O‘ZBEKISTON RESPUBLIKASI OLIY VA O‘RTA MAXSUS TA’LIM VAZIRLIGI

ISLOM KARIMOV NOMIDAGI TOSHKENT DAVLAT TEXNIKA UNIVERSITETI

ELEKTR YURITMA ASOSLARI

fanidan kurs loyihasini bajarish uchun

USLUBIY KO‘RSATMALAR

TOSHKENT 2019

“Elektr yuritma asoslari” fanidan kurs loyihasini bajarish uchun uslubiy qo‘llanma. – Toshkent: ToshDTU, 2019. 36 b.

Ushbu kurs loyihasini bajarish uchun uslubiy qo‘llanma “Elektr yuritma asoslari” fanining “Metall qirquvchi dastgoh bosh mexanizmining elektr yuritmasi”ga bag‘ishlangan.

Uslubiy qo‘llanma talabalarga kurs loyihasini bajarish, hisobot tayyorlash, motorning mexanik va dinamik xarakteristikalarini hisoblash va qurishni o‘rganishda yordam beradi.

Mazkur uslubiy qo‘llanma Elektr yuritma asoslari” kursining dasturiga muvofiq yozildi.

Ushbu o‘quv qo‘llanma “Elektr yuritma asoslari” fanining uslubiy qo‘llanma 5310700 - “Elektr texnikasi, elektr mexanikasi va elektr texnologiyalari” yo‘nalishining bakalavriat talabalariga mo‘ljallangan.

Islom Karimov nomidagi Toshkent davlat texnika universitetining Ilmiy- uslubiy kengashi tomonidan chop etishga tavsiya etildi

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Kurs ishining tarkibiy qismlari

1. Berilgan mexanizmning kinematik sxemasidagi tishli g‘ildiraklar va elektr yuritmaning inersiya momentlarini hisoblash.

2. Ishchi mexanizmning statik momenti va quvvatini hisoblash.

3. Motorning taxminiy quvvatini hisoblash va katalogdan motor tanlash.

4. Motorning elektromexanik va mexanik tavsiflarini hisoblash va grafigini qurish.

5. Elektr yuritmani ishga tushirish va tormozlash o‘tkinchi jarayonlarini hisoblash.

6. Motorni dinamik tormozlash.

KIRISH

“Elektr yuritma asoslari” fanidan kurs loyihasini bajarishdan maqsad talabalarning o‘tilgan mavzularni mukammal o‘zlashtirishlariga yordam berish, mustaqil fikr yuritishga o‘rgatish maxsus texnik va boshqa adabiyotlardan hamda ma’lumotnomalardan samarali foydalanishga o‘rgatishdan iboratdir.

Ishlab chiqarishning barcha sohalarida turli texnologik jarayonlarni boshqarishda konstruktiv jihatdan va ishlash asoslari xilma – xil bo‘lgan mashina va mexanizmlar qo‘llaniladi va ularning ish unumdorligiga va ishlab chiqarilayotgan mahsulotlarining sifatlariga qo‘yiladigan yuqori darajadagi talablar elektr yuritmalarining avtomatlashtirish asosida amalga oshiriladi.

Sanoat mashina va mexanizmlarining harakatga keltiruvchi elektr yuritmalarining motorlarini yuklanish turi, xarakteri va ish rejimlarini hisobga olgan holda tanlash, ularning ish sifatini yaxshilashga olib keladi, motorning uzoq muddat ta’mirsiz ishlashini ta’minlaydi va energiya isrofini kamaytirish imkonini beradi.

METALL QIRQUVCHI DASTGOH BOSH MEXANIZMINING ELEKTR YURITMASI

KURS LOYIHASINING MAZMUNI

1. Berilgan mexanizmning kinematik sxemasidagi tishli g‘ildiraklarning va elektr yuritmaning inersiya momentlarini hisoblash.

2. Ishchi mexanizmning statik momenti va quvvatini hisoblash.

3. Motorning tahminiy quvvatini hisoblash va katalogdagi mos motorni tanlash.

4. Motorning elektromexanik va mexanik tavsiflarini hisoblash va grafigini qurish.

5. Elektr yuritmaning ishga tushirish va tormozlash qarshiliklarini hisoblash.

6. Elektr yuritmaning ishga tushirish va tormozlash o‘tkinchi jarayonlarini hisoblash.

7. Kurs loyihasining grafik qismini rasmiylashtirish.

1) Elektr yuritmaning kinematik sxemasi.

2) Elektr yuritmaning prinsipial sxemasi.

3) Motorning tabiiy elektromexanik va mexanik xaraktiristikasi $\omega=f(t)$, $\omega=f(t)$.

4) Elektr yuritmaning ishga tushurishning elektromexanik tavsiflari.

5) Elektr yuritmaning yuklanish $\omega=f(t)$, $I=f(t)$ va elektr yuritmaning dinamik tormozlash diagrammasi.

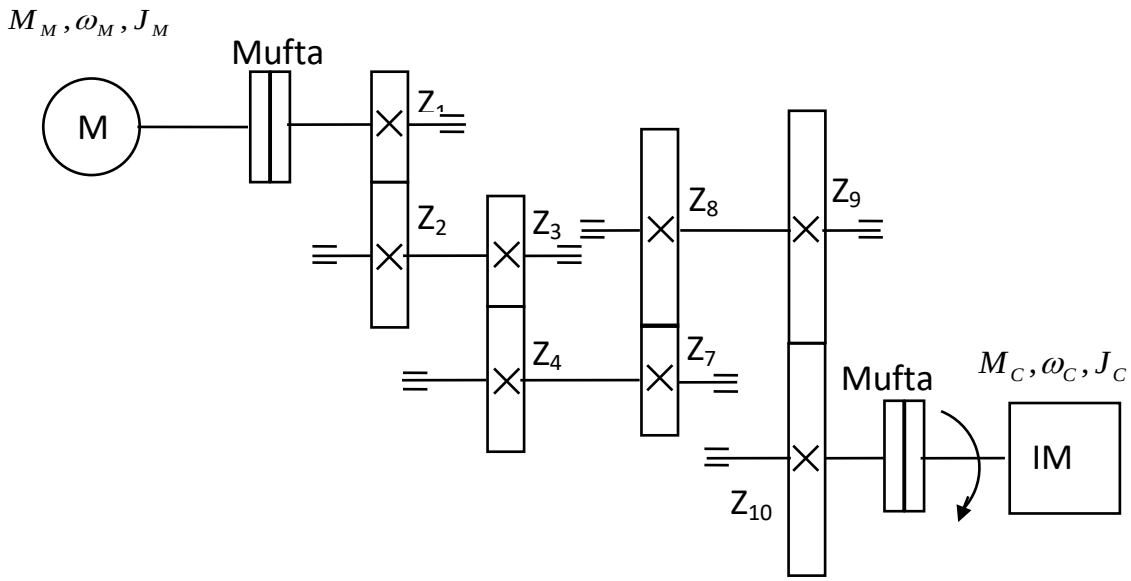
Talabalarning har biri kurs loyihasini mustaqil bajarishlari uchun ular alohida individual variantlarni bajarishlari kerak va bu variantlarning raqamlari 1-jadvalda berilgan bo‘lib, uning uchun ma’lumotlar 2-jadvallarda keltirilgan.

1-jadval

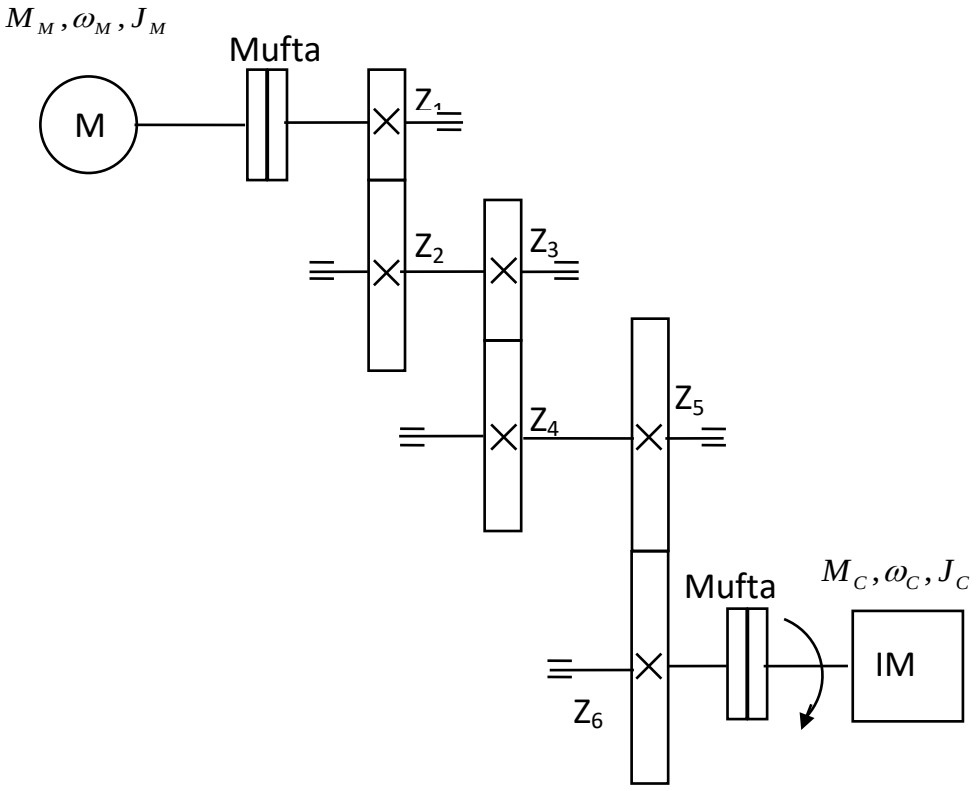
Variant raqamlari	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
$M_s\ 10^4$,Nm	0,4	0,85	0,5	0,4	0,12	0,3	0,6	0,7	1,2	1,4	1,5	0,9	0,75	0,85	1
1-kin.sxema, ω_s, s^{-1}	4,8	3,2	2,0	4,5	3	2,4	5	4,3	2,7	2,6	2,3	2,4	2,8	3,2	4,8
Variant raqamlari	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
$M_s\ 10^4$, Nm	0,4	0,85	0,5	0,4	0,12	0,3	0,6	0,7	1,2	1,4	1,5	0,9	0,75	0,85	1
2-kin.sxema, ω_s, s^{-1}	12	8	18	9,5	11	19	13	9	14	15	10	12	14	9	11

