Kuch transformatori shikastlanishlarini komplekt tekshirish: nosozlik turlari va keltirib chiqaruvchi omillarni tahlil qilish

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Dolzarblik: kuch transformatorlaridagi shikastlanishlari sonini kamaytirish orqali ularning xizmat ko‘rsatish muddatini uzaytirish va shu bilan birga elektr energetikasi tizimi ishonchliliginni ortirish mumkin. Kuch transformatorini ta’mirlash uchun sarflangan vaqt va ishchi kuchi elektr ta’minoti korxonasi va ishlab chiqarish korxonasi uchun katta iqtisodiy zararlariga ishlaydi. Buning kamaytirish uchun kuch transformatorlaridagi shikastlanishlarni tahlil qilish va kamaytirish orqali uning ishdan chiqishlar soni kamaytirish va elektr ta'minoti ishonchliligini oshirish ishning dolazarbligini ifodalaydi.
Maqsad: kuch transformatordagi shikastlanishlarni tadqiq qilish, shikastlanish turlar va ularni keltirib chiqaruvchi omillarni tahliliy ko‘rib chiqish, kuch transformatorini ishdan chiqishiga eng ko‘p sababchi bo‘layotgan omillar aniqlash, elementlardagi shikastlanishlarni aniqlashda qo‘llaniladigan diagnostikalash usullari aniqlashdan iborat.
Usullar: kuch transformatorlarining shikastlanishini har tomonlama tekshirish, nosozlik turlari va ularni keltirib chiqaruvchi omillarni tahlil qilishda IEEE Xplore, Research Gate, Springer Link, Pro Quest, Elsevier, Google Scholar kabi ma’lumotlar bazalarida so‘nggi yillarda chop etilgan ilmiy tadqiqot ishlaridan foydalanildi. Tizimli tahlil usuli kuch transformatorini va uning elementlaridagi shikastlanishlarni tahlil qilishda ishlatilgan. Kuch transformatori shikastlanishining statistikasi qismida statistik tahlil usuli qo‘llanilgan.
Natijalar: tarmoqdagi qisqa tutashuvlar, moyning ifloslanishi, elektr ta'minotidagi cheklovlar kuch transformatorining ishdan chiqishiga salbiy ta’sir qilishi aniqlandi. Qisqa tutashuv va izolyatsiyaning eskirishi kuch transformatorining barcha elementlarini shikastlantiruvchi omil degan xulosaga kelindi. Barcha elementlarda mexanik shikastlanish kuzatildi. Chulg’amdagi mexanik shikastlanishlarni aniqlashda yuqori aniqlikka ega usul chastota ta’siri tahlili (FRA) usuli ekanligi aniqlandi. Chulg’amning shikastlanishi kuch transformatorini eng ko’p ishdan chiqaruvchi omil bo’lib va yuqori kuchlanishlarga qaraganda quyi kuchlanishlarda tez-tez uchraydi.
Kalit so‘zlar: shikastlanish omillari, ishdan chiqish, elementlar shikastlanishi, shikastlanish sabablari, shikastlanish turlari, diagnostikalash usullari, ishdan chiqishlar statistikasi, CIGRE.

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Комплексное обследование повреждений силовых трансформаторов: анализ видов неисправностей и причинных факторов

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Актуальность: уменьшая количество неисправностей трансформаторов питания, можно продлить срок их службы, и в то же время повысить надежность поставок электроэнергии. Время и объём работ, потраченные на ремонт силовых трансформаторов, приводят к огромным экономическим затратам для предприятий систем энергоснабжения. Актуальность работы заключается в анализе возможностей уменьшения ущерба из-за неисправностей силовых трансформаторов систем электроснабжения.
Цель: исследование повреждений в силовых трансформаторах, аналитический обзор типов повреждений и факторов, наиболее часто вызывающих повреждения, а также идентификация диагностических методов, используемых для обнаружении повреждения в элементах силовых трансформаторов.
Методы: при комплексном обследовании повреждений силовых трансформаторов, анализе типов отказов и факторов, вызывающих их, использовались научно-исследовательские работы, опубликованные в последние годы в таких базах данных, как IEEE Xplore, Research Gate, Springer Link, Pro Quest, Elsevier, Google Scholar. Для выявления причин повреждений силовых трансформаторов и их элементов использованы методы системного и статистического анализа.
Результаты: установлено, что на выход из строя силовых трансформаторов негативно влияют короткие замыкания в сети, загрязнения нефтепродуктами, перебои в электроснабжении. Подтверждено, что короткие замыкания и старение изоляции являются основными факторами повреждений силовых трансформаторов и их элементов. Наблюдались механические повреждения элементов, которые анализировались методом частотных эффектов (ЧЭ). Повреждения обмоток являются наиболее

