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Study of the causes of corrosion in the insulating materials of traction motors

O.T. Kasimov[1][a], R.M. Isroilov[1][b], Z.T. Isomov[1][c]

[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: This article presents information on ways to improve the reliability of locomotive traction motors and useful methods for their repair by optimizing the distribution of loads between the components of the insulation material in the traction electric motor system, increasing its power, and adapting the potential load levels of the insulation layers to their functional purpose. It also emphasizes the main causes of damage to the insulation materials, concepts such as wear of the insulation materials in the motor, and possible ways to prevent such situations are explained through formulas and calculations.

Keywords: Insulation, cooling system, wear, permeability, moisture content, thermal load

Tortuv elektr dvigetelining izolyatsion materiallarida uchraydigan shikastlanishlarni sabablarini o'rganish

Kasimov O.T.[1][a], Isroilov R.M.[1][b], Isomov Z.T.[1][c]

[1]Tashkent davlat transport universiteti, Toshkent, O'zbekiston

Annotatsiya: Ushbu maqolada tortuv elektr dvigatelining sistemasida izolyatsiya materialining tarkibiy qismlari o'rtasida yuklanishining taqsimlanishini optimallashtirish, quvvatini oshirish va izolyatsiya qatlamlarining potensial yuklanish darajalarini ularning funksional maqsadiga moslashtirish orqali lokomotiv tortuv dvigatellarining ishonchliligini oshirish yo'llari va uni ta'mirlashdagi foydali yo'llar haqida ma'lumotlar keltirib o'tilgan. Hamda izolyatsiya materiallarida ucharydigan shikastlanishlarning asosiy sabablari, dvigateldagi izolatsiya materiallarining eskirish kabi tushunchalarga urg'u berib o'tiladi va bunday holatlarni oldini oluvchi ehtimoliy yo'llar formula va xisob kitoblar orqali ayon etiladi.

Kalit so'zlar: Izolyatsiya, sovutish tizimi, eskirish, o'tkazuvchanlik, namlanish darajasi, termik yuklanish

1. Kirish

Tortuv elektr dvigateli lokomotivning elektr energiyasimi mexanik energiyaga aylantirib beruvchi lokomotivning eng asosiy qismlaridan biri hisoblanadi, uning izolyatsiyasi totruv elektr dvigatelida ehtimolli bo'lishi mumkin bo'lgan yuklanish va shu yuklanishni oqibatida bu tortuv elektr dvigatelining ishdan chiqishini oldini oluvchi asosiy elementi hisoblanadi. Izolyatsiya materialining tarkibiy qismlari o'rtasida elektr yuklanishlarining taqsimlanishini optimallashtirish va izolyatsiya qatlamlarining potensial yuklanish darajalarini ularning funksional maqsadiga moslashtirish orqali lokomotiv tortuv dvigatellarining izolyatsiyasining ishonchliligini oshirishdan iborat. Izolyaatsiya turli xil vaziyatlarda, masalan;yuqori kuchlanish, turli xil issiq sovuqyoki yog'ongarchiliklarda uni stabil ishlashini ta'minlashga xizmat qiladi [1].

2. Tadqiqot metodikasi

Bugungi kunda temir yo'l transportida tortuv elektr dvigatellarining izolyatsiyasini takomillashtirish tizimida turli xil muammolar jumladan uni turli xil haroratlarda va doimiy yuklanishlar ostida ishlatish natijasida muammolar yuzaga kelmoqda hamda qo'shimcha ravishda undagi sovutish qismidagi nosozliklar ham yana bir asosiy sabablardan biri hisoblanadi.

Bunda biz NB-418k tortuv elektro dvigatelining izalyatsion tuzilishini ko'rib chiqamiz.Bu tortuv elektro dvigateli turli xil ob xavo sharoitlarida ishonchliligi bilan ajralib turadi.

Quyida keltirilgan rasmda esa biz izolyatsiyalangan NB-418K tortuv elektro dvigateli yakori va uni izalyatsiya bilan qoplangan xolatida ko'rishimiz mumkin(1):

1-rasm. izolyatsiyalangan NB-418K tortuv elektro dvigateli yakori va uni izalyatsiya bilan qoplangan xolatida

[a] https://orcid.org/0000-0003-1918-0294
[b] https://orcid.org/0009-0008-5974-924X
[c] https://orcid.org/0009-0003-1287-9788

Bu tortuv elektro dvigatelining izolyatsiyasi asosan slyuda moddasi va izolyatsion qog'oz ishtirokida tayyorlangan.hamda qanday qilib tortuv elektr dvigatelidagi nosozliklarni aniqlay olamiz va bu bizga unda yuzaga kelishi mumkin bo'lgan jiddiy zararlarni oldini oladigan yo'llarni ko'rib chiqmiz[7].