2-jadval

№	Z	b	d_B	d	δ	d_2	d_1
	-	mm	mm	mm	mm	mm	Mm
1	24	90	100	192	-	-	-
2	72	90	120	575	30	530	200
3	52	90	120	426	30	360	200
4	54	90	120	424	30	360	200
5	33	120	120	330	-	-	-
6	83	120	240	830	80	600	420
7	28	110	120	280	-	-	-
8	56	110	150	560	30	480	240
9	20	250	150	320	-	-	-
10	100	250	240	1600	50	1400	400



1-rasm. Elektr yuritmaning 1-kinematik sxemasi



2-rasm. Elektr yuritmaning 2-kinematik sxemasi

1. BERILGAN MEXANIZMNING KINEMATIK SXEMASIDAGI TISHLI G‘ILDIRAKLAR VA ELEKTR YURITMANING INERSIYA MOMENTLARINI HISOBLASH

$M_S = 0{,}35 \cdot 10^4$ Nm $\omega_c = 4{,}8c^{-1}$ 1-kinematik sxema uchun

Metall yo‘nuvchi dastgohning kinematik sxemasidagi har bir tishli g‘ildirakning inersiya momentini hisoblaymiz.

Z_2, Z_3, Z_4, Z_6, $Z_{8,}$ Z_{10} tishli g‘ildiraklarning har biri uchun inersiya momentini quyidagi formula yordamida hisoblaymiz.

$$J_{Zi} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}\left(d^4 - d_b^4\right) - \left(b - \delta\right)\cdot\left(d_2^4 - d_1^4\right)\right]\left[kg/m^2\right].$$

$$J_{Z2} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}(d^4 - d_b^4) - (b - \delta)(d_2^4 - d_1^4)\right] =$$

$$= \frac{3{,}14 \cdot 7800}{16}\left[\frac{0{,}09}{2}(0{,}575^4 - 0{,}12^4) - (0{,}09 - 0{,}03)(0{,}53^4 - 0{,}2^4)\right]$$

$$= 0{,}415\left[kg/m^2\right]$$

$$J_{Z3} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}(d^4 - d_b^4) - (b - \delta)(d_2^4 - d_1^4)\right] =$$

$$= \frac{3{,}14 \cdot 7800}{16}\left[\frac{0{,}09}{2}(0{,}426^4 - 0{,}12^4) - (0{,}09 - 0{,}03)(0{,}36^4 - 0{,}2^4)\right] =$$

$$= 0{,}858\, kg/m^2$$

$$J_{Z4} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}(d^4 - d_b^4) - (b - \delta)(d_2^4 - d_1^4)\right] =$$

$$= \frac{3{,}14 \cdot 7800}{16}\left[\frac{0{,}09}{2}(0{,}424^4 - 0{,}12^4) - (0{,}09 - 0{,}03)(0{,}36^4 - 0{,}2^4)\right] =$$

$$= 0{,}816\left[kg/m^2\right]$$

$$J_{Z6} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}(d^4 - d_b^4) - (b - \delta)(d_2^4 - d_1^4)\right] =$$

$$= \frac{3{,}14 \cdot 7800}{16}\left[\frac{0{,}12}{2}(0{,}83^4 - 0{,}24^4) - (0{,}12 - 0{,}08)(0{,}6^4 - 0{,}42^4)\right] =$$

$$= 37{,}253\left[kg/m^2\right]$$

$$J_{Z8} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}(d^4 - d_b^4) - (b - \delta)(d_2^4 - d_1^4)\right] =$$

$$= \frac{3{,}14 \cdot 7800}{16}\left[\frac{0{,}11}{2}(0{,}56^4 - 0{,}15^4) - (0{,}11 - 0{,}03)(0{,}48^4 - 0{,}24^4)\right] =$$

$$= 2{,}142\left[kg/m^2\right]$$

$$J_{Z10} = \frac{\pi \cdot \gamma}{16}\left[\frac{b}{2}(d^4 - d_b^4) - (b - \delta)(d_2^4 - d_1^4)\right] =$$

$$= \frac{3{,}14 \cdot 7800}{16}\left[\frac{0{,}25}{2}(1{,}6^4 - 0{,}24^4) - (0{,}25 - 0{,}05)(1{,}4^4 - 0{,}4^4)\right] =$$

$$= 85{,}087\left[kg/m^2\right]$$

Z_1, Z_5, Z_7, Z_9 tishli g‘ildiraklarning har biri uchun inersiya momentini quyidagi formula yordamida hisoblaymiz

$$J_{Zi} = \frac{\pi \cdot \gamma \cdot b}{32}\left(d^4 - d_b^4\right)\left[kg/m^2\right]$$

$$J_{Z1} = \frac{\pi \cdot \gamma \cdot b}{32}(d^4 - d_b^4) = \frac{3{,}14 \cdot 7800 \cdot 0{,}09}{32}(0{,}19^4 - 0{,}1^4) = 0{,}08\left[kg/m^2\right]$$

$$J_{Z5} = \frac{\pi \cdot \gamma \cdot b}{32}(d^4 - d_b^4) = \frac{3{,}14 \cdot 7800 \cdot 0{,}12}{32}(0{,}33^4 - 0{,}12^4) = 1{,}1\left[kg/m^2\right]$$

$$J_{Z7} = \frac{\pi \cdot \gamma \cdot b}{32}(d^4 - d_b^4) = \frac{3{,}14 \cdot 7800 \cdot 0{,}11}{32}(0{,}28^4 - 0{,}12^4) = 0{,}5\left[kg/m^2\right]$$

$$J_{Z9} = \frac{\pi \cdot \gamma \cdot b}{32}(d^4 - d_b^4) = \frac{3{,}14 \cdot 7800 \cdot 0{,}25}{32}(0{,}32^4 - 0{,}15^4 = 1{,}90\left[kg/m^2\right]$$

bu yerda $\gamma = 7{,}8m/м^3 = 7800kg/m^3$.

Tishli g‘ildiraklarning o‘lchamlari *mm* da berilgan bo‘lib, ularni metrga keltirib formulalarga qo‘yib hisoblanadi.

Har bir tishli g‘ildirakning inersiya momenti aniqlanganidan so‘ng elektr yuritmaning yig‘indi inersiya momentini hisoblaymiz.

1 – kinematik sxema

$$J_{\sum} = J_M + J_1 + \frac{J_2 + J_3}{\left(\frac{Z_2}{Z_1}\right)^2} + \frac{J_4 + J_7}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\right)^2} + \frac{J_6 + J_9}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\cdot\frac{Z_8}{Z_7}\right)^2} +$$

$$+ \frac{J_{10}}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\cdot\frac{Z_8}{Z_7}\cdot\frac{Z_{10}}{Z_9}\right)^2}\left[kg/m^2\right]$$

$$J_{\sum} = J_M + J_1 + \frac{J_2 + J_3}{\left(\frac{Z_2}{Z_1}\right)^2} + \frac{J_4 + J_7}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\right)^2} + \frac{J_6 + J_9}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\cdot\frac{Z_8}{Z_7}\right)^2} +$$

$$+ \frac{J_{10}}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\cdot\frac{Z_8}{Z_7}\cdot\frac{Z_{10}}{Z_9}\right)^2} = 0,16 + 0,086 + \frac{0,415 + 0,858}{\left(\frac{72}{24}\right)^2} + \frac{0,816 + 0,5}{\left(\frac{72}{24}\cdot\frac{54}{52}\right)^2} +$$

$$+ \frac{37,253 + 1,9}{\left(\frac{72}{24}\cdot\frac{54}{52}\cdot\frac{56}{28}\right)^2} + \frac{85,087}{\left(\frac{72}{24}\cdot\frac{54}{52}\cdot\frac{56}{28}\cdot\frac{100}{20}\right)^2} = 1,484\left[kg/m^2\right]$$

2 – kinematik sxema

$$J_{\sum} = J_M + J_1 + \frac{J_2 + J_3}{\left(\frac{Z_2}{Z_1}\right)^2} + \frac{J_4 + J_7}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\right)^2} + \frac{J_6}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\frac{Z_6}{Z_5}\right)^2}\left[kg/m^2\right]$$

$$J_{\sum} = J_M + J_1 + \frac{J_2 + J_3}{\left(\frac{Z_2}{Z_1}\right)^2} + \frac{J_4 + J_7}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\right)^2} + \frac{J_6}{\left(\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\frac{Z_6}{Z_5}\right)^2} = 0{,}16 + 0{,}086 +$$

$$+ \frac{0{,}415 + 0{,}858}{\left(\frac{72}{24}\right)^2} + \frac{0{,}816 + 0{,}5}{\left(\frac{72}{24}\cdot\frac{54}{52}\right)^2} + \frac{37{,}253}{\left(\frac{72}{24}\cdot\frac{54}{52}\cdot\frac{83}{33}\right)^2} = 1{,}13\left[kg/m^2\right]$$

bu yerda $J_1 \div J_{10}$– kinematik sxema alohida bo‘g‘inlarining inersiya momentlari, $Z_1 \div Z_{10}$ – tishli g‘ildiraklarning tishlari soni, J_M – motorning inersiya momenti, $J_{\sum}$ – elektr yuritmaning motor o‘qiga keltirilgan yig‘indi inersiya momenti.