распространенными причинами отказов силовых трансформаторов, чаще встречаются при более низких напряжениях, чем при более высоких.
Ключевые слова: факторы повреждения, отказы, отказ элемента, причины отказа, виды отказов, методы диагностики, статистика отказов, СИГРЭ.

Comprehensive inspection of power transformer damage: analysis of fault types and causative factors

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Relevance: by reducing the number of damages in power transformers, it is possible to extend their service life and at the same time increase the reliability of the electric power system. The time and manpower spent on repairing the power transformer would result in huge economic losses for the power supply company and the production company. To reduce this, by analyzing and reducing damage in power transformers, reducing the number of breakdowns and increasing the reliability of the power supply represents the relevance of the work.
Aim: Research of damage in power transformer, analytical review of types of damage and factors that cause them, identification of the factors most likely to cause power transformer failure, identification of diagnostic methods used in detection of damage in elements.
Methods: In the comprehensive examination of power transformer damage, analysis of failure types and factors causing them Scientific research works published in recent years in databases such as IEEE Xplore, Research Gate, Springer Link, Pro Quest, Elsevier, Google Scholar were used. The systematic analysis method was used to reveal the power transformer and the analysis of injuries in its elements. In the statistics part of power transformer damage the statistical analysis method was used.
Results: It was determined that short circuits in the network, the oil pollution, constraints in electricity supply were negative affect failure of power transformer it was concluded that short-circuit and aging of isolation were factor of damage of all elements of the power transformer. It was observed mechanically injured in all elements. In determining mechanical injuries in the winding, a high accuracy method was found to be frequency effects (FRA) method. Winding damage is the most common cause of power transformer failure and is more common at lower voltages than at higher voltages.
Keywords: damage factors, failure, element failure, causes of failure, failure types, diagnostic methods, failure statistics, CIGRE.

1. Kirish (Introduction)

Dunyo aholisi sonining ortib borishi va inson hayot-tarzini yengillashtiruvchi jihozlarning ishlab chiqarilishi natijasida bugungi kunda elektr energiyasiga bo‘lgan talab kudan-kunga ortib bormoqda. Iste’molchilarni elektr energiyasi bilan ta’minlashda ishtirok etadigan kuch transformatorlari energetika tiziming eng asosiy va qimmatbaho qurilmalaridan biri hisoblanadi [1–2].

Kuch transformatorlari chastota va quvvat qiymatini doimiy ravishda ushlab turgan holda kuchlanish va tok kuchini bir qiymatdan ikkinchisiga o‘zgartirish orqali elektr energiyasini uzatish va taqsimlash vazifasini bajaradi. Kuch transformatorlaridagi har qanday turdagi shikastlanishlar elektr energetika tizimini ishonchliligini kamaytiradi va qitisodiy yo‘qotishlarga sababchi bo‘ladi [3]. Bugungi kunda kuch transformatorlarning ishdan chiqishi va ularning ishlash ishonchliligini oshirish bo‘yicha dunyo olimlar tomonidan bir qator standartlar ishlab chiqilgan [4–5]. Monitoring, baholash va tuzatish ishlari energiya tizimining quvvat transformatorlarini ekspluatatsiya qilish va texnik xizmat ko‘rsatish tadbirlariga kiritilgan [2], [6]. Tadqiqot natijalariga ko‘ra, uzoq muddat foydalanilgan kuch transformatorlarining qisqa tutashuvga chidamliligi yangi ishga tushurilgan kuch transformatorlariga qaraganda pastroqdir bo‘ladi [2,7].

