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Tashkent state transport university

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Energy efficiency of electric motors based on magnetically soft materials

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Abstract: The article examines approaches to improving the energy efficiency of electric motors through the application of composite soft magnetic materials in the manufacturing of structural components. The main groups of alloys with varying magnetic characteristics and significantly different hysteresis loop configurations were analyzed. It is demonstrated that an increase in energy efficiency is directly associated with the reduction of internal losses in the electric motor, which consequently leads to an extension of its operational lifetime. One of the most promising directions for enhancing the energy performance of electric machines is the use of soft magnetic materials produced by powder metallurgy techniques. This technology enables the fabrication of stator and rotor components in complex three-dimensional geometries, in contrast to conventional laminated constructions. The controlled formation of the material's internal microstructure during the powder processing stage contributes to the reduction of magnetic and thermal losses. As a result, operating regimes become more stable, the efficiency coefficient increases, and the overall performance characteristics of the electric motor are improved.

Keywords: composition, materials, motors, energy, magnetic alloys, optimization, innovative technologies, characteristics, mechanical and magnetic hardness, efficiency

Magnit yumshoq materiallar asosida yaratilgan elektr motorlarning energiya samaradorligi

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Annotatsiya: Maqolada kompozision magnit yumshok materiallardan foydalanib elektr motorlarning elementlari va detallarini ishlab chiqarish asosida energiya samaradorligiga erishish usullari ko‘rilgan. Magnit tavsiflarining miqdori va o‘ta farqlanadigan gisterezis egri chiziq shakllari uchun qotishmalarning asosiy gruppalari o‘rganilgan. Energiya samaradorlik darajasi ortishi bilan elektr motorning xizmat muddatining uzayishi elektr motordagi isroflarga bog‘liq. Elektr motorlarning energiya samaradorligini oshirishning istiqbolli yo‘nalishlaridan biri – magnit yumshoq materiallarni kukun metallurgiyasi asosida tayyorlashdir. Ushbu texnologiya yordamida stator va rotor elementlarini an’anaviy laminatsiyalangan konstruksiyalardan farqli ravishda uch o‘lchamli shakllarda ishlab chiqish mumkin. Kukunli texnologiya qo‘llanilganda materialning ichki tuzilmasi boshqariladigan tarzda shakllantiriladi, bu esa magnit va issiqlik yo‘qotishlarini kamaytirishga xizmat qiladi. Natijada elektr motorlarning ish rejimlari barqarorlashadi, foydali ish koeffisiyenti ortadi va qurilmaning ekspluatatsion ko‘rsatkichlari yaxshilanadi.

Kalit so‘zlar: kompozision, materiallar, matorlar, energiya, magnit qotishmalar, optimallashtirish, innovasion texnologiyalar, tavsiflar, mexanik va magnit qattiqliklari, samaradorlik

1. Kirish

Bugungi kunda sanoat va transport sohalarida ishlatilayotgan umumiy elektr energiyaning asosiy qismi elektr yuritmalar hissasiga to‘g‘ri keladi. Shuning uchun elektr motorlarning konstruktiv va material tarkibini takomillashtirish orqali ularning foydali ish koeffisiyentini oshirish dolzarb ilmiy-texnik vazifalardan biri hisoblanadi.

Energiya tejamkor elektr mashinalarini yaratish nafaqat ishlab chiqarish xarajatlarini kamaytiradi, balki issiqlik ajralishini pasaytirish orqali qurilmaning ishonchliligi va xizmat muddatini ham oshiradi. Shu nuqtai nazardan magnit yumshoq kompozision materiallardan foydalanish istiqbolli yo‘nalish sifatida qaralmoqda.