- Tebranishning oshib ketishi: Ishlash davomida noodatiy yoki kuchli vibratsiya bilan ishlayotgan bo'lsa bu tortuv elektr dvigatelida kamchilik borligini va uni zudlik bilan tekshirish zarurligini bildiradi.
- Noodatiy tovushlar: Turli xil tovushlar, shovqinlar tortuv elektrdvigatelida kamchilik borligini yana bir sababi.
- Ruhsat etilgan haroratning oshib ketishi: agar tortuv elektr dvigateli odatdagidan ortiq qizib ketsa unda kamchik borligini yoki yuklanishning oshib ketganini bildiradi.
- Tortuv kuchini yo'qolishi: lokomotivning qo'zg'alishida uning sezilarli darajada qo'zg'alishining kamayishi bunda tortuv elektr dvigatelida nosozlik bor ekanligini ko'rsatadi.
- Tutun yoki kuygan hidi: ko'zga ko'rinadigan darajada tutun yoki sezilarli kuygan hidi tortuv elektr dvigatelidagi kamchilikning belgisi.
- USTA tizimidagi indikatorlarning yonishi.
- Mexanik shikastlar; tortuv elektr dvigatelidagi darzlar, yoriqlar yoki shunga o'xshash mexanik shikastlar unda kamchilik borligini bildiradi.

Hamda shuni qo'shimcha qilib o'tish kerakki tortuv elektro dvigatelini doimiy ravishda nazorat qilish harakat havfsizligini va nojo'ya holatlarni oldini oladi. [15]

Tortuv elektro dvigateliga tushadigan yuklanishlarni hisobga olgan holda, ekspluatatsion va texnologik omillar ta'sirida tortuv elektr mashinalarini izolyatsiyalashda sodir bo'ladigan fizik jarayonlarni o'rganishga qaratilgan ilmiy tadqiqot dasturi, albatta, ko'p qatlamli izolyatsiyalarda kuchlanish tarqalish qonuniyatlarini o'rganish bilan bog'liq masalalarni o'z ichiga olishi kerak. Tortuv elektr dvigatelida izolyatsiyaning yemrilishi asosan ortiqcha yuklanish tufayli yuzaga keladi. Buni hisoblashda bizga dielektrik material ya'ni izolyatsiya materialning qancha kuchlanishga yoki qancha temperaturaga bardosh berishini bilishimiz kerak bo'ladi. Quyida keltirilgan hisob kitoblarda izolyatsiya yemrilishiga sabab bo'ladigan xolatlarni ko'rib chiqamiz:

1. Izolyatsiya matertialining yuqori kuchlanishga bardoshliligi [7]

(U_b) materialning turi va qalinligiga bog'liq.

$$U_b = E_d \cdot d$$

bu yerda:

E_d - izolyatsiya matrialining dielektrik kuchi (V/m)

d - izolyatsiya materialining qalinligi (m)

Masalan: slyudadan tayyorlangan materialning dielektrik kuchi 25 kV/mm va izolyatsiya qalinligi o'rtacha 0.015m.

$U_b = E_d \cdot d = 25 \cdot 0.015 = 37{,}5\ V$ ga teng bo'ladi.

2. Kuchlanishga chidamlilikni hisoblash

Kuchlanishga chidamlilik U_S

$$U_s = \frac{U}{d}$$

U - kuchlanish (V)

d - chulg'amdagi simning qalinligi.

Masalan, NB 418k tortuv elektrodvigatelidaki U(kuchlanish) 790 kVt simlarining qalinligi o'ratacha 1,5 mm

$$U_s = \frac{790 \cdot 10^3}{1{,}5 \cdot 10^{-3}} = 526\ kV/mm$$

Agarda $U_s > E_d$ bo'lganda izolyatsiya yemrilishi xosil bo'ladi.

