiymatlarida $U_\mu = f(\alpha^*)$ bog'liqlik egri chiziqlari



4-rasm. β_3 ning turli xil qiymatlarida $Q_\mu = f(\alpha^*)$ bog'liqlik egri chiziqlari

O'rta dumaloq magnit zanjirdagi I_x tokining magnit maydon kuchlanganligi quyidagicha aniqlanadi:

$$H_x = \frac{1}{\alpha_м} Z_{\mu п1} \int_0^{\alpha_м} Q_\mu(\alpha) d\alpha = \frac{F_x}{\alpha_м \Delta}\left\{\left[\frac{\gamma Z_{\mu 0}}{Z_{\mu п}}\left[ch(\gamma\alpha_м) - 1\right] + sh(\gamma\alpha_м)\right]\right\}. \quad (16)$$

(14), (15) va (16) ifodalar MO’TO’ tomonidan ishlab chiqarilgan magnit zanjirlarning matematik modellari bo'lib, halqasimon o’zaklarining magnit qarshiligining taqsimlangan qismi va ushbu kovaksimon joylashgan o’zaklar orasidagi magnit sig'imini hisobga olgan holda ishlab chiqilgan.

Xulosa

AEM(avtonom enrgiya manbalari)ni nazorat qilish va boshqarish tizimlarida ishlatiladigan (o’zgarmas tok o’zgartirgichi)O’TO’ boshqariladigan ob'ektdagi tok yo'nalishiga sezgir bo'lishi, yuqori differentsial sezgirlik, o’lchashning aniqliligi, konversiya xususiyatlarining chiziqliligi, ishonchliligi va shu bilan birga yuqori toklar sohasini o'lchashda kam quvvat istemol qilishililigidir.

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