Ishchi mexanizm qarshilik momentini motor o‘qiga keltirish quyidagi formula bilan hisoblaymiz

(1 – kinematik sxema)

$$M_C^{`} = \frac{M_C}{\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\cdot\frac{Z_8}{Z_7}\cdot\frac{Z_{10}}{Z_9}\cdot\eta_1\cdot\eta_2\cdot\eta_3\cdot\eta_4}\left[Nm\right]$$

$$M_C^{`} = \frac{M_C}{\frac{Z_2}{Z_1}\cdot\frac{Z_4}{Z_3}\cdot\frac{Z_8}{Z_7}\cdot\frac{Z_{10}}{Z_9}\cdot\eta_1\cdot\eta_2\cdot\eta_3\cdot\eta_4} = \frac{0{,}35}{\frac{72}{24}\cdot\frac{54}{52}\cdot\frac{56}{28}\cdot\frac{100}{20}\cdot 0{,}99^4} =$$

$$= 116{,}95\left[Nm\right]$$

(2 – kinematik sxema)

$$M_C^{`} = \frac{M_C}{\frac{Z_2}{Z_1} \cdot \frac{Z_4}{Z_3} \cdot \frac{Z_6}{Z_5} \cdot \eta_1 \cdot \eta_2 \cdot \eta_3} [Nm]$$

$$M_C^{`} = \frac{M_C}{\frac{Z_2}{Z_1} \cdot \frac{Z_4}{Z_3} \cdot \frac{Z_6}{Z_5} \cdot \eta_1 \cdot \eta_2 \cdot \eta_3} = \frac{0,35}{\frac{72}{24} \cdot \frac{54}{52} \cdot \frac{56}{28} \cdot 0,99^3} = 460,34[Nm]$$

Tishli g‘ildiraklarning tishlari to‘g‘ri profilli bo‘lgani uchun ularning foydali ish koeffitsiyentlarini $\eta_1, \eta_2, \eta_3, \eta_4 = 0,99$ deb qabul qilamiz.

2. ISHCHI MEXANIZMNING STATIK MOMENTI VA QUVVATINI HISOBLASH

Ishchi mexanizmning statik momenti M_S qiymati va burchak tezligi ω_C har bir variant uchun 3.1 – jadvalda berilgan.

Ishchi mexanizm o‘qidagi statik quvvat

$$P_C = M_C \cdot \omega_C = \frac{3500}{9,81} \cdot \frac{9,55}{4,8} = 16354,74[Vt]$$

Metall yo‘nuvchi dastgoh ishchi mexanizmi qisqa muddatli qaytariluvchi ish rejimida ishlashi sababli uning ulanish davomiyligini PV = 40% deb qabul qilamiz.

$$\varepsilon = \frac{t_{иш}}{(t_{иш} + t_{пауза})} = \frac{t_{иш}}{T_ц} = 0,4,$$

bu yerda $\varepsilon -$ nisbiy ulanish davomiyligi.

U holda qisqa muddatli qaytariluvchi ish rejimida ishlaydigan ishchi mexanizm o‘qidagi quvvat

$$P_C^{`} = P_C \sqrt{\varepsilon} = 16354,74\sqrt{0,4} = 10343,65[Vt]$$

3. MOTORNING TAXMINIY QUVVATINI HISOBLASH VA KATALOGDAN MOTOR TANLASH

Motorning quvvatini quyidagi formula bilan aniqlaymiz

$$P_M = \frac{K_3 \cdot P_C^{`}}{\eta_{uz}} = \frac{1,2 \cdot 10343,65}{0,99^4} = 12537,75 \ [Vt]$$

bu yerda K_Z – elektr yuritmaning dinamik ish rejimlarini hisobga oluvchi zaxira koeffitsiyenti, $K_3 = 1,15 \div 1,2$ η_{uz} – mexanik uzatkich qutichasining foydali ish koeffitsiyenti, $\eta_{uz} = \eta_1 \cdot \eta_2 \cdot ... \eta_n$.

Motor tezligini aniqlaymiz:

(1 – kinematik sxema uchun)

$$\omega_M = \omega_C \left(\frac{Z_2}{Z_1} \cdot \frac{Z_4}{Z_3} \cdot \frac{Z_8}{Z_7} \cdot \frac{Z_{10}}{Z_9} \right) = 4,8 \left(\frac{72}{24} \cdot \frac{54}{52} \cdot \frac{56}{28} \cdot \frac{100}{20} \right) = 149,53 [s^{-1}]$$

(2 – kinematik sxema uchun)

$$\omega_M = \omega_C \left(\frac{Z_2}{Z_1} \cdot \frac{Z_4}{Z_3} \cdot \frac{Z_6}{Z_5} \right), [s^{-1}].$$

Aniqlangan motor quvvati va tezligi asosida katalogdan mos quvvatli motor tanlanadi

$$P_M \geq P_c^{`}. \quad 12537,75 \geq 10343,65$$

Motor ishlashi jarayonida uning barcha tashkil etuvchi qismlari qiziydi. Uzoq vaqt ishlashi jarayonida motorning hamma qismlaridagi harorat o‘zining turg‘un holati darajasigacha qizib ulguradi va o‘zgarmas bo‘lib turadi.

Odatda kataloglarda yakor, qo‘shimcha qutb va komenzatsion chulg‘amlarning qarshiliklari ularning $t = 15^0 C$ harorati holatlari uchun berilgan bo‘ladi. Ularning qarshiliklari qiymatlarini ishchi haroratlari holatidagi qiymatlariga keltirish uchun motorlarning geometrik o‘lchamlariga bog‘liq bo‘lgan quyidagi harorat koeffitsiyentlaridan foydalaniladi:

$K_t = 1{,}24 -$ birinchi – uchinchi geometrik o‘lchamli motorlar uchun;

$K_t = 1{,}32 -$ to‘rtinchi – oltinchi geometrik o‘lchamli motorlar uchun;

$K_t = 1{,}40 -$ yettinchi – o‘n birinchi geometrik o‘lchamli motorlar uchun.

Chulg‘amlar qarshiliklarini ishchi haroratlari uchun keltirib hisoblamaslik motor tavsiflarini hisoblashda xatoliklarga olib keladi va bu xatoliklar elektr yuritmaning bir qancha ko‘rsatkichlariga ta’sir qiladi.

4. MOTORNING ELEKTROMEXANIK VA MEXANIK TAVSIFLARINI HISOBLASH VA GRAFIGINI QURISH

Motorning nominal burchak tezligi

$$\omega_C = \frac{2 \cdot \pi \cdot \mathrm{n_{ном}}}{60} = \frac{\pi \cdot \mathrm{n_{ном}}}{30} = \frac{3{,}14 \cdot 1500}{30} = 157\left[s^{-1}\right]$$

Motorning nominal EYUK

$$E_{НОМ} = \mathrm{U_{НОМ}} - \mathrm{R_{Я\sum M}} \cdot \mathrm{I_{Я.НОМ}} = 220 - 0{,}172 \cdot 73{,}5 = 207{,}29[V]$$

bu yerda $\mathrm{R_{Я\sum M}} = \kappa_m (r_я + \mathrm{r_{кк}} + \mathrm{r_{кч}}) = 1{,}32(0{,}127 + 0{,}004) = 0{,}172\left[Om\right]$.