Zamonaviy elektr mashinasozlik sohasida yuqori samaradorlikka ega yangi avlod motorlarini yaratish jarayoni ilg‘or texnologik yondashuvlar hamda ko‘p komponentli kompozision materiallardan foydalanishni talab etadi. Elektr motorlarning konstruktiv va material tarkibini optimallashtirishda ularning magnit, issiqlik va mexanik xossalarini kompleks tahlil qilish muhim ahamiyat kasb etadi. Materiallarni tayyorlash texnologiyasining o‘ziga xos xususiyatlarini hisobga olgan holda energiya yo‘qotishlarini kamaytirish va energiya tejamkor ish rejimlarini oldindan modellashtirish imkoniyati kengayadi.

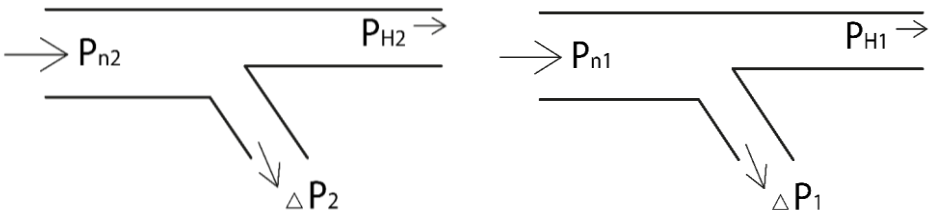
Respublikada energiya resurslaridan samarali foydalanish va ishlab chiqarish jarayonlarining energiya sig‘imini pasaytirish bo‘yicha tizimli chora-tadbirlar amalga oshirilmoqda. 2022–2026 yillarga mo‘ljallangan rivojlanish dasturlarida iqtisodiyot tarmoqlarini barqaror elektr ta’minoti bilan ta’minlash, ekologik yuklamani kamaytirish hamda energiya samaradorligini bosqichma-bosqich oshirish ustuvor vazifalar qatorida belgilangan. Ushbu vazifalarni amalga oshirish texnologik jarayonlarni modernizatsiya qilish va yuqori samaradorlikka ega materiallarni joriy etishni taqozo etadi.

Kukun metallurgiyasi asosidagi texnologiyalar elektr motorlarning magnit o‘tkazgich elementlarini shakllantirishda energiya sarfini kamaytirish va ichki yo‘qotishlarni optimallashtirish imkonini beradi. Zarrachalarning izolyasion qatlam bilan qoplanishi uyurma toklarni cheklaydi, natijada magnit yo‘qotishlar kamayadi va umumiy foydali ish koeffisiyenti ortadi. Shu bois kukunli materiallar asosida elektr motorlar ishlab chiqarish jarayonini chuqur ilmiy asosda tadqiq etish va ularning parametrlarini matematik modellashtirish dolzarb ilmiy vazifa hisoblanadi.

2. Tadqiqot metodologiyasi

O‘tkazilgan tadqiqotlar natijasida elektr motorlar ishlash rejimlarini optimallashtirish masalalarida muayyan yutuqlarga erishilib, zamonaviy boshqarish tizimlari, boshqarish algoritmlari, elektr yuritmalar aylanish tezligini ravon o‘zgartirish usullari ishlab chiqilgan. Shu bilan birga, qayd etish lozimki, magnit yumshoq kukunli materiallar asosidagi elektr motorlarni ishlab chiqish masalasi yetarli darajada o‘rganilmagan.

1-rasmda elektr energiyasidan foydalanishning ikki xil holati tasvirlangan: (a) variantda energiya yo‘qotishlari yuqori bo‘lgan, samarasiz ishlash rejimi, (b) variantda esa energiya resurslaridan oqilona va tejamkor foydalanish holati ko‘rsatilgan. Mazkur taqqoslash elektr qurilmalarda ichki yo‘qotishlarni kamaytirish samaradorlikka bevosita ta’sir qilishini ko‘rsatadi [1, 3].



a) b)

1-rasm. Elektr energiyasidan foydalanish samaradorligini taqqoslash sxemasi

Faraz qilaylik, ikkita qabul qilgichning foydali yuklama quvvati teng bo‘lsin, ya’ni

$$P_{n1} = P_{n2} = P_n.$$

Biroq ularning ichki yo‘qotishlari turlicha: birinchi qabul qilgichda yo‘qotishlar ΔR_1, ikkinchisida esa ΔR_2 bo‘lib, $\Delta R_1 > \Delta R_2$.