Korxonalar uchun iqtisodiy va energiya samaradorligini oshirishga kuch transformatorlarining holatini doimiy ravishda monitoring qilib boriladi. Monitoring va diagnostika qilish natijalari asosida ishlab chiqilgan chora-tadbirlarni qo‘llash orqali kuch transformatorlarining ishlash ishonchliligini oshiriladi [2,8-9].

Olib borilgan tadqiqot ishi [5] ga ko‘ra, normal sharoitda kuch transformatorlarining ishlash muddati 40 yilni tashkil etadi, 40 yildan ortiq foydalanilgan kuch transformatorlarining ishdan chiqish ehtimoli ortadi. Agar kuch transformatorlariga sifatsiz xizmat ko‘rsatilsa, kuch transformatori nonormal sharoitda ishlasa va tarmoqda va kuch transformatorlarida qisqa tutashuvlar ko‘p sodir bo‘lsa, bu kuch transformatorlarining ishlash muddati qisqarishiga olib keladi. Xizmat ko‘rsatish sifatini yaxshilash va eskirgan transformatorlarning ishlash xarajatlarini kamaytirish uchun hozirgi vaqtda turli xil ichki nosozliklarni tashxislash uchun turli holat monitoringi va tekshirish usullari qo‘llanib kelinmoqda [10].

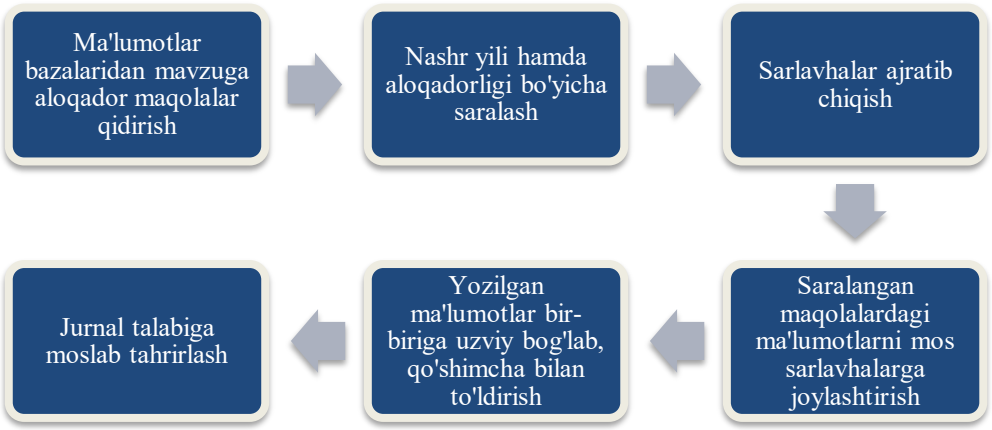
Bir qator tadqiqotlar shuni ko‘rsatmoqdaki, kuch transformatorning ishdan chiqishi ehtimoli elektr,

issiqlik, mexanik, fizik, kimyoviy kuchlanishlar kabi ta'sirlarga bog'liq [2,11]. Kuch transformatorning eskirishi ulardan uzoq muddat foydalanish natijasida uning mexanik va dielektrik kuchining pasayishi bilan bog'liq [2,7].

Bugungi kunga kelib, kuch transformatorlaridagi nosozliklarni aniqlash uchun ko'plab diagnostikalash usullari o'rganilgan [2], [12-15]. Kelajakda kuch transformatorlarining ishdan chiqish ehtimolini kamaytirish va katta moliyaviy yo'qotishlarga yo'l qo'ymaslik, shuningdek energiya tizimining ishonchliligini oshirish maqsadida ushbu maqolada kuch transformatorlarining ishdan chiqish sabablari ko'rib chiqiladi.

2. Materiallar va usullar (Methods and materials)

Ushbu tahliliy tadqiqot ishini yozish algoritmi 1-rasmda keltirilgan bo'lib, dastlab kuch transformatori, uning elementlari shikastlanishiga aloqador bo'lgan maqolalarni IEEE Xplore, Research Gate, Springer Link, Pro Quest, Elsevier va Google Scholar ma'lumotlar bazalaridan foydalangan holda to'plandi. Ushbu to'plangan maqolalar nashr yillari hamda mavzuga aloqadorligi bo'yicha saralab chiqildi. Kuch transformatori va uning elementlari shikastlanishlarini ochib berish maqsadida tizimli tahlil usulidan foydalanildi. Kuch transformatorlar shikastlanish statistikasi bo'limida statistik tahlil usuli qo'llanildi [16].



