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ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

To‘plam elektron ko‘rinishda (pdf formatida) mualliflarga taqdim etiladi. To‘plamga kiritiladigan maqolalarning mazmuni, ulardagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligiga hamda har qanday fikr - mulohazalarga mualliflarning o‘zlari mas’ul hisoblanadilar. Talablarga javob bermaydigan maqolalar to‘plamga kiritilmaydi. Tashkiliy qo‘mita maqola matnini qisqartirish, qisman tuzatish kiritish, seksiyalarga joylashtirish huquqiga ega.

ISSN 3030-3907

ELEKTR YURITMALI AVTOTRANSPORT VOSITALARINING ENERGETIK QISIMLARINI TAHLIL QILISH

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Annotatsiya. Xalqaro hamjamiyatlar hisobotlariga ko‘ra elektromobillardan foydalanuvchilar soni jadallik bilan ortib bormoqda. Jumladan issiq iqlim mintaqa davlatlari xususan O‘rta Osiyoda ham bundan mustasno emas. Ushbu maqolada elektr yuritmali avtotransport energetik qurilmalarini so‘ngra harakatlanish zaxirasiga asosiy ta’sir ko‘rsatuvchi faktorlarga bog‘liq bo‘lgan holatda issiq iqlim sharoitida xusuiyatlarni o‘rganadi. Bunda dastlab akkumulyator batareyalar bloki, elektrodvigatellar, inverterlar va o‘zgartirgichlarini ko‘rib chiqiladi. Keyinchalik esa ularni boshqarish tizimlari: akkumulyator batareyasini boshqarish tizimi (BMS), energiya boshqarish tizimi (EMS), issiqlik boshqaruv tizimi (TMS) o‘rganiladi. Gibrid va elektromobillarning ushbu iqlim sharoitida energiya sarfi ko‘rsatkichlariga ta’sir etish imkoniyatlari tahlili amalga oshiriladi.

Kalit so‘zlar. Elektromobil, gibrid avtomobillar, savdo hajmi, akkumulyator batareyasi, inverter, elektrodvigatel, boshqarish tizimlari, issiqlik ta’siri

Аннотация. Согласно отчетам международного сообщества, число пользователей электромобилей быстро растет. В частности, страны жаркого климатического региона, в частности Центральная Азия, не являются исключением. В данной статье рассматриваются характеристики энергетических устройств автомобилей с электрическим приводом в жарком климате в зависимости от основных факторов, влияющих на запас хода. В данном случае в первую очередь рассматриваются аккумуляторный блок, электродвигатели, инверторы и преобразователи. Затем изучаются их системы управления: система управления батареями (BMS), система управления энергией (EMS), система управления тепловым режимом (TMS). Проводится анализ возможностей влияния гибридных и электрических автомобилей на показатели энергопотребления в этих климатических условиях.

Ключевые слова. Электромобиль, гибридные автомобили, объем продаж, аккумулятор, инвертор, электродвигатель, системы управления.

ISSN 3030-3907

Abstract. According to international community reports, the number of electric vehicle users is growing rapidly. In particular, the countries of the hot climate region, in particular Central Asia, are no exception. This article examines the characteristics of electrically driven motor vehicle energy devices in hot climates, depending on the main factors affecting the movement reserve. In this case, the battery block, electric motors, inverters, and converters are considered first. Subsequently, their control systems are studied: battery management system (BMS), energy management system (EMS), heat management system (TMS). An analysis of the possibilities of the influence of hybrid and electric vehicles on energy consumption indicators in these climatic conditions is carried out.

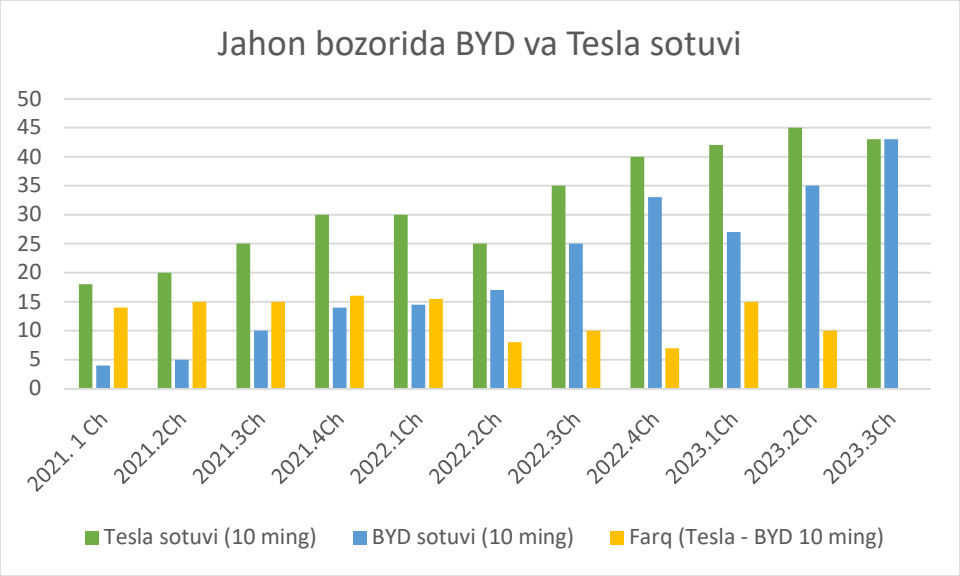
Keywords. Electric car, hybrid cars, sales volume, battery, inverter, electric motor, control systems.