Motorning nominal EYUK koeffitsiyenti

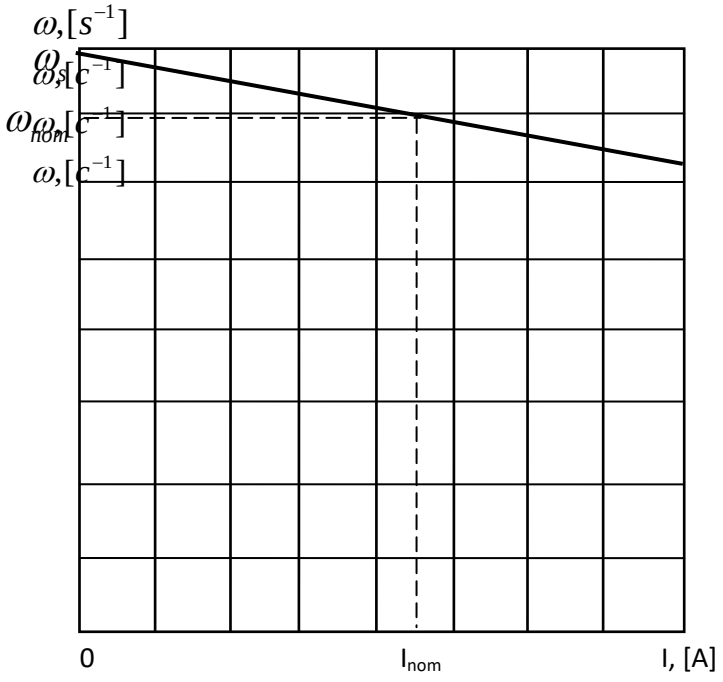
$$K_E = C_e \Phi_H = \frac{\mathrm{U_{НОМ}}}{\omega_{\mathrm{НОМ}}} - \frac{\mathrm{R_{Я\sum M}}}{\omega_{\mathrm{НОМ}}} \cdot \mathrm{I_{Я.НОМ}} = \frac{220 - 0{,}172 \cdot 73{,}5}{157} = 1{,}32\left[Vs\right]$$

Motorning nominal elektromagnit momenti

$$M_{ЭМ} = C_M \Phi \cdot \mathrm{I}_{\text{Я.НОМ}} = 1,32 \cdot 73,5 = 97,04 \left[Nm \right] C_M \approx C_e .$$

Motorning o‘qidagi nominal moment

$$M_{HOM} = \frac{P_{HOM} \cdot 10^3}{\omega_{HOM}},$$



3 – rasm. Motorning elektromexanik tavsifi

Motorning ideal salt yurish burchak tezligi

$$\omega_0 = \frac{U_{HOM}}{C_e \Phi_н} = \frac{220}{1,32} = 166,62 \left[s^{-1} \right]$$

Moment isrofi

$$\Delta M = M_{ЭМ} - M = 97,04 - 89,17 = 7,87 \left[Nm \right]$$

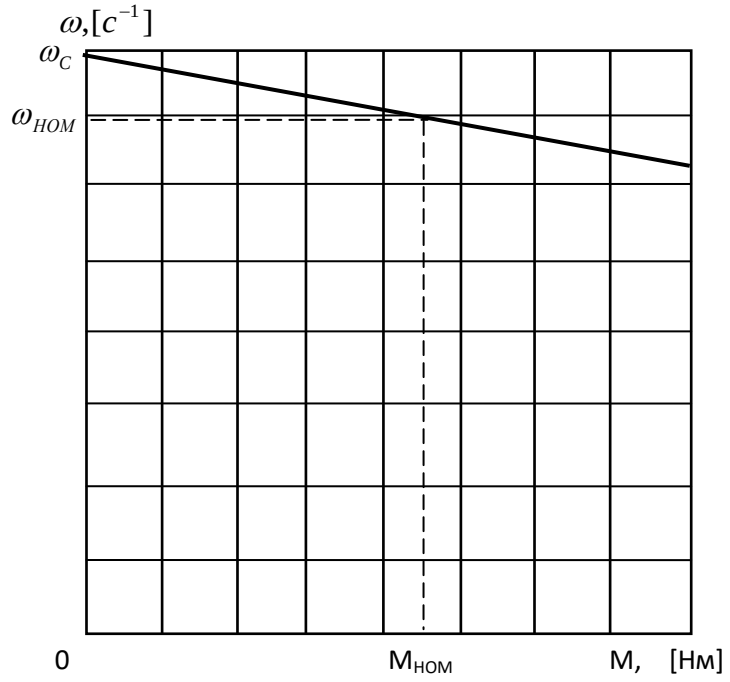
Motorning elektromexanik tavsifini qurish uchun quyidagi formuladan foydalaniladi:

$$\omega = \frac{U_{HOM}}{C_e \Phi_H} - \frac{\mathrm{R}_{\text{я}\sum\text{M}}}{\mathrm{C}_\text{e}\Phi_H} \cdot \mathrm{I}_\text{я} \left[s^{-1} \right]$$

Motorning mexanik tavsifini qurish uchun quyidagi formuladan foydalanamiz

$$\omega = \frac{U_{HOM}}{C_e \Phi_H} - \frac{\mathrm{R}_{\text{я}\sum\text{M}}}{(\mathrm{C}_\text{e}\Phi_H)^2} \cdot \mathrm{M}, [\mathrm{s}^{-1}].$$

3 – rasmda motorning elektromexanik va 4 – rasmda esa mexanik tavsiflarining grafiklari tasvirlangan.



4– rasm. Motorning mexanik tavsifi

5. ELEKTR YURITMANI ISHGA TUSHIRISH VA TORMOZLASH O‘TKINCHI JARAYONLARINI HISOBLASH

Motorni tarmoqqa ulab ishga tushirilganda motorning yakor zanjiridan ($15 \div 20$)I_{NOM} tok o‘tishi mumkin va natijada yakor, qo‘shimcha qutblar va kommutatsiya chulg‘amlarining izolyatsiyalarida termik teshilish yuzaga kelib motor ishdan chiqishiga olib kelishi mumkin. Yakor zanjiridagi tokni cheklash maqsadida yakor chulg‘amiga ketma – ket qo‘shimcha qarshiliklar ulanadi. Motorni silliq ishga tushirish uchun bu qarshiliklar bir necha pog‘onali qilib ulanadi (5 – rasm).

Shu sabali elektr yuritmaning o‘tkinchi jarayoniga elektromagnit inersiyaning ta’siri juda kam bo‘ladi,

$$T_Э = \frac{L_Я}{R_{Я\sum}}$$

bo‘yicha aniqlanadi, bu yerda $T_Э -$ motorning elektromagnit vaqt doimiyligi va uni ko‘pincha hisobga olmasa ham bo‘ladi.

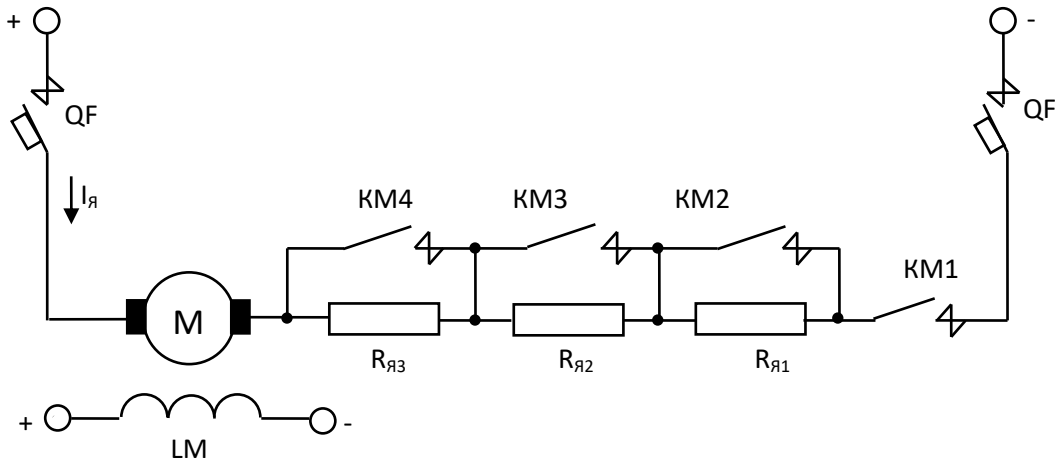
Motorning elektromexanik vaqt doimiyligi

$$T_M = J_\sum \frac{R_{Я\sum}}{(C_e \Phi_{HOM})^2} = 1{,}48 \frac{0{,}17}{1{,}32^2} = 0{,}14[c]$$

Motorning induktiv qarshiligi quyidagi formula yordamida aniqlanadi:

$$L_Я = \beta \frac{U_{НОМ}}{p\omega_{ном} \cdot I_{НОМ}} = 0{,}25 \frac{220}{2 \cdot 157 \cdot 73{,}5} = 0{,}0023[Гн]$$

bu yerda $\beta = 0{,}6 -$ kompensatsiya qilinmagan motorlar uchun (kompensatsion chulg‘ami bo‘lmagan); $\beta = 0{,}25 -$ kompensatsiya qilingan motorlar uchun (kompensatsion chulg‘ami bo‘lgan); r – qutblar soni.



5 – rasm. Mustaqil qo‘zg‘atish chulg‘amli o‘zgarmas tok motorini qo‘shimcha qarshiliklar yordamida ishga tushirish prinsipial elektr sxemasi:QF – avtomatik ulagich; KM1, KM2, KM3, KM4 – o‘zgarmas tok kontaktorlari. R_{YA1}, R_{YA2}, R_{YA3} – qarshiliklar

Motorni ishga tushirish qarshiliklari quyidagi ketma – ketlikda aniqlanadi.

Maksimal tokni $I_1 = (2 \div 2{,}5) I_{HOM}$ deb qabul qilamiz.

$$I_1 = (2 \div 2{,}5) I_{HOM} = 2{,}5 \cdot 73{,}5 = 183{,}75[A]$$

Maksimal ulanish toki

$$I_2 = I_1 \sqrt[K]{\frac{R_{я\sum} \cdot I_1}{U_{HOM}}} = 183{,}75 \sqrt[3]{\frac{0{,}17 \cdot 183{,}75}{220}} = 96{,}4[A]$$

bu yerda K – pog‘onalar soni; $R_{я\sum} = r_{Я} + r_{KK} + r_{KЧ}$ – yakor zanjiri chulg‘amlarining yig‘indi qarshiligi.