3. Dvigatelni qizishga tekshirish

Dvigatelni qizishi davomida izolyatsiya materialining eskirishini tezlashtiradi. Buni hisoblashda Arrenius tenglamasidan foydalaniladi - $t = t_0 \cdot e^{\frac{E_a}{k}(\frac{1}{T}-\frac{1}{T_o})}$

bu yerda

t - izolyatsiya materialning taxminiy xizmat davri(soatlarda)

t_o -normal haroratda ishlash vaqti-20000 soat=20000·3600=72·10^6sek

E_a - faollashtirish energiyasi(J)

K - Boltsman doimiysi (1.38·10^{-23} J/K)

T - ishlash davomidagi temperatura (K)

T_o – ruhsat etilgan temperatura (K)

Agar tortuv elektr dvigateli normadan yuqori temperaturada ishlasa bu uning izolyatsiyasining xizmat qilish muddatini qisqarishiga sabab bo'ladi.

Misol uchun E_a-1.44·10^{-19}J. t_o-20000soat, T_o=403K(130°C), T-433K (160°C),e-0.1661

$t=t_o \cdot e^{\frac{E_a}{k}(\frac{1}{T}-\frac{1}{T_o})}$

$=e^{\frac{1.4*10^{-19}}{1.38*10^{-23}}(\frac{1}{433}-\frac{1}{403})}$=200·3600·$e^{1.774}$=1.22·$10^7$sek=3392soat

Bundan kelib chiqadiki agar temperatura me'yoridan qancha yuqori ishlasa u 20000 soatdan deyarli 3400 soatgacha qisqarishi mumkin.

4. Izolyatsiyadagi magnit maydon intensivligi.

Elektr dvigatelning izolatsiya qatlamiga magnit maydon kuchi uning dielektrik kuchida pastroq bo'lishi kerak.

$$E = {}^{U}/_{d}$$

bu yerda: E - magnit maydon intensivligi (kV/m)

U - Tortuv elektr dvigatelidagi kuchlanish (kV)

d - izolyatsiyaning qalinligi (m)

Masalan: Tortuv elektr dvigateli uchun 790kV , d=1.5·10^{-3}m (izolyatsiya qalinligi)

$$E = \frac{790 \cdot 10^3}{1.5 \cdot 10^{-3}} = 526{,}6\ MV/m$$

Agar shu qiymat yuqorida keltirilgan E_d dan katta bo'lib ketsa izolyatsiya qatlamida darzlar yuzaga kela boshlaydi.

5. Izolyatsiya materiallarning qarshiligini hisoblash [12,13]

Izolyatsiya materiali meyorida ortiq qizib ketganida yuzaga keladi va quvvat yo'qotilishi yuzaga keladi. Izolyatsiya materialining qizishi oqibatida quvvat yo'qotilishi quyidagicha ifodalaniladi:

$$P = \frac{U^2}{R}$$

bu yerda: P - quvvat yo'qolishi (W)

U - izolyatsiya bo'ylab kuchlanish yuklanishi(V)

R - izolyatsiya qarshiligi(Ω)

Izolyatsiya qarshiligi quyidagicha ifodalanadi

$$R = \rho \cdot l/\mathrm{S}$$

bu yerda: p - izolyatsiya materialining nisbiy qarshiligi (Ωm)

l - izolyatsiya materialining qalinligi(m)

S - izolyatsiya materialining yuzasi (m^2)

https://doi.org/10.56143/2181-2438-2025-1-154-157 Research, Innovation, Results

Misol uchun : Slyudadan bo‘lgan izolyatsiya uchun $p=10^{12}\Omega m$, qalinligi esa $1.5\cdot10^{-3}m$ (0,015m), va yuzasi $0,1m^2$.

$$R = \frac{0.015 \cdot 10^{12}}{0,1} = 15 \cdot 10^{10}\ \Omega$$

Agar kuchlanish U=*790kV*

$$P = \frac{(790 \cdot 10^3)^2}{15 \cdot 10^{10}} = 4.16\ W$$

Agar bu energiya tarqalmasligi oqibatida izolyatsiya qatlamida darzlar yuzaga keladi.