1-rasm. Maqolani yozish algoritmi
Fig. 1. Article writing algorithm

Saralab olingan maqolalarni tahlil qilish orqali maqolalarning sarlavhalari ishlab chiqildi. Maqola ichidagi qo'shimcha ma'lumotlarni o'rganish davomida qo'shimcha maqolalar to'plandi. Barcha to'plangan maqolalardagi ma'lumotlarni ishlab chiqilgan sarlavhalarga joylab chiqildi. To'plangan ma'lumotlarni o'zaro mazmunan bog'lab, qo'shimchalar bilan to'ldirib chiqildi. Kuch transformatori elementidagi shikastlanishlarni diganostikalash usullari o'rganib chiqildi va maqola qo'shimcha ma'lumotlar bilan boyitildi.

3. Muhokama (Discution)

Kuch transformatorning ishlamay qolishi ehtimoli elektr, dielektrik, issiqlik, mexanik, fizik-kimyoviy va tasniflanmagan kuchlanishlar kabi asosiy nosozliklarning kelib chiqishiga bog'liq. Kuch transformatorini ishdan chiqishiga olib keluvchi omillar quyidagilar [2,11,17-19]:

- Izolyatsiyaning shikastlanishi
- Qisqa tutashuv
- Ishlab chiqarishdagi nuqsonlar
- O'ta yuklanish
- Sifatsiz texnik xizmat ko'rsatish
- Chaqmoq
- Kuchlanish tebranishi
- Namlik
- Transformator moyining ifloslanishi
- Kontaktlarning yermirilishi
- Nochiziqli yuklamalar
- Elektr ta'minotidagi cheklovlar
- Boshqa omillar

Elektr nuqtai nazaridan, chaqmoq va kommutatsiya kuchlanishlari o‘zak va chulg‘am izolyatsiyasining buzilishiga olib keladi. Bundan tashqari, mexanik kuchlanishlar va chulg‘am deformatsiyalari sovutish tizimiga ta’sir qilishi va qisqa tutashuvlarni kelib chiqishiga sabab bo‘ladigan haroratning tez oshishiga hissa qo‘shishi mumkin. Bundan tashqari, agar namlik zarralari har qanday texnik holat tufayli qo‘shilsa, bu izolyatsiya tizimining tez buzilishiga olib keladi [2,20].

Izolyatsiyaning buzilishi va kuchlanish tebranishih kuch transformatorlarning shikastlanishiga olib keladigan omillarning 46,5% ni, qolgan omillar esa 53,5% ni tashkil qiladi [17]. Olib borilgan tadqiqot natijalariga ko‘ra [21], kuch transformatorlarining ishdan chiqishining asosiy sabablari o‘ta kuchlanish, chulg‘am shikastlanishi va izolyatsiyaning buzilishi ekanligi aniqlandi.

Kuch transformator elementlari va ularning shikastlanish sabablari. Kuch transformatorlari elementlarining shikastlanishi kuch transformatorlarini ishdan chiqishiga olib keladi [1,2,17,18]. Kuch transformatorlarining ishdan chiqish sabablarini tahlil qilish natijalariga ko‘ra, uzoq muddatli qisqa tutashuv toklarining ta’siri tufayli chulg‘amlardagi geometrik o‘zgarishlar, o‘ramlararo qisqa tutashuvlar, yong‘in va portlashlar kabi shikastlanishlarni keltirib chiqaradi [13]. Quyidagi kuch transformatorning ishdan chiqishiga olib kelishi mumkin bo‘lgan elementlarning shikastlanishi keltirib o‘tilgan.

Chulg‘am kuch transformatorining asosiy elementlaridan biri hisoblanadi [1,2]. Qisqa tutashuvli toklari natijasida hosil bo‘lgan mexanik kuchlar transformator chulg‘amlarining deformatsiyalanishi va siljishlarini keltirib chiqaradi. Bunday deformatsiyalar transformatorni kelajakdagi mexanik va dielektrik kuchlanishlarga bardosh berish qobiliyati sezilarli darajada kamaytiradi [30].