KIRISH

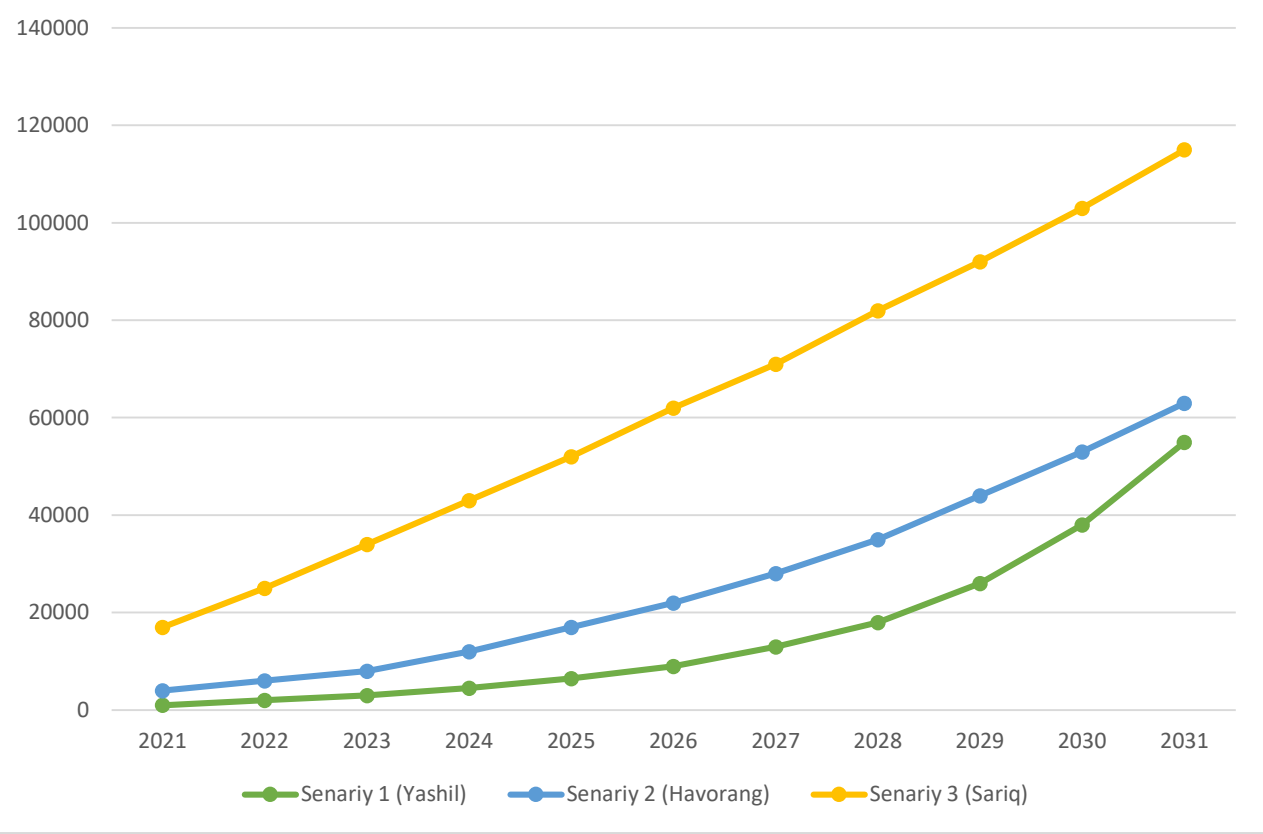
Dunyoda issiqxona effekti kun sayin ng dolzarb muammolardan biri sifatida xalqaro hamjamiyatda xavotirlar uyg‘otmoqda [1]. Turli tadqiqotlar hisobotlariga ko‘ra zararli gazlarning ortib borishida ichki yonuv dvigatellari bilan jihozlangan avtotransport vositalarining qisman bo‘lsada o‘z ta’siriga ega ekanligini e’tirof etishmoqda. [2]. Bu esa o‘z navbatida kelgusi yillarda xususan 2020–2030-yillarda elektr yuritmali transport vositalariga bo‘lgan talabning oshishini muhim omillaridan biri bu atrof-muhit global ekologik muammolaridan biri bo‘lgan zaharli gazlarni ya’ni emissiyani kamaytirish uchun o‘z yo‘liga ega ekanligini ko‘rsatadi. Shuning uchun jahon bozorida kun sayin elektr yuritmali avtotransport voistalariga bo‘lgan talab ortib bormoqda. 1-rasmda Jahon bozorida BYD va Tesla kompaniyalarining 2023-yildagi investorlar bilan o‘zaro hisobotlari asosidagi savdo hajmilari miqdori ko‘rsatilgan.