Yuklama quvvati bir xil bo‘lgan sharoitda ichki isroflari kamroq bo‘lgan qurilma tarmoqdan kamroq energiya iste’mol qiladi. Shu sababli ikkinchi qabul qilgichning umumiy foydali ish koeffisiyenti yuqoriroq bo‘ladi va u energiya jihatidan samaraliroq hisoblanadi [2, 7, 9].

Energiya samaradorligi deganda ma’lum mexanik yuklama sharoitida elektr energiya sarfini minimal darajaga tushirish tushuniladi. Bunda chiqish quvvati saqlanib qoladi, biroq kirish quvvati va ichki yo‘qotishlar kamaytiriladi.

Elektr motorlarda samaradorlik ko‘rsatkichi odatda foydali ish koeffisiyenti orqali ifodalanadi:

$$\eta = \frac{P_{foydali}}{P_{kirish}} \quad (1)$$

bu yerda:

$P_{foydali}$ – valdagi mexanik quvvat,

P_{kirish} – tarmoqdan olinadigan aktiv quvvat.

Elektr motorning energiya samaradorligi oshishi bilan uning ekspluatatsion ishonchliligi va xizmat muddati ham ortadi [3, 4]. Qurilmaning ishlash davomiyligi asosan ichki energiya yo‘qotishlari miqdoriga bog‘liq bo‘lib, bu yo‘qotishlar issiqlik ajralishi orqali namoyon bo‘ladi.

Elektr motorlarda yo‘qotishlar odatda quyidagi turlarga ajratiladi:

- mexanik yo‘qotishlar (podshipnik ishqalanishi va ventilyatsiya bilan bog‘liq);
- magnit yo‘qotishlar (gisterezis va uyurma toklar natijasida yuzaga keladigan);
- elektr yo‘qotishlar (chulg‘amlarning aktiv qarshiligi sababli I^2R ko‘rinishida yuzaga keladigan).

Mazkur yo‘qotishlar ortishi motorning qizishiga olib keladi. Agar qurilma ruxsat etilgan ish haroratidan 8–10°C yuqori sharoitda uzoq muddat ishlasa, izolyatsiya materiali tezroq degradatsiyaga uchraydi va uning xizmat muddati taxminan ikki baravar kamayishi mumkin.

Elektr motor samaradorligini oshirish uchun konstruktiv va texnologik chora-tadbirlarni kompleks ravishda amalga oshirish talab etiladi [5, 6, 8]:

Elektr motorlarning energiya samaradorligini oshirish uchun quyidagi konstruktiv va texnologik choralarni amalga oshirish maqsadga muvofiq:

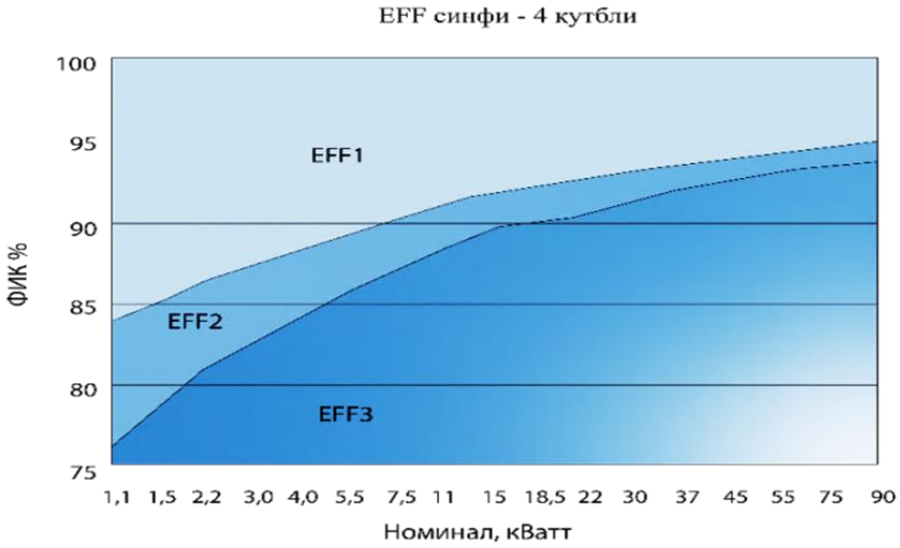
1. Magnit yo‘qotishlari past bo‘lgan, yuqori magnit o‘tkazuvchanlikka ega elektrotexnik po‘latlardan foydalanish yoki stator hamda rotor o‘zaklarini kukun metallurgiyasi asosida shakllantirish;
2. Termik va mexanik ishlov berish jarayonlarini optimallashtirish orqali materialning magnit xossalarini tiklash va barqarorlashtirish;
3. Ventilyatsiya tizimini takomillashtirish va aerodinamik qarshilikni kamaytirish orqali mexanik yo‘qotishlarni pasaytirish;