Shikastlanish sabablari: ishlab chiqarishdagi nuqsonlar, o‘ta kuchlanish, qisqa tutashuv, ualnishlardagi nuqsonlar, transportirovkalashdagi shikastlanish [1,17,18].

Shikastlanish turlari: izolyatsiyaning eskirishi, chulg‘am deformatsiyalanishi (o‘qiy siljish, radial deformatsiya), o‘ramlaro qisqa tutashuv, o‘zakdagi yerlashishning yo‘qolishi, disklararo qisqa tutashuv, disk maydoning o‘zgarishi, issiqlik yo‘qolishi [1,17,23,24]

Diagnostikalash usullari: Erigan gaz tahlili (DGA) [25], chastota ta’siri tahlili (FRA) [26], uzatish funksiyasi va boshqalar [27].

Kuchlanishni rostlash qurilmasi (OLTC) kuchlanishni nazorat qilish funksiyasini bajaradi. Bu funksiyani transformator ikkilamchi chulg‘amidagi o‘ramlar sonini o‘zgartirish orqali amalga oshiradi [1].

Shikastlanish sabablari: diskdagi bo‘sh joyning o‘zgarishi, sifatsiz texnik xizmat ko‘rsatish, kondansatorlarning eskirishi, muntazam foydalanish, o‘ta kuchlanish, noto‘g‘ri foydalanish va boshqalar [1,28]

Shikastlanish turlari: mexanik tizimning shikastlanishi, tok zanjiridagi nuqsonlarni, izolyatsiya tizimida nuqsonlar [28].

Diagnostikalash usullari: Akustik usullar [28,29], Erigan gaz tahlili (DGA) [30],

O‘zak kuch transformatorida magnit oqimini o‘tkazish hamda mexanik mustahkamlik berish vazifasini bajaradi [1,19].

Shikastlanish sabablari: o‘zgarmas tok magnitlanishi, haddan tashqari qizib ketish, o‘zakning siljishi [1,17,19].

Shikastlanish turlari: po‘lat o‘zakning siljishi,

Diagnostikalash usullari: Erigan gaz tahlili, online tok kuchi, tebranish signali tahlili, vibroakustikani aniqlash [19,31,32].

Vtulka yuqori kuchlanishli elektr o‘tkazgich izolyatsion vtulkalar bilan himoyalangan holda yerlatkich o‘tkazgichdan o‘tishi mumkin. Transformatorlarda u tokning qobiq devoridan o‘tishi uchun marshrutni yaratadi. Odatda, vtulkalar vaqt o‘tishi bilan shikastlanadi [1,[6,33].

Shikastlanish sabablari: qisqa tutashuvlar, o‘tkazgich ulanishlarining mahamligining kamayishi, kuchlanishni tasodifan ortib ketishi, suvning kirib borishi, eskirish yoki haddan tashqari dielektrik yo‘qotishlar, moyni almashtirish yoki moyning yetishmasligi, zilzila, materialdagi nosozliklar va boshqalar [1,19].

Shikastlanish turlari: chinni yoriqlari, yomon qistirmalari, izolyatsiya ichiga suvning kirib borishi

Diagnostikalash usullari: Davriy tekshirish va texnik xizmat ko‘rsatish, quvvat omili va sig‘im, qisman razryadlanish [19,34].

Izolyatsiya uchta maqsadga xizmat qiladi. Avvalo, transformator yoqilganda, u elektr zaryadini saqlaydi va transformator tarkibiy qismlarining turli kuchlanishlarini ajratish uchun dielektrik vazifasini bajaradi. Bundan tashqari, chulg‘amning mexanik mustahkamligini oshirish va moy uchun sovutish kanallarini hosil qilib, transformatorning issiqlik holatini yaxshilashga xizmat qiladi. Izolyatsiya ikki turga bo‘lingan: qattiq (qog‘oz) izolyatsiya va moyli izolyatsiya.

Qattiq izolyatsiya chulg‘amlar orasidagi elektr izolyatsiya sifatida qo‘llanilib, sellyulozadan tayyorlangan press taxta va qog‘oz ishlatiladi.