Xalqaro va milliy Iqtisodiy tadqiqotlar va islohotlar markazlarining hisobotlariga ko‘ra olib borilgan tahlillar shuni ko‘rsatmoqdaki, elektr yuritmali turli transport vositalari segmenti faol rivojlanayotganligi oldingi yillarga nisbatnan sezirarli oshib bormoqda. Ushbu tendensiya nafaqat xalqaro miqiyosda balki markaziy osiyo davlatlarida ham, xususan O‘zbekiston va Qirg‘iziston respublikalarida 2021–2025 yillar davomida ushbu turdagi transport vositalari ichki yonuv dvigatelli ommabop avtomobillarga qaraganda aholi o‘rtasida ommalashish holati bir necha barobarga o‘sganligini buning yaqqol isboti hisoblanadi. [3][4]

ISSN 3030-3907



1-rasm. Jahon bozorida BYD va Tesla kompaniyalarining 2023-yildagi investorlar bilan hisoboti asosidagi savdo hajmi. Eslatma: PHV gibrid transport vositalari hisobga olinmagan.



2-rasm. Elektromobillarning soni

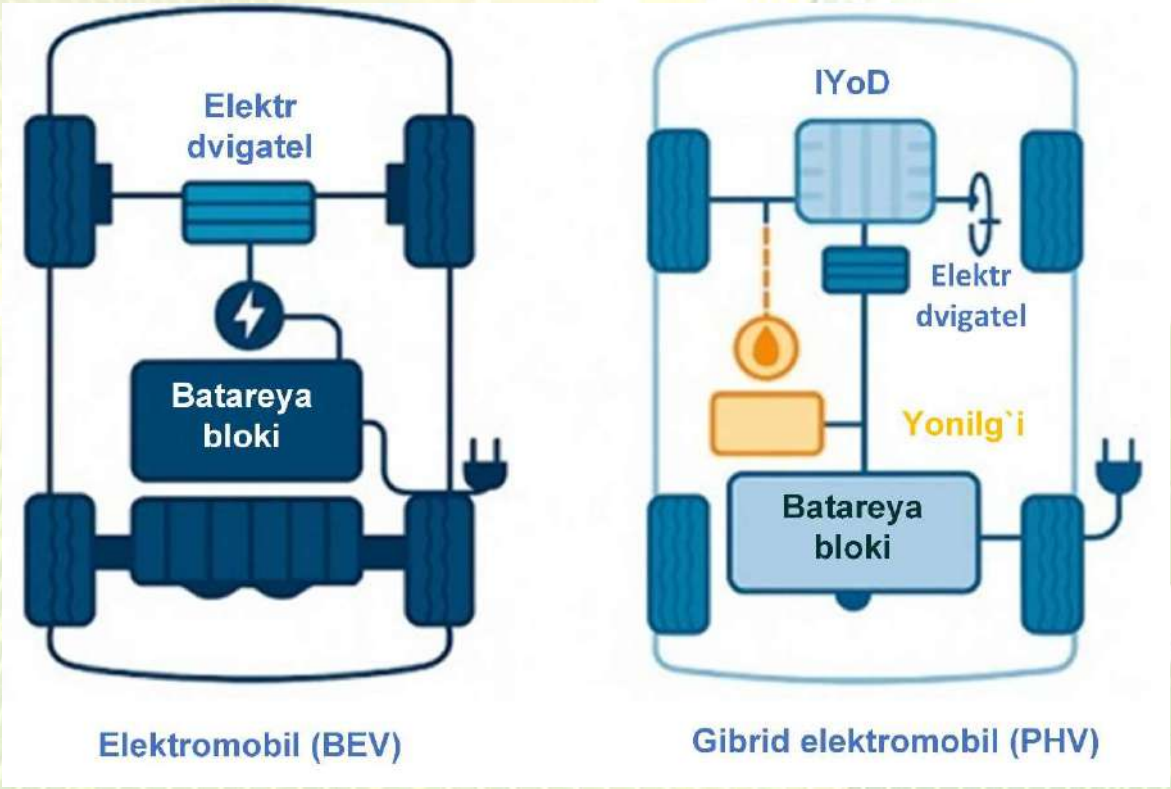
Kelasi istiqbolda elektr yuritmali transport vositalaridan foydalanuvchi aholi soni o‘sishi kutilmoqda. 2-rasmda Elektromobillardan foydalanuvchilar sonining ortib borishi miqdori 3 xil senariy asosida turli olimlar va statistikalarning qiymatlari keltirib o‘tilgan. Bunda bu senariylar global bozorda iqtisodiy sakrashlar omillarini olimlar va statistik manbalar bashorat qilishgan. Demak, dunyodagi turli