https://doi.org/10.56143/2181-2438-2026-1-156-160 Research, Innovation, Results

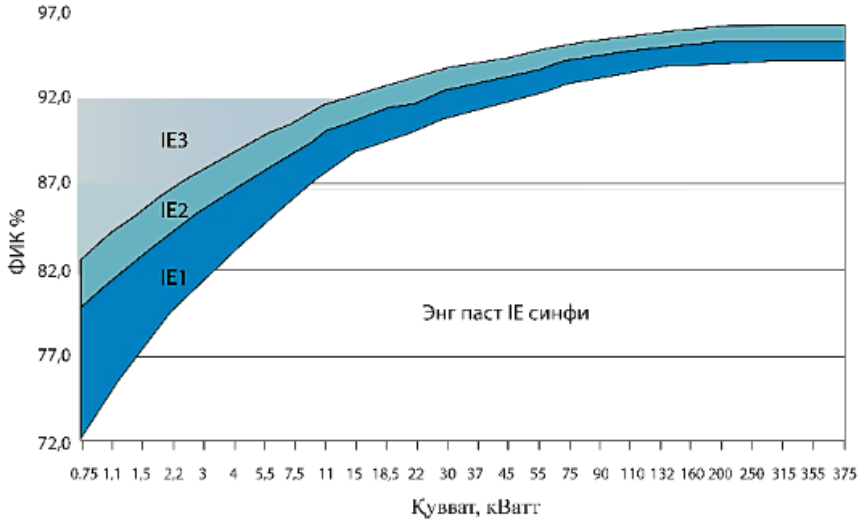
4. Yuqori issiqlikka chidamli va dielektrik mustahkamligi yuqori bo‘lgan zamonaviy izolyatsiya materiallarini qo‘llash;
5. Ishqalanish koeffisiyenti past va uzoq xizmat muddatiga ega podshipniklarni tanlash;
6. Rotor va stator elementlarini yuqori aniqlikda mexanik ishlov berish orqali havo oralig‘ini optimallashtirish;
7. Elektr yuritmalarda chastota o‘zgartirgichlardan foydalanish orqali yuklama va tezlikni silliq boshqarish;
8. Tarmoqdan olinadigan aktiv quvvat ulushini oshirish maqsadida quvvat koeffisiyentini yaxshilash.

Elektr motorlarning energiya samaradorligini baholash tizimi xalqaro darajada 2007–2008 yillarda takomillashtirilib, standartlashtirilgan sinflarga ajratildi. Dastlab samaradorlik ko‘rsatkichlari EFF1, EFF2 va EFF3 belgilar orqali ifodalangan bo‘lib, bu tasnif IEC 60034-2 standartiga asoslangan edi [8, 12]. Mazkur hujjat asosan foydali ish koeffisiyentini aniqlash metodikasini va sinov tartibini belgilab bergan.

