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DIAPAZONI ROSTLANADIGAN FERROMAGNIT TOK O‘ZGARTIRGICHLARINING ISHONCHLILIGINI OSHIRISH

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ANOTATSIYA

Diapazoni rostlanadigan ferromagnit tok o‘zgartirgichlarining ishonchliligini oshirish. Sinov muddati mobaynida ishdan chiqqan FMTO‘ yangisi bilan almashtirilmadi. Umumiy sinov muddati $T_0=200\cdot10^3$soat Ushbu muddat mobaynida chulg‘amlar izolyasiyasi, ularning kirish va chiqish qismalarining ishdan chiqishi hamda FMTO‘ lar ishchi holatining o‘zgarishi 1- FMTO‘ ning ishdan chiqish intensivligini, yuqori chegarasi, 90 % li resursning ikki tomonlama ishonchlilik chegaraviy qiymatlari topish va hisoblash.

Kalit so'zlar: Ferro magnetli tok o’tkazgichlar, Eksponensial taqsimlanish qonuniyatida, quyi va yuqori ishonchlilik chegaralarining qiymatlari, ishdan chiqmasdan ishlash ehtimoli.

Повышение надежности диапазоннорегулируемых ферромагнитных трансформаторов тока За период испытаний вышедший из строя ФМТЎ на новый не заменялся. Общий период испытаний $T_0=200\cdot10^3$ ч. За этот период происходит изоляция труб, выход из строя их входной и выходной частей, а также изменение рабочего состояния ФМТЎ 1-Интенсивность отказа ФМТЎ, верхний предел, двусторонний 90% ресурса найти и рассчитать надежность предельные значения.

Ключевые слова: Ферромагнитные проводники тока, Показательный закон распределения, значения нижнего и верхнего пределов надежности, вероятность безотказной работы.

Increasing the reliability of range-adjustable ferromagnetic current transformers. During the test period, the failed FMTO‘ was not replaced with a new one. Total test period $T_0=200\cdot10^3$ hours During this period, insulation of pipes, failure of their input and output parts, and changes in the working state of FMTO‘

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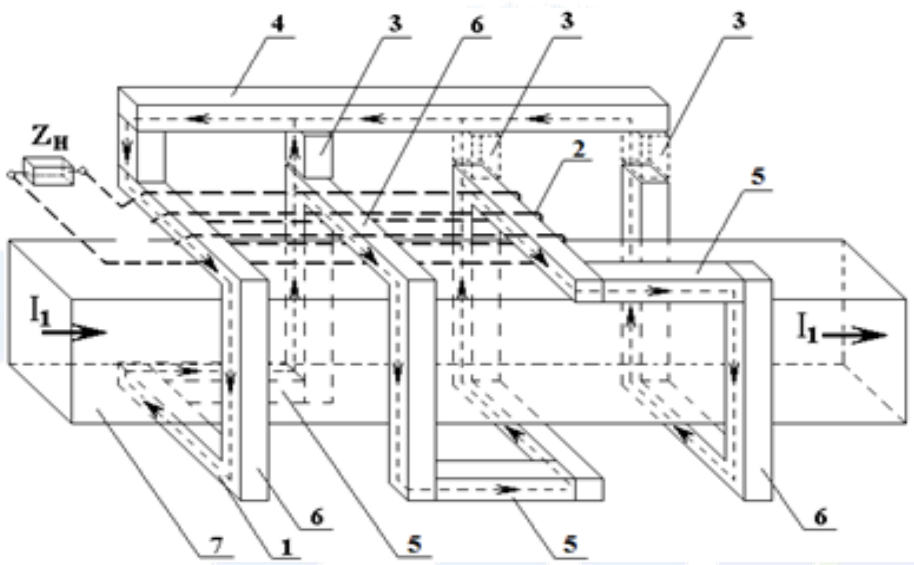
1-FMTO‘ failure intensity, upper limit, bilateral of 90% resource find and calculate reliability limit values.

Key words: Ferromagnetic current conductors, Exponential distribution law, values of lower and upper reliability limits, probability of operation without failure.

Biz tomonidan taklif qilingan ferromagnit oqim o’zgartirgichning ishonchlilik ko'rsatkichlarini hisoblash va qiyosiy baholashga misollar keltiramiz.