ISSN 3030-3907

iqlim mintaqalarda bunday turdagi transportni ma’qul ko‘radigan insonlar o‘z navbatida qulaylik va uzoq masofaga harakat qilishni istashi tabiiy hol deb qaralishi mumkin. [5][6]

TADQIQOT

Elektr yuritmali avtotransport vositalarining sxematik tuzilishi. Elektr yuritmali transport vositalari ishlab chiqarilishiga ko‘ra ushbu sinflarga ajratilgan bo‘lib ularga akkumulyatorli elektromobillar (BEV), qo‘shilgan gibrid elektromobillar (PHEV), gibrid elektromobillar (HEV) va yonilg‘i elementli elektromobillarga (FCEV) kiradi. ularning har biri alohida ekspluatatsion xususiyatlarga ega. [7][8][9] Eng ko‘p foydalanuvchi soniga ega Elektr yuritmali avtotransport vositalari sifatida elektromobillar va gibrid avtomobillar hisoblanadi [10]. 3-rasmda elektromobillarning va gibrid elektromobillarning umumiy sxematik tuzilishi keltirib o‘tilgan [11].



3-rasm. Elektromobillarning va gibrid elektromobillarning umumiy sxematik tuzilishi. [12]

Ular turlaridan qa’tiy nazar umumiy bo‘lgan energetik qismlarga ega. Asosiy tarkibiy qismlariga akkumulyator va akkumulyator batareyasi, zaryadlash porti, o‘zgarmas tok o‘zgartirgichi yoki invertor, elektr dvigateli, bort zaryadlagichi, kuchlanishlar va kuchlarning elektronik qismlarining kontrolleri, issiqlik sovutish tizimi va elektr uzatma kiradi. Quyida ushbu qismlar sanab o‘tilgan.

Elektomobillar energetik qismlari:

1. Energiya manbasi – akkumulyator batareyalari bloki;

ISSN 3030-3907

2. Akkumulyator batareyalari boshqaruv bloki (BMS);
3. Issiqlik holatini boshqaruv bloki (TMS);
4. Kuchlanish kontrolleri;
5. DC – DC konvertor;
6. DC – AC invertor;
7. ED – Elektrodvigatel;
8. Quvvat boshqaruv moduli (PCM);
9. Mikrokontroller;
10. DC qurilmalari (o‘zgarmas tok qurilmalari);
11. AC qurilmalari (o‘zgaruvchan tok qurilmalari).
12. Regenerativ tormozlash tizimi.

Gibrid avtomobillar elektromobillar kabi va qo‘shimcha quyidagi asosiy energetik qismlardan iborat:

1. Yonilg‘i saqlovchi sig‘im yo’ni bak;
2. Ichki yonuv dvigateli;
3. Generator;
4. AC – DC konvertor.

Akkumulyator blokining vazifasi: energiyani saqlash ya’ni asosiy harakatlanish zaxira faktori hisoblanadi.

Quvvat boshqaruv moduli (PCM): batareyadagi doimiy tokni (DC) motor ishlatadigan o'zgaruvchan toikka (AC) aylantirish nazorati, tezlik, burovchi moment, samaradorlikni ta’minlash uchun xizmat qiladi

DC – AC invertor batareya blokining DC quvvatini 3 fazali AC quvvatiga o‘zgartirish vazifasini bajaradi.

DC – DC konvertor batareya blokining yuqori kuchlanishini (400V yoki 800V) 12V ga o‘zgartirish ya’ni chiroqlar, monitor, kontrollerlar uchun stabil quvvatni ta’minlash maqsadida foydalaniladi.