Keyinchalik energiya samaradorligini yanada aniqlik bilan tasniflash maqsadida IEC 60034-30 standarti joriy etilgan. Ushbu standart elektr motorlarni IE1, IE2, IE3 va undan yuqori sinflarga ajratish tizimini belgilaydi (3-rasm) hamda samaradorlikni baholashda kengroq parametrlarni hisobga olishni nazarda tutadi. Natijada energiya samaradorligi sinflanishi yanada mukammallashtirildi va xalqaro miqyosda yagona mezon shakllantirildi.



2-rasm. IEC 60034-2 standarti asosida elektr motorlarning energiya samaradorligi bo‘yicha tasnifi (avvalgi klassifikatsiya tizimi)



3-rasm. IEC 60034-30 standarti asosida elektr motorlarning energiya samaradorligi sinflari (yangilangan tasnif tizimi)

Energiya samaradorligini oshirish usullaridan biri kukunli texnologiyani qo‘llash bilan bog‘liq [5, 8, 9].

Kukun metallurgiyasi asosida tayyorlangan magnit yumshoq materiallar an’anaviy laminatsiyalangan po‘latlarga nisbatan bir qator ustunliklarga ega. Har bir zarracha izolyasion qatlam bilan qoplanganligi sababli uyurma toklar cheklanadi va natijada magnit yo‘qotishlar kamayadi [12].

Qayta magnitlanish jarayonidagi umumiy yo‘qotishlar quyidagicha ifodalanadi:

$$\Delta P = \Delta P_h + \Delta P_e \quad (2)$$

bu yerda:

ΔP_h– gisterezis yo‘qotishlari,

ΔP_e– uyurma tok yo‘qotishlari.

Zarrachalarning izolyasiyalangan tuzilishi tufayli ΔP_e sezilarli kamayadi. Bu esa yuqori chastotali ishlash rejimlarida ayniqsa muhim ahamiyat kasb etadi [4, 7, 12].

ASC100.29 tipidagi kompozision material asosida tayyorlangan magnit o‘tkazgichlar yuqori magnit o‘tkazuvchanlik va sezilarli induksiya qiymatlari bilan tavsiflanadi [11, 13, 15]. Ushbu materialning tuzilmasi zarrachalarning maxsus izolyasion qatlam bilan qoplanishi orqali shakllantiriladi, bu esa uyurma toklarning paydo bo‘lishini sezilarli darajada cheklaydi.

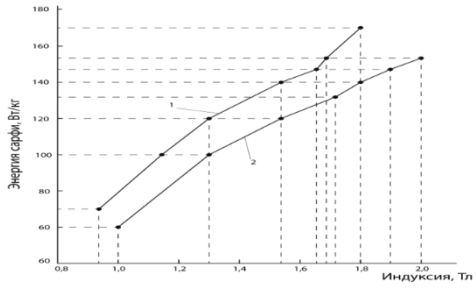
$$\Delta P_в = \frac{\pi B_m f h}{\delta \rho} \quad (3)$$

bu yerda B_m magnit induksiyasi, f – chastota; h – list qalinligi, ρ – солиштирма қаршилик.

Bu yerda ΔR_n dan kelib chiqib, elektr motorda magnit yumshoq materiallardan tayyorlangan kukunlarning qo‘llanishi isroflarni kamaytirib, o‘z navbatida energiya samaradorlik darajasini, demak, foydali ish koeffisiyentini ham yaxshilaydi [4, 7, 14].

4-rasmda ASC100.29 markali kompozision magnit materialning past chastotali (1 kGs) rejimdagi qayta magnitlanish jarayonida kuzatilgan yo‘qotishlari keltirilgan. Tajriba natijalari material 350°C haroratda vakuum sharoitida 3 soat davomida issiqlik bilan ishlov berilishidan oldingi va keyingi holatlarni solishtirish asosida olingan.

Issiqlik ishlovi natijasida umumiy magnit yo‘qotishlar kamaygani hamda magnit induksiya qiymati taxminan 5–8% ga ortgani aniqlangan [13, 15]. Bu holat materialning ichki kuchlanishlari kamayishi va magnit domen tuzilmasining barqarorlashuvi bilan izohlanadi.