1-rasm. Diapazoni rostlanadigan ferromagnit tok o‘zgartirgichi.

Quyida keltirilgan 1-rasmda keltirilgan yangi uchta (1-, 2- va 3-) FMTO‘ uchun ishonchlilik ko‘rsatkichlarini hisoblaymiz. 2020-2021 yillarda o‘tkazilgan tajriba tadqiqotlari “O‘zbekiston temir yo‘llari” AJ ga qarashli “Elektr ta’minoti” boshqarmasi bilan kelishilgan holda GOST asosida bajarildi [42].

[N, U, T] kuzatuv rejasi tanlangan bo‘lib, FMTO‘ lar soni N=50 ga teng. Sinov muddati mobaynida ishdan chiqqan FMTO‘ yangisi bilan almashtirilmadi. Umumiy sinov muddati $T_0=200\cdot10^3$soat. Ushbu muddat mobaynida chulg‘amlar izolyasiyasi, ularning kirish va chiqish qismalarining ishdan chiqishi hamda FMTO‘ lar ishchi holatining o‘zgarishi kuzatildi. FMTO‘ lar chiqish kuchlanishlarining ko‘rsatishlariga matematik kutilish M[u(t)] va dispersiya D[u(t)] larni inobatga olgan holda tegishli tuzatishlar kiritildi.

Sinov muddati mobaynida $d = 2$ ta ishdan chiqqan FMTO‘ aniqlandi. FMTO‘ ning yig‘ilgan detallari bo‘yicha ishlashi muddatlariga oid ma’lumotlar 1- jadvalda keltirilgan.[1].

1- jadval

1- FMTO‘ ning ishlash muddatlari	80;82;94;98;101;140,3;142;170,4; 181,7;	$\sum t_i = 1472$

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2- va 3- FMTO‘ lar-ning ishlash muddat-lari	51;78;93;101;103;111;121;127;130; 131;132;148;151;157;163;171;174; 178;180;182;193;195;197	$\sum t_i = 3267$

Qaralayotgan FMTO‘ ishdan chiqquncha ishlash muddatlarining taqsimlanishi eksponensial qonuniyatga bo‘yso‘nishini e’tiborga olgan holda GOST 17509-72 asosida 1- rasmdagi FMTO‘ ning yig‘ilgan elementlari uchun quyidagi parametrlar qiymatlarini aniqlaymiz: $T_{o'r}$ – ishdan chiqquncha ishlash muddatining o‘rtacha qiymati; $P(t)$ - $t = 4 \cdot 10^5$ soat mobaynida ishdan chiqmasdan ishlash ehtimoli; $\lambda(t)$ – ishdan chiqish intensivligi; T_γ - $\gamma = 90$ uchun gamma-foiz resurslari. Eksponensial taqsimlanish qonuniyatida $\hat{\lambda} = \lambda = \text{const}$ ekanligini inobatga olib, GOST 17509-72 dagi 1-jadval bo‘yicha $[N, U, T]$ reja uchun 1-FMTO‘ ning ishdan chiqish intensivligini quyidagicha hisoblab topamiz:

$$\lambda_1 = \frac{d}{\sum_{i=1}^{d} t_i + (N-d)T_0} = \frac{2}{1472+(50-2)\times 200\times 10^3} = 0{,}21 \cdot 10^{-6}\ \text{soat}^{-1}. \quad (1)$$

λ_1 uchun ikki tomonlama ishonchlilik chegara qiymatlarini $\beta = 0{,}9$ ishonchlilik ehtimoli bilan aniqlaymiz. $[N, U, T]$ reja uchun GOST 17509-72 ilovasidagi 1- jadvalga ko‘ra quyidagilarni hisoblab topamiz:

quyi chegarasi:

$$\lambda_{1q} = \frac{\hat{\lambda} N \chi^2_{\frac{1-\beta}{2},2d}}{d\left(2N-d+\frac{1}{2}\chi^2_{\frac{1-\beta}{2},2d}\right)} = \frac{0{,}21\times 10^{-6}\times 50\times 5{,}45}{2\left(2\times 50-2+\frac{1}{2}\times 5{,}45\right)} = 0{,}105 \cdot 10^{-6}\ \text{soat}^{-1}; \quad (2)$$