Toklar nisbatini $\lambda = \frac{I_1}{I_2} = \frac{183{,}75}{96{,}4} = 1{,}9$ deb belgilaymiz. Seksiya qarshiliklarini quyidagi ifodalar vositasida aniqlaymiz:

$$R_1 = \frac{U_{HOM}}{\mathrm{I}_1} = \frac{220}{183,75} = 1,19\left[Om\right]$$

$$R_2 = \frac{R_1}{\lambda} = \frac{1,19}{1,9} = 0,62\left[Om\right]$$

$$R_3 = \frac{R_2}{\lambda} = \frac{0,62}{1,9} = 0,32\left[Om\right]$$

$$------$$

$$R_n = \frac{R_{n-1}}{\lambda} = \frac{R_1}{\lambda^{n-1}}.$$

Pog‘ona qarshiliklarini quyidagi ifodalar bo‘yicha aniqlaymiz:

$$R_{Я1} = R_1 - R_2 = 1,19 - 0,62 = 0,56\left[Om\right]$$

$$R_{Я2} = R_2 - R_3 = 0,62 - 0,32 = 0,29\left[Om\right]$$

$$R_{Я3} = R_3 - R_4 = 0,32 - 0 = 0,32\left[Om\right]$$

$$--------$$

$$R_{Яn} = R_{n-1} - R_n.$$

6 – rasmda motorni yakor zanjiriga ketma-ket qarshiliklar ulab ishga tushirishning elektromexanik tavsifi va qarshiliklarning pog‘onalar bo‘ylab taqsimlanishi grafiklari tasvirlangan.

Motorni ishga tushirish grafigi quyidagi ifoda yordamida hisoblanadi:

$$\omega_i = \omega_{ci} + (\omega_{боши} - \omega_{ci})e^{-\frac{t_i}{T_{mi}}};$$

$$I_Я = \mathrm{I}_c + (I_1 - I_c)e^{-\frac{t_i}{T_{mi}}};$$

bu yerda T_{Mi}- i pog‘onaning elektromexanik vaqt doimiyligi, t_i- i pog‘onaning ishga tushirish vaqti.

Elektr yuritmaning elektromexanik vaqt doimiyligi

$$T_{Mi} = J_{\sum} \frac{R_{Я\sum i}}{(C_e \Phi_н)^2}[s]$$

$$T_{M1} = J_{\sum} \frac{R_{Я\sum 1}}{(C_e \Phi_н)^2} = 1,48 \frac{1,37}{1,32^2} = 1,16[s]$$

$$T_{M2} = J_{\sum} \frac{R_{Я\sum 2}}{(C_e \Phi_н)^2} = 1,48 \frac{0,8}{1,32^2} = 0,68[s]$$

$$T_{M3} = J_{\sum} \frac{R_{Я\sum 3}}{(C_e \Phi_н)^2} = 1,48 \frac{0,5}{1,32^2} = 0,42[s]$$

$$T_{M4} = J_{\sum} \frac{R_{Я\sum 4}}{(C_e \Phi_н)^2} = 1,48 \frac{0,17}{1,32^2} = 0,14[s]$$

Pog‘onalar soni uchga teng. Birinchi pog‘onaning umumiy qarshiligi

$$R_{Я\sum 1} = R_Я + R_{Я1} + R_{Я2} + R_{Я3} = 1,37[Om]$$

$$R_{Я\sum 2} = R_Я + R_{Я2} + R_{Я3} = 0,8[Om]$$

$$R_{Я\sum 3} = R_Я + R_{Я3} = 0,5[Om]$$

$$R_{Я\sum 4} = R_Я = 0,17[Om]$$

$J_{\sum} = 2 \cdot J_M$ – elektr yuritmaning inersiya momenti.

Birinchi pog‘onaning ishga tushirish vaqti

$$t_1 = T_{Mi} \ln \frac{I_1 - I_c}{I_2 - I_c},$$

bu yerda $I_c = 0{,}3 \cdot I_{HOM} = 0{,}3 \cdot 73{,}5 = 22{,}05[A]$ deb qabul qilamiz;

$$t_1 = T_{M1} \ln \frac{I_1 - I_c}{I_2 - I_c} = 1{,}16 \ln \frac{183{,}75 - 22{,}05}{96{,}4 - 22{,}05} = 0{,}9[s]$$

$$t_2 = T_{M2} \ln \frac{I_1 - I_c}{I_2 - I_c} = 0{,}07 \ln \frac{183{,}75 - 22{,}05}{96{,}4 - 22{,}05} = 0{,}53[s]$$

$$t_3 = T_{M3} \ln \frac{I_1 - I_c}{I_2 - I_c} = 0{,}04 \ln \frac{183{,}75 - 22{,}05}{96{,}4 - 22{,}05} = 0{,}33[s]$$

$$t_4 = T_{M4} \ln \frac{I_1 - I_c}{I_2 - I_c} = 0{,}01 \ln \frac{183{,}75 - 22{,}05}{96{,}4 - 22{,}05} = 0{,}11[s]$$

Birinchi pog‘ona o‘tkinchi jarayoni $\omega = f(t), I = f(t)$ tavsiflarini quyidagi tengliklardan foydalanib hisoblaymiz va grafiklarini quramiz:

$$\omega_c = \omega_{c1} + (\omega_{бош1} - \omega_{c1}) e^{-\frac{t}{T_{M1}}};$$

$$\omega_{c1} = \frac{U_{HOM}}{C_e \Phi_H} - \frac{R_{я\sum M}}{C_e \Phi_H} \cdot I_c$$

$$\omega_{c1} = \frac{U_{HOM}}{C_e \Phi_H} - \frac{R_{я\sum 1}}{C_e \Phi_H} \cdot I_c = \frac{220}{1{,}32} - \frac{1{,}37}{1{,}32} 22{,}05 = 143{,}74\left[s^{-1}\right]$$

$$\omega_{c2} = \frac{U_{HOM}}{C_e \Phi_H} - \frac{R_{я\sum 2}}{C_e \Phi_H} \cdot I_c = \frac{220}{1{,}32} - \frac{0{,}8}{1{,}32} 22{,}05 = 153{,}24\left[s^{-1}\right]$$

$$\omega_{c3} = \frac{U_{HOM}}{C_e \Phi_H} - \frac{R_{я\sum 3}}{C_e \Phi_H} \cdot I_c = \frac{220}{1{,}32} - \frac{0{,}5}{1{,}32} 22{,}05 = 158{,}24\left[s^{-1}\right]$$

$$\omega_{c4} = \frac{U_{HOM}}{C_e \Phi_H} - \frac{R_{я\sum 4}}{C_e \Phi_H} \cdot I_c = \frac{220}{1{,}32} - \frac{0{,}17}{1{,}32} 22{,}05 = 163{,}73\left[s^{-1}\right]$$

$$\omega_{бош2} = \omega_{o1}\ \omega_{бош3} = \omega_{o2}\ \omega_{бош4} = \omega_{o3}$$

$$\omega_{o1} = \omega_{c1} + (\omega_{бош1} - \omega_{c1})e^{-\frac{t}{T_{M1}}} = 143,74 + (0 - 143,74)e^{-\frac{0,9}{1,16}} =$$
$$= 77,86\left[s^{-1}\right]$$

$$\omega_{o2} = \omega_{c2} + (\omega_{бош2} - \omega_{c2})e^{-\frac{t}{T_{M1}}} = 153,24 + (77,86 - 153,24)e^{-\frac{0,05}{0,07}} =$$
$$= 118,69\left[s^{-1}\right]$$

$$\omega_{o3} = \omega_{c3} + (\omega_{бош3} - \omega_{c3})e^{-\frac{t}{T_{M1}}} = 158,23 + (118,69 - 158,23)e^{-\frac{0,03}{0,04}} =$$
$$= 140,11\left[s^{-1}\right]$$

$$\omega_{c} = \omega_{c4} + (\omega_{бош4} - \omega_{c4})e^{-\frac{t}{T_{M1}}} = 163,73 + (140,11 - 163,73)e^{-\frac{0,01}{0,01}} =$$
$$= 152,91\left[s^{-1}\right]$$

Birinchi pog‘ona o‘tkinchi jarayoni 0 dan t_1 gacha vaqt oralig‘ida kechadi.

Qolgan pog‘onalar o‘tkinchi jarayonlari ham xuddi birinchi pog‘ona o‘tkinchi jarayonlari tavsiflarini hisoblangandek hisoblanadi.