Shikatlanish sabablari: transportirovkalash, qisqa tutashuvlar, izolyatsiyaning eskirishi, oksidlanish, namlik, o‘ta yuklanish, sifatsiz moy, transformatorni siljitish, qisqa tutashuvlar paytida

hosil bo‘lgan kuchlar.

Shikatlanish turlari: mexanik shikastlanish, haroratni ortishi

Diagnostikalash turlari: erigan gaz tahlili, qisman razryadlanish, izolyatsiya qarshilik sinovi, polarizatsiya indeksi, qayta tiklash kuchlanishini o‘lchash, tangens deltasi, polimerlanish darajasi [35-38]

Moy izolyatsiyasi chulg‘amlar orasidagi izolyatsiya va transformatorning mos sovishini ta’minlaydi

Shikastlanish sabablari: moy aylanmasining noto‘g‘ri ishlashi, ikkilamchi sovutish pallasiga issiqlikning yomon o‘tishi, izolyatsiyaning haddan tashqari qizib ketishi, izolyatsiyaning eskirishi, moy aylanish tizimini shikastlanishi, namlik, qisqa tutashuv

Shikastlanish turlari: ifloslanish, suv zarralari qo‘shilishi, yuqori harorat, yopishqoqligining oshishi, ikkinchi sovutish pallasida juda yuqori harorat, o‘tkazuvchan zarrachalarning paydo bo‘lishi, moy izolatsiyasining buzilishi

Diagnostikalash usullari: erigan gaz tahlili, kimyoviy diagnostika, Raman usullari [19,39]

Sovutish tizimi suv bilan sovutilgan issiqlik almashinuvchilari, moy nasoslari va sovutish ventelyatorlaridan iborat.

Shikastlanish sabablari: atroh muhitning ta’siri, korroziya, yuqori namlik va quyosh nurlanishi, sifatsiz texnik xizmat ko‘rsatish, ortiqcha foydalanish yoki dvigatelning eskirishi, sifatsiz termostatlar

Shikastlanish turlari: transformatorning shamollash tizimini shikastlanishi, past issiqlik almashinuvini, sovutish ventelyatorlaridagi nosozliklar va boshqalar [1]

Diagnostikalash usullari: radiator harorati, infraqizil termografiya, tasvirni qayta ishlash usuli [32,40].

Himoya tizimi transformatorni nosozliklardan himoya qilish asosiy maqsadi hisoblanadi [19].

Shikastlanish sabablari: moyning haddan tashqari qizishi, sifatsiz moy, yuqori kuchlanish, namlik, ifloslanish

Shikastlanish turlari: portlash, dielektrik shikastlanishlari

Diagnostikalash usullari: Buchholz himoyasi sinovi [41].

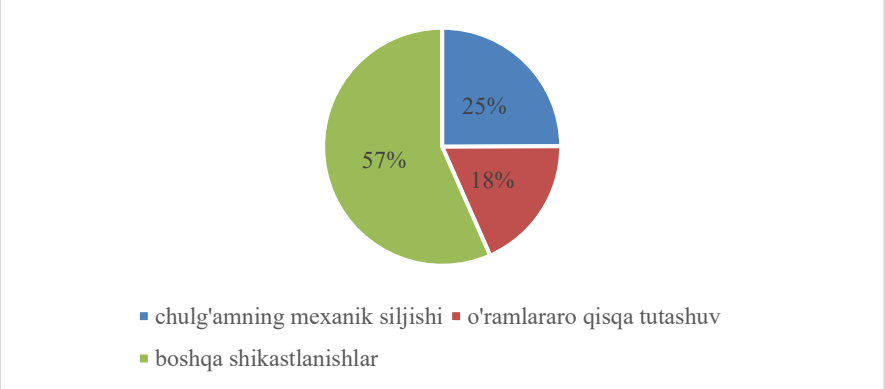
Qobiq transformatorlar ichidagi ishlatiladigan moyni saqlash va tashqi ta’sirlardan himoyalash uchun xizmat qiladi. Transformatorlar qobig‘i transformator bilan bog‘liq qo‘shimcha uskunalarni qo‘llab-quvvatlash vazifasini ham bajaradi [19].

Shikastlanish sabablari: atrof-muhitning ta’siri, korroziya, yuqori namlik va quyosh nurlanishi, moy darajasining pasayishi.