yuqori chegarasi:

$$\lambda_{1yu} = \frac{\hat{\lambda} N \chi^2_{\frac{1+\beta}{2},2d}}{d\left(2N-d+\frac{1}{2}\chi^2_{\frac{1+\beta}{2},2d}\right)} = \frac{0{,}21\times 10^{-6}\times 50\times 15{,}7}{2\left(2\times 50-2+\frac{1}{2}\times 15{,}7\right)} =$$

$$= 0{,}78 \cdot 10^{-6}\ \text{soat}^{-1}, \quad (3)$$

bu yerda $\chi^2_{\frac{1-\beta}{2},2d} = 5{,}45$ va $\chi^2_{\frac{1+\beta}{2},2d} = 15{,}7$ lar [42] da keltirilgan ma’lumotlar asosida topilgan.

(1)-(3) ifodalar qiymatlaridan ko‘rinib turibdiki, λ ning qiymati λ_q va λ_{yu} qiymatlari oralig‘ida yotadi.

FMTO‘ ishdan chiqquncha ishlash muddatining o‘rtacha qiymati quyidagicha hisoblanadi:

$$T_{1o'r} = \frac{1}{\lambda} = \frac{1}{0{,}21\times 10^{-6}} = 4{,}76 \cdot 10^6\ \text{soat}. \quad (4)$$

FMTO‘ ishdan chiqquncha o‘rtacha ishlash muddatining quyi va yuqori ishonchlilik chegaralarining qiymatlari mos ravishda quyidagilarga teng bo‘ladi:

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$$T_{1o'r.q} = \frac{1}{\lambda_{yu}} = \frac{1}{0{,}78\times10^{-6}} = 1{,}28\cdot10^{6} \text{ soat}, \quad (5)$$

$$T_{1o'r.yu} = \frac{1}{\lambda_{q}} = \frac{1}{0{,}105\times10^{-6}} = 9{,}52\cdot10^{6} \text{ soat}. \quad (6)$$

1- FMTO‘ ning ishdan chiqmasdan ishlash ehtimoli va uning ikki tomonlama ishonchlilik chegaraviy qiymatlari quyidagiga teng bo‘ladi:

$$P_1(t) = e^{-\lambda t} = e^{-0{,}21\cdot10^{-6}\cdot400\cdot10^{3}} = 0{,}919\,, \quad (7)$$

$$P_1(t)_{yu} = e^{-\lambda_q t} = e^{-0{,}105\cdot10^{-6}\cdot400\cdot10^{3}} = 0{,}958, \quad (8)$$

$$P_1(t)_{q} = e^{-\lambda_{yu} t} = e^{-0{,}78\cdot10^{-6}\cdot400\cdot10^{3}} = 0{,}73. \quad (9)$$

1- FMTO‘ uchun 90 % li resurs (γ=90%) quyidagicha aniqlanadi:

$$T_{1\gamma} = \frac{1}{\lambda}\left(-\ln\frac{\gamma}{100}\right) = \frac{1}{1{,}32\cdot10^{-6}}\left(-\ln\frac{90}{100}\right) = 79{,}8\cdot10^{6} \text{ soat}, \quad (10)$$

ya’ni 90 % li resurs 1-FMTO‘ uchun $0{,}501\cdot10^{6}$ soatdan kamni tashkil etadi.

90 % li resursning ikki tomonlama ishonchlilik chegaraviy qiymatlari quyidagicha topiladi:

$$T_{1\gamma q} = \frac{1}{\lambda_{yu}}(-\ln 0{,}9) = \frac{1}{0{,}78\cdot10^{-6}}(-\ln 0{,}9) = 0{,}135\cdot10^{6} \text{ soat}, \quad (11)$$

$$T_{1\gamma yu} = \frac{1}{\lambda_{q}}(-\ln 0{,}9) = \frac{1}{0{,}642\cdot10^{-6}}(-\ln 0{,}9) = 1{,}03\cdot10^{6} \text{ soat}. \quad (12)$$