Elektr yuritmaning tabiiy elektromexanik (mexanik) o‘tkinchi tavsiflarining nodavriy yoki tebranma xarakterga ega bo‘lishi, yakor zanjirida faqat yakor zanjiri chulg‘amlari qarshiliklarigina qolganligini hisobga olsak, miotorning elektromexanik va elektromagnit vaqt doimiyliklarining nisbatigagina bog‘liq bo‘ladi. Agar $m = \frac{T_{M.Таб}}{T_{Я}} \succ 4$ bo‘lsa, u holda o‘tkinchi jarayonlar nodavriy xarakterga ega bo‘ladi va ularni hisoblashda yuqorida keltirilgan formulalardan foydalaniladi. Agar $m = \frac{T_{M.Таб}}{T_{Я}} \prec 4$ bo‘lsa, u holda o‘tkinchi jarayonlar tebranma xarakterga ega bo‘ladi va ularni hisoblashda quyida keltirilayotgan formulalardan foydalaniladi:

$$T_Э T_M \frac{\mathrm{d}^2\omega}{dt^2} + T_M \frac{d\omega}{dt} + \omega = \omega_0 - \frac{M_c}{\beta} = \omega_c;$$

$$T_Э T_M \frac{\mathrm{d}^2 I}{dt^2} + T_M \frac{dI}{dt} + I = I_c;$$

bu yerda $\beta = \frac{(C_e \Phi)^2}{\mathrm{R}_{я\sum}}, H \cdot м \cdot c -$ motor mexanik tavsifining bikrlik moduli.

Tenglamaning ildizini topamiz

$$\mathrm{p}_{1,2} = -\frac{1}{2} T_Э \pm \mathrm{j}\sqrt{\frac{1}{\mathrm{T_M} T_Э} - \frac{1}{4} T_Э^2} = -\alpha \pm \mathrm{j}\Omega_\mathrm{p},$$

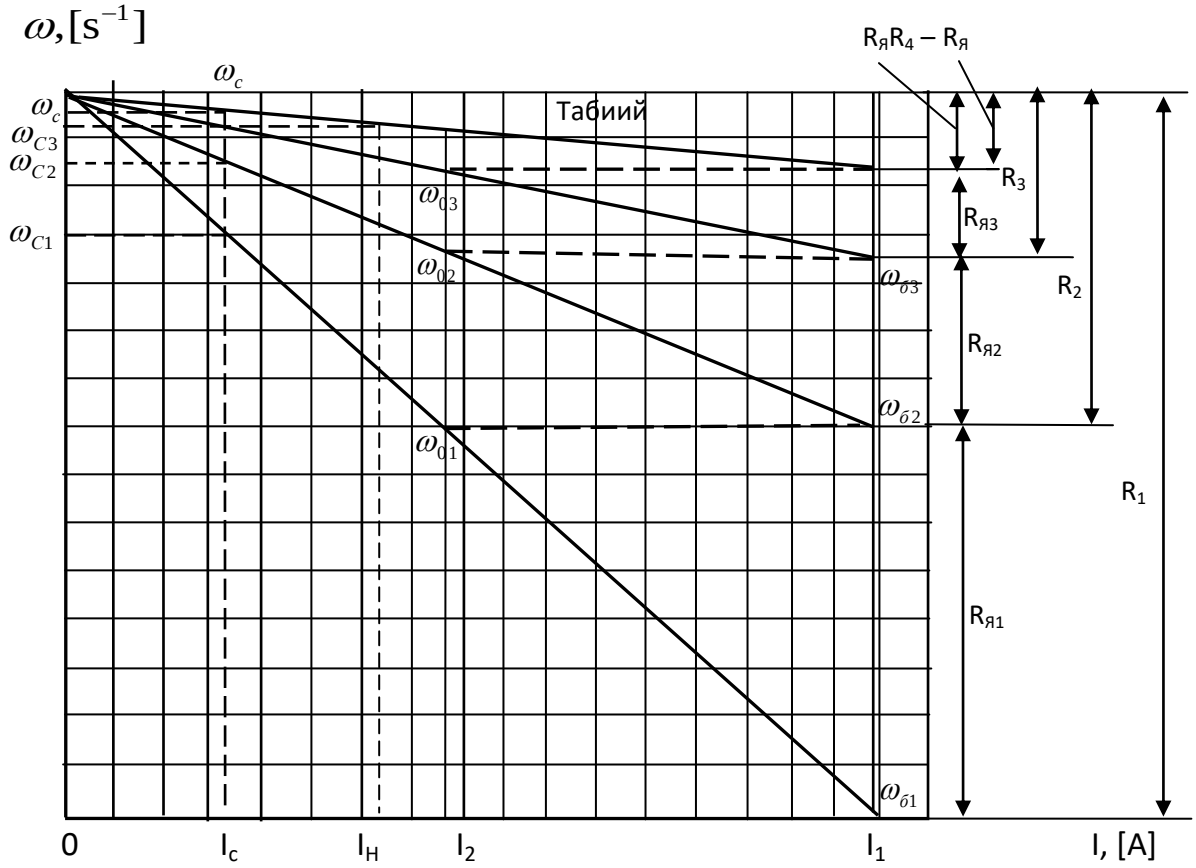
bu yerda $\alpha = -\frac{1}{2} T_Э; \Omega_p = \sqrt{\frac{1}{T_Э T_M} - \frac{1}{4} T_Э^2}.$

Quyida kompleks sonli tenglama yechimlari asosida o‘tkinchi jarayonlar $\omega = f(t), I = f(t)$ ko‘rsatkichlarini hisoblaymiz va ularning grafiklarini qurishimiz mumkin bo‘ladi:

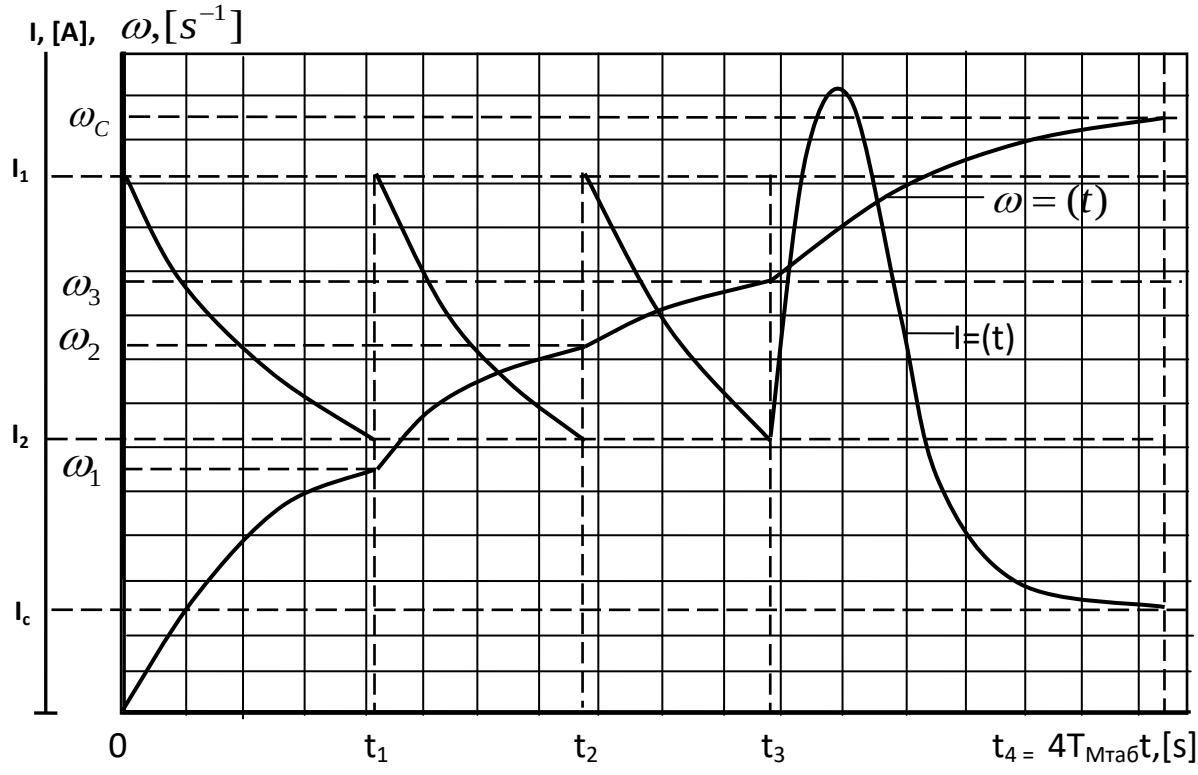
$$\omega = \omega_c + e^{-\alpha t}(\omega_{бош} - \omega_c)\left[\cos\Omega_\mathrm{p}\mathrm{t}) + \left(\frac{kI_{бош} - \mathrm{kI_c} \cdot kI_{НОМ}}{\omega_{бош} - \omega_c \omega_o \mathrm{J}_\sum \Omega_p} + \frac{\alpha}{\Omega_p}\right)\sin\Omega_p t\right];$$

$$I = kI_c + e^{-\alpha t}(kI_{бош} - kI_c)\left[\begin{array}{l}\cos\Omega_p t + \\ + \dfrac{\beta\Delta\omega_{НОМ} / (\kappa \mathrm{I_{НОМ}} - \mathrm{kI_{бош}})(1 - \alpha T_Э) - \alpha T_Э k\mathrm{I_C}}{\mathrm{T_Э}\Omega_p t(\mathrm{kI_{бош}} - \mathrm{kI_C})} \sin\Omega_p t\end{array}\right],$$

7 – rasmda motorni yakor zanjiriga ketma-ket qarshiliklar ulab ishga tushirishning o‘tkinchi jarayonlarining tavsiflari grafiklari tasvirlangan.