Shikastlanish turlari: mexanik shikastlanish, yuqori gaz bosimining ko‘tarilishi, korroziya va qistirmalarning oqishi, qobiq devorlarining oqishi yoki yoriqlari, moy oqishi [19]

Diagnostikalash usullari: tebranish signali tahlili [42]

Kuch transformatorlarining shikastlanish statistikasi. Energiya tizimida muhim rol o‘ynaydigan kuch transformatorlarida statistik tahlil o‘tkazish orqali ulardagi shikastlanishlar sonini kamaytirishga erishish mumkin. Olib borilgan tadqiqotlarga ko‘ra 10/0,4 kV kuchlanishli shikastlangan kuch transformatorlarni ularning quvvati bo‘yicha tahlil qilinganda, eng ko‘p sihdan chiqqan kuch transformatorlari 100 kVA ga to‘g‘ri keldi. Keyingi o‘rinlarni 63 kVA va 25 kVA quvvatli kuch transformatorlari egalladi [17,19]. IEEE C57.125 standartiga ko‘ra, moyli transformatorning ishlash muddati taxminan 20,55 yilni tashkil qiladi [17,19].

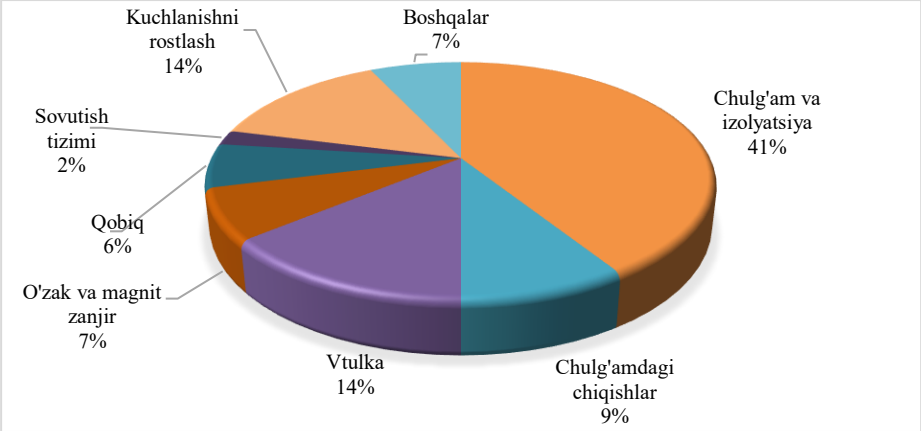


2-rasm. Rossiya energetika tizimidagi taqsimlash tarmoqlaridagi 10/0,4 kV kuchlanishli kuch transformatorlariga ta’sir qiluvchi nosozliklar statistikasi va asosiy shikastlanish turlari

Fig. 2. Failure statistics and main types of damage affecting power transformers of 10/0.4 kV in the distribution grids of one the Russian power systems

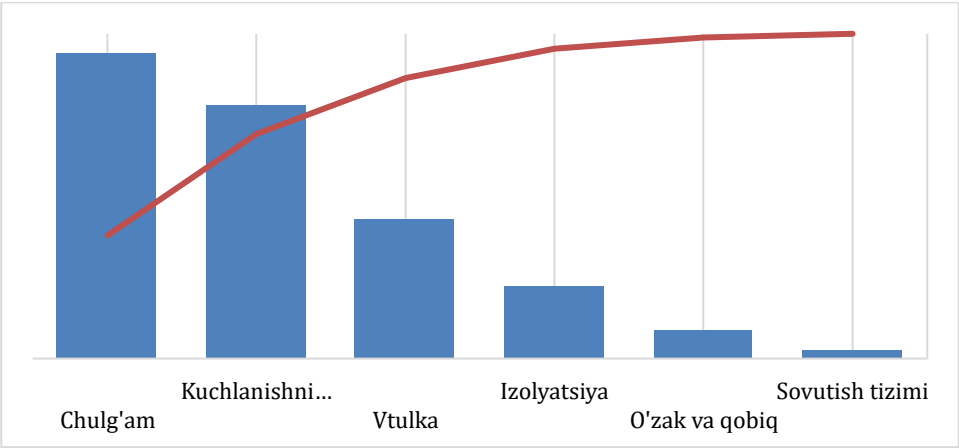
2-rasmda Rossiya energetika tizimmi taqsimlash tarmoqlarida 10/0,4 kV kuchlanishli kuch transformatorlarga ta'sir qiluvchi nosozliklar statistikasi va asosiy shikastlanish turlari ko'rsatilgan. Unga ko'ra, transformator barcha shikastlanishlarining 25% chulg'amlarni mexanik siljishi tufayli yuzaga kelgan. Transformatorning ishdan chiqishining 18% qisqa tutashuvlar natijasida yuzaga kelagan.