Endi 2- va 3- FMTO‘ lari uchun ishonchlilik ko‘rsatkichlari qiymatlarini yuqorida keltirilgan formulalar yordamida hisoblash natijalarini keltiramiz:

$$\lambda_{2,3} = \frac{d}{\sum_{i=1}^{d} t_i + (N-d)L_0} = \frac{2}{3267+(50-2)200\cdot10^{3}} = 0{,}15\cdot10^{-6} \text{ soat}^{-1}, \quad (13)$$

$$\lambda_{2,3q} = \frac{\lambda_{2,3}N\chi^2_{\frac{1-\beta}{2},2d}}{d\left(2N-d+\frac{1}{2}\chi^2_{\frac{1-\beta}{2},2d}\right)} = \frac{0{,}15\cdot10^{-6}\cdot50\cdot5{,}45}{2\left(2\cdot50-2+\frac{1}{2}\cdot5{,}45\right)} = 0{,}083\cdot10^{-6} \text{ soat}^{-1}, \quad (14)$$

$$\lambda_{2,3yu} = \frac{\lambda_{2,3}N\chi^2_{\frac{1-\beta}{2},2d}}{d\left(2N-d"+\frac{1}{2}\chi^2_{\frac{1+\beta}{2},2d}\right)} = \frac{0{,}15\cdot10^{-6}\cdot50\cdot15{,}7}{2\left(2\times50-2+\frac{1}{2}\cdot15{,}7\right)} = 0{,}556\cdot10^{-6} \text{ soat}^{-1}, \quad (15)$$

$$T_{2,3o'r} = \frac{1}{0{,}15\cdot10^{-6}} = 6{,}67\cdot10^{6} \text{ soat}, \quad (16)$$

$$T_{2,3o'r.q} = \frac{1}{\lambda_{2,3yu}} = \frac{1}{0{,}556\cdot10^{-6}} = 1{,}798\cdot10^{6} \text{ soat}, \quad (17)$$

$$T_{2,3o'r.yu} = \frac{1}{\lambda_{2,3q}} = \frac{1}{0{,}083\cdot10^{-6}} = 12{,}048\cdot10^{6} \text{ soat}, \quad (18)$$

$$P_{2,3}(t) = e^{-\lambda_{2,3} t} = e^{-0{,}15\cdot10^{-6}\cdot400\cdot10^{3}} = 0{,}941, \quad (19)$$

$$P_{2,3yu}(t) = e^{-\lambda_{2,3q} t} = e^{-0{,}083\cdot10^{-6}\cdot400\cdot10^{3}} = 0{,}967, \quad (20)$$

$$P_{2,3q}(t) = e^{-\lambda_{2,3yu} t} = e^{-0{,}556\cdot10^{-6}\cdot400\cdot10^{3}} = 0{,}800, \quad (21)$$

$$T_{2,3\gamma} = \frac{1}{\lambda_{2,3yu}}\left(-\ln\frac{\gamma}{100}\right) = \frac{1}{-0{,}15\times10^{-6}}\left(-\ln\frac{90}{100}\right) = 0{,}702\times10^{6} \text{ soat}, \quad (22)$$

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$$T_{2,3\gamma yu} = \frac{1}{\lambda_{2,3yu}}\left(-\ln\frac{\gamma}{100}\right) = \frac{1}{0{,}053\cdot 10^{-6}}\left(-\ln\frac{90}{100}\right) = 1{,}269\cdot 10^{6} \text{ soat}, \quad (23)$$

$$T_{2,3\gamma q} = \frac{1}{\lambda_{2,3q}}\left(-\ln\frac{\gamma}{100}\right) = \frac{1}{0{,}556\cdot 10^{-6}}\left(-\ln\frac{90}{100}\right) = 0{,}189\cdot 10^{6} \text{ soat}. \quad (24)$$

Ko‘rib chiqilgan yangi FMTO‘ lar ishonchlilik ko‘rsatkichlarining tahlili shuni ko‘rsatadiki, uchala O‘O‘ larining ishdan chiqmasdan ishlash ehtimoli TETQ larining ABT lari tomonidan qo‘yiladigan talab darajasi(0,90)dan yuqori, 1- hamda 2- va 3- FMTO‘ lari ishonchlilik ko‘rsatkichlarining farqi ularda qo‘llanilgan materiallar resurs imkoniyatlari hamda mexanik, issiqlik,elektr va magnit xossalarining turlichaligi bilan izohlanishi aniqlandi.

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