6. Qisman razryadlanishning boshlang‘ich kuchlanishi

Kuchlanishning qisman yo‘qotilishi qachonki izolyatsiyada bo‘shliqlar yuzaga kelganda yuzaga keladi. Buni quyidagicha ifodalanadi.

$$U_{PDIV} = 3 \cdot (\frac{d}{\varepsilon_r})^{0,5}$$

bu yerda: U_{PDIV} kuchlanishning doimiy yo‘qotilishi miqdori (V),

d – izolyatsiya materialining qalinligi(m)

ε_r - izolyatsiyaning nisbiy o‘tkazuvchanligi

Misol uchun: Slyuda uchun $\varepsilon_r = 6$ va $d = 2\ 10^{-3}m$

$$U_{PDIV} = 3 \cdot (\frac{2 \cdot 10^{-3}}{6})^{0,5} = 3 \cdot 0,018 = 0.05V$$

Agar amaldagi kuchlanish 0.05V dan oshsa kuchlanishning qisman yo‘qotilishi yuzaga keladi.

3. Natijalar

Termik yuklanishlaring ortishi tufayli elektr dvigatellarda issiqlik jarayonlarini to‘liq tahlil qilish zarur bo‘ladi. Bu issiqlik oqimlarining dvigatel bo‘ylab uch o‘lchovli taqsimlanishini, haroratga bog‘liq bo‘lgan materiallarning termofizik xususiyatlarining o‘zgarishini, yakor qismida issiqlik manbalarining notekis taqsimlanishini, sovutish muhitini isitishni hisobga olgan holda amalga oshirilishi kerak. Magistral elektrovozlarning tortuv elektr dvigatellari qiyin ish sharoitida ishlaydi. Ular temir yo‘lning notekisligi, atrof-muhit haroratining kuchli o‘zgarishi (+40 dan -50 ° C gacha) va kontakt tarmog‘idagi kuchlanishning mumkin bo‘lgan keskin tebranishlaridan kelib chiqadigan sezilarli dinamik kuchlarga duchor bo‘ladi. Harakat davomidagi qarshiligi nominalga nisbatan ikki yoki undan ko‘p marta kamayganda tortuv dvigatelining aylanish tezligi oshishi mumkin va tok kuchi, yuklanishi, ayniqsa poyezdni ishga tushirganda, nominaldan ikki baravar ko‘payishi mumkin. Har qanday uchastka bo‘ylab yurish paytida dvigatelning yuklanishi turli yo‘l profillari, o‘zgaruvchan lokomotiv tezligi va kontakt tarmog‘idagi kuchlanishning o‘zgarishi tufayli o‘zgaradi. Shunday qilib, generator tomonidan ishlab chiqilgan quvvat juda keng chegaralarda o‘zgaradi. Natijada, chiziqdagi tortuv elektr dvigatellarining ish sharoitlarini to‘liq tavsiflovchi nominal quvvatni tanlash deyarli mumkin emas. Tortuv elektr dvigatellar keskin o‘zgaruvchan yuklanishlar bilan ishlashini va ularning qismlarining maksimal haroratiga ma’lum bir yuklanishning uzoq muddatli ta'sirida ham, qisqa muddatli kattaroq yuklanish ta’sirida ham erishish mumkinligini hisobga olinishi kerak.

4. Xulosa

Natijalar shuni ko‘rsatadiki, elektravozlarda yoki teplavozlarda tortuv elektr dvigatellarning izolyatsiyasini optimallashtirish birinchi navbatta harakat havfsizligini ta’minlash, uning xizmat qilish muddatini oshirish, ortiqcha energiya sarfini kamaytirish, foydali ishning ortishi va ortiqcha yuklanishlardan xalos bo‘lishni ta’minlaydi.

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Mualliflar to‘g‘risida ma’lumot/ Information about the authors

Kasimov Obidjon Toirjonovich / Kasimov Obidjon Toirjonovich	Toshkent davlat transport universiteti “lokomotivlar va lokomotivxo’jaligi” kafedrasi tfn dotsent E-mail: kasimom7072726@mail.ru Tel.: +998974334342 https://orcid.org/0000-0003-1918-0294
Isroilov Ruslan Maqsud o‘g‘li/ Isroilov Ruslan Maksud ugli	Toshkent davlat transport universiteti “lokomotivlar va lokomotiv xo’jaligi” kafedrasi magistratura talabasi. E-mail: ruslanmisroilov@gmail.com Tel.: +998909090519 https://orcid.org/0009-0008-5974-924X
Isomov Ziyodjon Toshpo‘lat o‘g‘li / Isomov Ziyodjon Toshpulat ugli	Toshkent davlat transport universiteti “Lokomotivlar va lokomotiv xo’jaligi” kafedrasi magistratura talabasi E-mail: isomovziyodjon8902@gmail.com Tel.: +998914668902 https://orcid.org/0009-0003-1287-9788

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