4-rasm. ASC100.29 kompozision magnit materiali uchun issiqlik bilan ishlov berishdan oldingi (1) va keyingi (2) holatlarda magnit yo‘qotishlar taqqoslanishi

Somalloy turidagi kompozision magnit materiallar hamda an’anaviy laminatsiyalangan elektrotexnik po‘latlardan foydalanish elektr mashinalarning issiqlik almashinuvi sharoitlarini yaxshilashga xizmat qiladi. Natijada sovitish jarayoni samaradorligi ortadi, ekspluatatsion barqarorlik oshadi va umumiy energiya yo‘qotishlari kamayadi. Bu esa elektr motorlarning foydali ish koeffisiyentini yaxshilashga bevosita ta’sir ko‘rsatadi.

Kukun metallurgiyasi asosidagi ishlab chiqarish texnologiyalari qo‘llanilganda konstruktiv parametrlarni optimallashtirish imkoniyati kengayadi. Xususan, Höganäs kompaniyasi tomonidan amalga oshirilgan ishlanmalarda motor massasini qariyb ikki baravar kamaytirish, konstruksiyaning uzunligini 36% gacha qisqartirish hamda murakkab fazoviy (3D) geometriyaga ega rotorlarni shakllantirishga erishilgan.

Bunday texnologik yondashuv magnit zanjir konfiguratsiyasini erkin loyihalash, issiqlik ajralishini kamaytirish va ichki energiya yo‘qotishlarini optimallashtirish imkonini beradi. Natijada elektr motorlarning umumiy energiya samaradorligi oshadi [8, 11, 15].

5-rasm. Kukun metallurgiyasi asosida ishlab chiqilgan magnit yumshoq kompozision materiallardan tayyorlangan stator va rotor konstruksiyasi

Kukun metallurgiyasi asosida tayyorlangan magnit yumshoq kompozision materiallardan ishlab chiqarilgan stator va rotor elementlarining konstruktiv ko‘rinishi 5-rasmda tasvirlangan. Bunday materiallar qo‘llanilganda magnit zanjirning fazoviy konfiguratsiyasini erkin shakllantirish va ichki yo‘qotishlarni kamaytirish imkoniyati paydo bo‘ladi.

Shuni ta’kidlash lozimki, elektr motorni yuqori energiya samaradorlik sinfiga kiritish uchun faqat nominal yuklama yoki qisman yuklama sharoitidagi foydali ish koeffisiyentini aniqlash yetarli emas [9, 15]. Zamonaviy standartlar samaradorlikni turli ish rejimlarida baholashni talab qiladi.

Xususan, IEC 60034-30-1 standartiga muvofiq IE3 sinfiga mansublikni aniqlashda motorning nominal rejimi bilan bir qatorda pasaytirilgan tezlik va moment sharoitidagi samaradorlik ko‘rsatkichlari ham hisobga olinadi. Yangi talablarga ko‘ra umumlashtirilgan samaradorlik qiymati ma’lum og‘irlik koeffisiyentlari asosida aniqlanadi va tegishli formula orqali hisoblab chiqiladi:

$$\eta = (\eta_1 + \eta_2 + \eta_3) \cdot 0{,}33 \quad (4)$$

bu yerda: η_1- nominal yuklama va nominal momentdagi FIK, η_2- nominal tezlikdan 75% darajadagi tezlik va 50%

darajadagi momentdagi FIK, n_3- nominal tezlikdan 50% darajadagi tezlik va 25% darajadagi momentdagi FIK.

3. Xulosa

Olib borilgan tadqiqotlar natijasida magnit yumshoq kompozision materiallar asosida ishlab chiqilgan elektr motorlarning barqaror va energiya tejamkor ishlash rejimlari aniqlashtirildi. Tajriba va hisob-kitob natijalari asosida stator o‘zaklarini tayyorlash jarayoniga qo‘yiladigan texnologik talablar, jumladan, presslash parametrlari, issiqlik bilan ishlov berish sharoitlari hamda materialning magnit xossalarini barqarorlashtirish mezonlari takomillashtirildi.