6 – rasm. Motorni yakor zanjiriga ketma-ket qarshiliklar ulab ishga tushirishning elektromexanik tavsifi grafigi



7 – rasm. Motorni yakor zanjiriga ketma-ket qarshiliklar ulab ishga tushirishning o‘tkinchi jarayonlarining tavsiflari grafiklari

6. MOTORNI DINAMIK TORMOZLASH

Motorni dinamik tormozlash uchun motor yakor zanjiri tarmoqdan uzilib qarshilikka parallel ulanadi. Bu qarshilikning qiymatini quyidagi formula bilan aniqlaymiz

$$R_{дин} = \frac{E_{бош}}{\mathrm{I}_{рЭ}} - \mathrm{R}_{я\sum} = \frac{216,18}{183,75} - 0,172 = 1,32\left[Om\right]$$

bu yerda

$$E_{бош} = C_e \Phi \cdot \omega_C = 1,32 \cdot 163,73 = 216,18\left[V\right]$$

$$\mathrm{I}_{РЭ} = (2 \div 2,5)\mathrm{I}_{НОМ} = 2,5 \cdot 73,5 = 183,75\left[A\right]$$

$$\mathrm{R}_{я\sum} = \kappa_m(\mathrm{r}_{я} + \mathrm{r}_{КК} + \mathrm{r}_{Кч}) = 1,32(0,127 + 0,004) = 0,172\left[Om\right]$$

Dinamik tormozlashdagi motorning elektromexanik vaqt doimiyligi

$$T_M = J_{\sum} \frac{R_{я\sum} + \mathrm{R}_{дин}}{\left(\mathrm{C}_e \Phi\right)^2} = 1,48 \frac{0,17 + 1,32}{1,32^2} = 1,27\left[s\right]$$

Dinamik tormozlash vaqti

$$\mathrm{t}_{дин} = T_M \ln \frac{\mathrm{I}_1 + I_C}{I_1} = 1,27 \ln \frac{183,75 + 22,05}{183,75} = 0,14\left[s\right]$$

Dinamik tormozlash o‘tkinchi jarayotlarining tavsiflari quyidagi formulalardan foydalanib hisoblaymiz va grafiklarini quramiz

$$\omega = \omega_{бош} \frac{\mathrm{I}_1 + I_C}{I_1} e^{-\frac{t}{T_M}} - \omega_{бош} \frac{\mathrm{I}_C}{\mathrm{I}_1}, \left[\mathrm{s}^{-1}\right];$$

$$\omega_1 = \omega_{бош}\frac{\mathrm{I}_1 + I_C}{I_1}e^{-\frac{t}{T_M}} - \omega_{бош}\frac{\mathrm{I}_C}{\mathrm{I}_1} =$$

$$= 163,73\frac{183,75+22,05}{183,75}e^{-\frac{0,5}{1,27}} - 163,73\frac{22,05}{183,75} = 104,23\left[s^{-1}\right]$$

$$\omega_2 = \omega_{бош}\frac{\mathrm{I}_1 + I_C}{I_1}e^{-\frac{t}{T_M}} - \omega_{бош}\frac{\mathrm{I}_C}{\mathrm{I}_1} =$$

$$163,73\frac{183,75+22,05}{183,75}e^{-\frac{1}{1,27}} - 163,73\frac{22,05}{183,75} = 64,04\left[s^{-1}\right]$$

$$\omega_3 = \omega_{бош}\frac{\mathrm{I}_1 + I_C}{I_1}e^{-\frac{t}{T_M}} - \omega_{бош}\frac{\mathrm{I}_C}{\mathrm{I}_1} =$$

$$163,73\frac{183,75+22,05}{183,75}e^{-\frac{1,5}{1,27}} - 163,73\frac{22,05}{183,75} = 36,88\left[s^{-1}\right]$$

$$\omega_4 = \omega_{бош}\frac{\mathrm{I}_1 + I_C}{I_1}e^{-\frac{t}{T_M}} - \omega_{бош}\frac{\mathrm{I}_C}{\mathrm{I}_1} =$$

$$163,73\frac{183,75+22,05}{183,75}e^{-\frac{2}{1,27}} - 163,73\frac{22,05}{183,75} = 18,54\left[s^{-1}\right]$$

$$\omega_5 = \omega_{бош}\frac{\mathrm{I}_1 + I_C}{I_1}e^{-\frac{t}{T_M}} - \omega_{бош}\frac{\mathrm{I}_C}{\mathrm{I}_1} =$$

$$163,73\frac{183,75+22,05}{183,75}e^{-\frac{3}{1,27}} - 163,73\frac{22,05}{183,75} = -2,21\left[s^{-1}\right]$$

$$I = -(I_1 + I_C)e^{-\frac{t}{T_M}} + I_C, [\mathrm{A}].$$

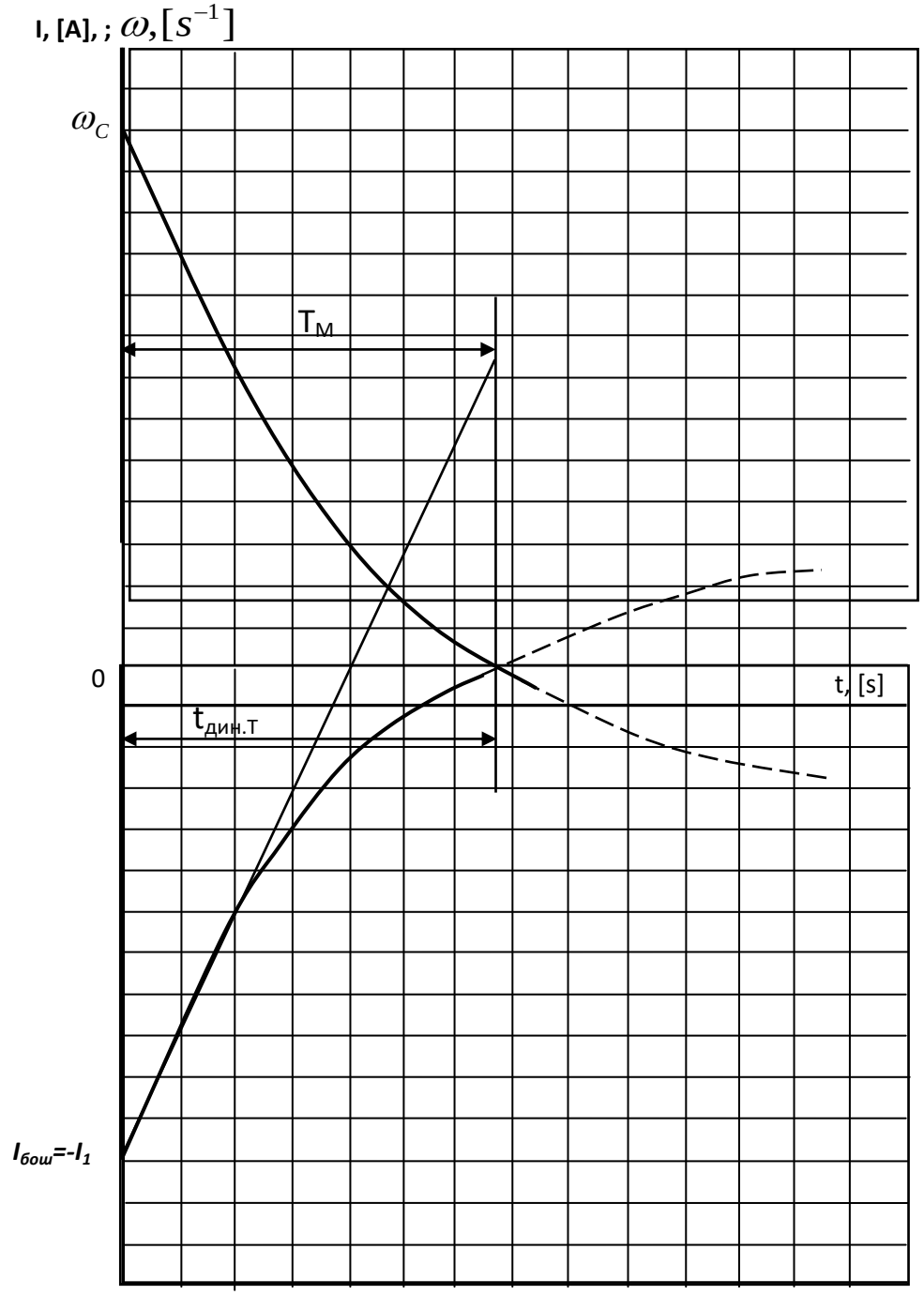
$$I = -(I_1 + I_C)e^{-\frac{t}{T_M}} + I_C = -(183,75+22,05)e^{-\frac{0,5}{1,27}} + 22,05 = -117,18[A]$$

$$I = -(I_1 + I_C)e^{-\frac{t}{T_M}} + I_C = -(183,75+22,05)e^{-\frac{1}{1,27}} + 22,05 = -72,14[A]$$

$$I = -(I_1 + I_C)e^{-\frac{t}{T_M}} + I_C = -(183{,}75 + 22{,}05)e^{-\frac{1{,}5}{1{,}27}} + 22{,}05 = -41{,}67[A]$$

$$I = -(I_1 + I_C)e^{-\frac{t}{T_M}} + I_C = -(183{,}75 + 22{,}05)e^{-\frac{2}{1{,}27}} + 22{,}05 = -21{,}16[A]$$

$$I = -(I_1 + I_C)e^{-\frac{t}{T_M}} + I_C = -(183{,}75 + 22{,}05)e^{-\frac{3}{1{,}27}} + 22{,}05 = 2{,}31[A]$$