3-rasmda kuch transformatorining shikastlanishini uning elementlariga bog'liqlik grafigi ko'rsatilgan [43]. Rasmga ko'rsatilishicha, chulg'am, izolyatsiya va o'zak kabi elementlar shikastlanganda kuch transformatori ishdan chiqadi. Eng ko'p ishdan chiqqan kuch transformatori elementi uning chulg'amlari va izolyatsiyasining shikastlanishi bo'lib, umumiy ishdan chiqishlarning 41% ni tashkil qildi. Keyingi o'rinda vtukla tufayli ishdan chiqish 14% bo'lgan.



3-rasm. Kuch transformatorlaridagi shikastlanishlar statistikasi
Fig.3. Failure statistics for power transformers

4-rasmda Kuch transformatori elementlarining ishdan chiqish statistikasi keltirilgan. Katta elektr tizimlari xalqaro kengashi (CIGRE) ishchi guruhi A2.37 1996-2010 yillarda kuch transformatorlari bilan sodir bo'lgan 964 ta asosiy nosozliklarni to'pladi



4-rasm. Kuch transformatori elementlarining ishdan chiqish statistikasi
Fig.4. Kuch transformatori elementlarining ishdan chiqish statistikasi

Energetika tizimi obyektlarida kuch transformatorlarning ishdan chiqishlari to'g'risidagi ma'lumotlar tahlili shuni ko'rsatadiki, shikastlanish 10/0,4 kV transformatorlarning 43% i va 110 kV kuchlanishli transformatorlarning 30% dan ortig'i ularning faol qismlarda, xususan chulg'amlardagi shikastlanishlar tufayli sodir bo'lgan.

4. Xulosa (Conclusion)

Ushbu maqolaning maqsadi kuch transformatordagi shikastlanishlarni tadqiq qilish, shikastlanish turlar va ularni keltirib chiqaruvchi omillarni tahliliy ko'rib chiqish edi. Kuch transformatori shikastlanishi keltirib chiqaruvchi omillarni tahlil qilish davomida qisqa tutashuv, sifatsiz xizmat

ko‘rsatish, moyning ifloslanish kabi omillarni bilan birga elektr ta’minotigi cheklovlar ham ta’sir qilishi aniqlandi.

Kuch transformatori elementlari va ularning shikastlanishi ko‘rib chiqish davomida qisqa tutashuv ham izolyatsiyaning eskirishi kuch transformatorining deyarli barcha elementlarini shikastlantiruvchi omil ekanligi va barcha elementlarda mexanik shikastlanish kuzatilishi aniqlandi. Diagnostikalash usullari orasida erigan gaz tahlili (DGA) usuli keng tarqalgan bo‘lib, kuch transformatoridagi ko‘plab elementlar shikastlanishlari aniqlashda foydalaniladi. Shu bilan birga chastota ta’siri tahlili (FRA) usuli chulg‘amdagi mexanik shikastlanishlarni aniqlashda yuqori aniqlikka ega ekanligi aniqlandi.

Chulg‘am shikastlanishi kuch transformatorining ishdan chiqaruvchi eng ko‘p omil bo‘lib, yuqori kuchlanishlarga nisbatan quyi kuchlanishlarda ko‘proq uchraydi. Kelgusi ilmiy tadqiqot ishlarida kuch transformatorining ishdan chiqishi kamaytirish va xizmat o‘tash muddatini uzaytirish uchun ularning chulg‘amlaridagi shikastlanishlar, ayniqsa mexanik shikastlanishlarga ko‘proq e’tirbor qaratish lozim.

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