Natijada konstruktiv elementlarning magnit va issiqlik ko‘rsatkichlarini optimallashtirish imkoniyati yaratildi, bu esa elektr motorlarning ishonchliligi va umumiy energiya samaradorligini oshirishga xizmat qiladi.

Foydalangan adabiyotlar / References

[1] Sustarsic B , Sirc A , Vilyavec D. SMS materailas in the design of small electric motors for domestic application // EURO PM 2004 Proc conf. Functional materials 2004 - 4 page 629 - 635

[2] Handley R.C. Modern magnetic materials principals and applications/ O’Handley – NY: John Wiley Sons, 2000. 347 page

[3] Berdiyev, U., Berdiyorov, U., Toshpulatova, M., Problems and Tasks of Creating Energy-Saving Electric Machines. AIP Conference Proceedings, 2022, 2432, 020002

[4] Berdiyev, U., Demedenko, O., Ashurov, M., Hasanov, F.F., Sulaymonov, U.B.

[5] Optimization of the method of oxide coating of metallic iron powder particles. E3S Web of Conferences, 2023, 383, 04039

[6] Berdiyev, U.T., Sharapov, S.A., Norboev,A.E., Beytullaeva, R.X.. Study of the speed control system for asynchronous machines by changing the frequency using mathematical modeling. International Conference on Thermal Engineering, 2024, 1(1)

[7] U.T.Berdiev, A.K. Vecher, F.F.Khasanov, Investigation of the frequency characteristics of composite iron powders with insulating oxide coatings. «Construction Mechanics, Hydraulics and Water Resources Engineering» (CONMECHYDRO – 2021), Uzbekistan, Tashkent, 1 – 3 aprelya.

[8] Amirov S.F., Sharapov S.A., Sulliev A.K., Boltaev O.T. Biparametric resonant transformer sensor of large linear movements //AIP Conference Proceedings. – AIP Publishing, 2023. – T. 2624. – №. 1. pp. 030007(1-9).

[9] Amirov S., Boltayev O., Akhmedova F. New created mathematical models of movable screens and a scatter parameters converters //Journal of Advanced Research in Dynamical and Control Systems. – 2020. – T. 12. – №. S2. – S.122-126.

[10] Sarkar K. Pai P.K , Katiyor P.K. Composite coatings from blast furnace pig iron by high velocity oxy - fuel (HVOF) process and their electrochemical behavior. Surf. Coat. Techol. 2019. No. 372. p72 – 83 DO1: 10.1016/j. surfcoat. 2019.05 /25

[11] Timofayev I.A. Elektrotexnicheskiye materialы i izdeliya - SPB; Izdatelstvo «Lan» 2012-272

[12] Vecher, A.K. Novыye kompozisionnыye materialы i ix primeneniye v elektronnoy texnike / A.K. Vecher // Nauka i innovasii. 2017, № 4,– S.23–24.

[13] Tyng M. Osobennost formirovaniya kompleksa magnitnыx svoystv poroshkovogo Fe-P materiala –analoga texnicheskogo jeleza, poluchennogo goryachey obyemnoy shtampovkoy poristoy zagatovki. Avtoref Rostov-na Don, 2010 27s

[14] H. K. Sauchuk1, N. P. Yurkevich1, A. P. Akhmedov2, I. K. Kolesnikov2, U. T. Berdiyev2, S. B. Khudoyberganov2, S.H. Khakimov2 Physical and thermal properties of binary (Bi-Ti-O)-TiO2 UHF-ceramics. Fifteen International Conference on Thermal Engineering: Theory and Applications May 28-June 1, 2024 Tashkent, Uzbekistan

[15] Sulaymonov U., Jelutkevich A., Nabiyevna M., Sayfullayev O., Berdiyorov U., “Research of energy-saving composite materials for electric motors”, 2023.

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