8 – rasm. Motorni dinamik tormozlashda tezlik va tokning vaqt bo‘yicha o‘zgarish tavsiflarining grafiklari

ILOVA

P seriyadagi magnit oqimini susaytirib tezligi rostlanadigan himoyalangan parallel qo‘zg‘atish chulg‘amli o‘zgarmas tok motorlarning nominal texnik ko‘rsatkichlari

Motor nomi	$U_{ном}$, V	$P_{ном}$, kVt	$n_{ном}$, ayl/min	$n_{мах}$, ayl/min	$I_{ном}$, A	$J \cdot 10^{-2}$, $kg \cdot m^2$	2p	2a	$W_Я$	$r_м \cdot 10^{-2} = r_я + r_{гг}$, Om	$r_{к-к} \cdot 10^{-2}$, Om	$W_ш$ (qutbi)	$r_ш$, Om
П-22	220	1,0	1500	3000	6,9	1,3	2	2	864	417	23,6	4800	712
П-32	220	1,0	1000	2000	5,7	2,9	2	2	720	317	9,2	3600	358
П-32	220	2,2	1500	3000	12,0	2,9	2	2	468	111,5	9,2	3600	358
П-41	220	3,2	1500	3000	18,4	3,8	4	2	486	103,2	3,28	1750	198
П-41	220	4,5	1000	2000	9,3	3,8	4	2	729	290	11,4	2100	280
П-41	220	1,0	750	1500	6,8	3,8	4	2	945	535	14	2100	280
П-42	220	3,3	1500	3000	25,4	4,5	4	2	378	78	3,92	1700	228
П-42	220	2,2	1000	2000	13,3	4,5	4	2	540	75	3,9	1800	243
П-42	220	1,5	750	1500	9,2	4,5	4	2	702	292	4,8	1800	242
П-51	220	6,0	1500	2250	33,2	8,75	4	2	341	47/2	0,73	1300	
П-51	220	3,2	1000	2000	18,3	8,75	4	2	527	105,1	4,4	1600	

П-51	220	2,2	750	1500	13,6	8,75	4	2	682	191	4,8	1600	
П-52	220	8,0	1500	2250	43,5	10	4	2	248	27	0,68	1500	150
П-52	220	4,5	1000	2000	25,2	10	4	2	372	63,2	3,26	1650	184
П-52	220	3,2	750	1500	19,0	10	4	2	496	107	4	1650	184
П-61	220	4,1	1500	2250	59,5	14	4	2	248	18,7	3,6	1800	133
П-61	220	6,0	1000	2000	32,6	14	4	2	372	49,4	0,9	1950	158
П-61	220	4,5	750	1500	26,0	14	4	2	496	76	3,26	2200	246
П-62	220	14	1500	2250	73,5	16	4	2	185	12,7	0,4	1600	166
П-62	220	8,0	1000	2000	43,0	16	4	2	279	32,8	0,7	1700	136
П-62	220	6,0	750	1500	33,5	16	4	2	372	53,1	2,2	1800	154
П-82	220	42	1500	2250	218	77	4	2	117	4,62	0,225	1350	79,2
П-82	220	25	1000	2000	133	77	4	2	162	8	0,316	936	40,4
П-82	220	17	750	1500	93	77	4	2	210	15,67	0,89	1300	73,3
П-91	220	55	1500	2250	287	48	4	2	105	2,57	0,102	760	35,8
П-91	220	32	1000	2000	171	48	4	2	165	6,66	0,23	870	35,8
П-91	220	25	750	1500	136	48	4	2	210	10,23	0,407	1000	44

П-91	220	19	600	1200	106	48	4	2	290	19,84	0,407	1000	44
П-91	220	14	500	1500	81/83	48	4	2	330	28,5	0,5	1000	44
П-91	220	11	500	1500	63/69	48	4	2	330	28,5	0,5	1000	44
П-92	220	75	1500	1900	381	175	4	2	81	1,38	0,12	830	31,8
П-92	220	42	1000	2000	219	175	4	2	145	5,47	0,12	1000	448,4
П-92	220	32	750	1500	169	175	4	2	162	5,63	0,12	830	31,8
П-92	220	25	600	1200	136	175	4	2	210	11,1	0,48	1000	48,4
П-92	220	18	500	1500	100	175	4	2	290	18,2	0,48	1000	48,4
П-92	220	13	500	2000	71/77	175	4	2	290	18,46	0,48	1000	48,4
П-101	220	100	1500	1800	508	258	4	2	152	1,34	0,054	950	37,8
П-101	220	55	1000	2500	286	258	4	2	111	2,42	0,054	950	37,8
П-101	220	42	750	2500	222	258	4	2	141	4,9	0,22	950	37,8
П-101	220	32	600	1200	172	258	4	2	186	7,49	0,216	050	37,8
П-101	220	27	500	1500	146/148	258	4	2	222	11,9	0,31	950	37,8
П-101	220	16	500	2000	86/96	258	4	2	222	12	0,31	950	37,8
П-102	220	125	1500	1800	632	300	4	2	114	0,85	0,0612	840	32,5

П-102	220	75	1000	1500	385	300	4	2	93	2,2	0,0612	840	32,5
П-102	220	55	750	1500	286	300	4	2	111	3,1	0,245	840	32,5
П-102	220	42	600	`1200	223	300	4	2	141	1,7	0,0612	840	32,5
П-102	220	34	500	1500	180	300	4	2	186	7,73	0,0612	840	32,5
П-111	220	160	1500	1800	809	510	4	2	108	0,64	0,027	850	28
П-111	220	100	1000	1500	511	510	4	2	162	1,53	0,091	850	28
П-111	220	75	750	1500	387	510	4	2	105	2,36	0,107	850	28
П-111	220	55	600	1200	287	510	4	2	123	3,62	0,2	850	28
П-111	220	33	400	1200	178	510	4	2	195	8,56	0,317	850	28
П-111	220	31	400	1600	166/170	510	4	2	195	8,56	0,317	850	28
П-112	220	200	1500	1500	1000	575	4	2	92	0,49	0,0254	750	24
П-112	220	125	1000	1500	632	575	4	2	123	1,02	0,055	750	24
П-112	220	85	750	1500	436	575	4	2	168	1,92	0,1	750	24
П-112	220	70	600	1200	361	575	4	2	105	2,62	0,12	750	24
П-112	220	36	400	1200	191	575	4	2	165	7,07	0,28	750	24

Topshiriq uchun savollar

1. Kurs ishining mazmuni.
2. Elektr yuritmaning kinematik sxemasini tushuntirib bering.
3. Elektr yuritmaning inersiya momentini hisoblashni tushuntiring.
4. O‘zgarmas tok motorlarini turlarini tushuntiring.
5. Kurs ishida qaysi elektr motordan foydalanganligizni tushuntiring.
6. Uzatish mexanizmi turlarini aytib bering.
7. O‘zgarmas tok elektr motorlarini katalogdan tanlash?
8. O‘zgarmas tok elektr motorlarini mexanik xarakteristikalarini hisoblash.
9. O‘zgarmas tok elektr motorlarini mexanik xarakteristikalarini grafigini qurish.
10. Elektr yuritmaning ishga tushurish usullarini tushuntiring.
11. Elektr motorlarda elektromexanik vaqt doimiysini hisoblash.
12. Elektr motorda ketma-ket qarshilik ulab ishga tushurish.
13. Elektr motorlarni ishga tushirishda bo‘ladigan o‘tkinchi jarayonlarni tushuntiring.
14. Elektr motorlarni tormozlash usullari.
15. Elektr dinamik vaqt doimiysini hisoblashni tushuntiring.
16. Elektr dinamik tormozlash tavsifini quring.

Baholashni 5 baholik shkaladan 100 ballik shkalaga o‘tkazish

JADVALI

5 baholik shkala	**100 ballik shkala**	**5 baholik shkala**	**100 ballik shkala**	**5 baholik shkala**	**100 ballik shkala**
5,00 — 4,96	100	4,30 — 4,26	86	3,60 — 3,56	72
4,95 — 4,91	99	4,25 — 4,21	85	3,55 — 3,51	71
4,90 — 4,86	98	4,20 — 4,16	84	3,50 — 3,46	70
4,85 — 4,81	97	4,15 — 4,11	83	3,45 — 3,41	69
4,80 — 4,76	96	4,10 — 4,06	82	3,40 — 3,36	68
4,75 — 4,71	95	4,05 — 4,01	81	3,35 — 3,31	67
4,70 — 4,66	94	4,00 — 3,96	80	3,30 — 3,26	66
4,65 — 4,61	93	3,95 — 3,91	79	3,25 — 3,21	65
4,60 — 4,56	92	3,90 — 3,86	78	3,20 — 3,16	64
4,55 — 4,51	91	3,85 — 3,81	77	3,15 — 3,11	63
4,50 — 4,46	90	3,80 — 3,76	76	3,10 — 3,06	62
4,45 — 4,41	89	3,75 — 3,71	75	3,05 — 3,01	61
4,40 — 4,36	88	3,70 — 3,66	74	3,00	60
4,35 — 4,31	87	3,65 — 3,61	73	**3,0 dan kam**	**60 dan kam**

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Qaydlar uchun

Mundarija

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