Mikrokontrollerning vazifasi: barcha hisob-kitoblarni bajaruvchi protsessor.

Issiqlik holatini boshqaruv bloki (TMS): akkumulyator batareya bloki (Battery Pack), optimal ishchi haroratida 20°C dan 40°C gacha ta’minlash, elektr dvigatel, quvvat boshqaruv moduli(PCM)ning qizib yoki sovub ketishini oldini olish, aks holda uning quvvati va foydali ish koeffitsienti (FIK) pasayadi. [13][14][15][16][17]

Elektr yuritmali tranport vositalari energetik baholash va hisoblash uchun odatda ma’lum ko‘rsatkichlardan foydalaniladi. Ushbu ko‘rsatkichlarning o‘zgarishi avtotransport vositasining harakatlanish zaxirasiga ta’sir ko‘rsatadi. Ushbu qiymatlar nomenklaturasi 1-jadvalda keltirib o‘tilgan.

ISSN 3030-3907

1-jadval

Elektr yuritmali transport vositalarining energetik ko‘rsatkichlarining nomenklaturasi.

	Inglizcha nomlanishi	O‘zbekcha ta’rifi	Birlik
I_{batt}	Battery current	Batareya toki	A
I_{load}	Load current	Yuklama toki	A
$I_{battref}$	Battery reference current	Batareya tayanch toki	A
Ah	Ampere hour	Amper-soat	Ah
V_{batt}	Battery voltage	Batareya kuchlanishi	V
$V_{battref}$	Battery reference voltage	Batareyaning tayanch kuchlanishi	V
V_{oc}	Open circuit voltage (OCV)	Ochiq zanjir kuchlanishi (OCV)	V
T	Temperature	Harorat	K
R_e	Pure resistance of battery	Batareyaning sof qarshiligi	Oh
R_p	Polarization resistance	Qutblanish qarshiligi	Oh
R_T	Total resistance	Umumiy qarshilik	Oh
t	time	Vaqt	s
P_{load}	Load power	Yuklama quvvati	W
P_{avg}	Average load power	O‘rtacha yuklama quvvati	W
Q_g	Total heat generation rate	Umumiy issiqlik hosil bo‘lish tezligi	W/m^3
Q_{rea}	Reaction heat generation rate	Reaksion issiqlik hosil bo‘lish tezligi	W/m^3
Q_{ohm}	Ohmic heat generation rate	Omik issiqlik hosil bo‘lish tezligi	W/m^3
Q_{pol}	Polarization heat generation rate	Qutblanish issiqlik hosil bo‘lish tezligi	W/m^3
η	Efficiency	Foydali ish koeffitsiyenti (Samaradorlik)	%
fsw	Switching frequency	Kommutatsiya chastotasi	H
G_{pbatt}	Battery positive slew coefficient	Batareyaning ijobiy og‘ish (slew) koeffitsiyenti	W/s
G_{nbatt}	Battery negative slew coefficient	Batareyaning salbiy og‘ish (slew) koeffitsiyenti	W/s
SoC_{batt}	Battery State of Charge	Batareyaning zaryadlanganlik holati (SoC)	-------

ISSN 3030-3907

SoD_{batt}	Battery State of Discharge	Batareyaning razryadlanish holati (SoD)	-------
SoH_{batt}	Battery State of health	Batareyaning ishga yararoqlik holati (SoH)	-------
C	capacity	oqim ko‘rsatkichi	-------

C oqim ko‘rsatkichi bu bir soat yoki qancha daqiqa davomida tok kuchi o‘tkaza olish miqdori hisoblanadi:

$$I(A) = \frac{t\ (soat)}{C(oqim)}$$

Masalan: 100 Ah lik Batareyaning C oqim ko‘rsatkichi:
1C bo‘lsa 1 [soat]/1[oqim]=1 [soat] yoki 60 [daqiqa] davomida 100 A 5C bo‘lsa 1 [soat]/5[oqim]=0,2 [soat] yoki 12 [daqiqa] davomida 100 A yoki 1 soatda 500 A beradi. 10C bo‘lsa 1 [soat]/10[oqim]=0,1 [soat] yoki 6 [daqiqa] davomida 100 A yoki 1 soatda 1 000 A beradi.
100 Ah lik Batareyaning C ko‘rsatkichi:

0,2C bo‘lsa 1 [soat]/0,2[oqim]=5 [soat] yoki 300 [daqiqa] davomida 100 A yoki 1 soatda 20 A beradi. 0,5C bo‘lsa 1 [soat]/0,5[oqim]=2 [soat] yoki 120 [daqiqa] davomida 100 A yoki 1 soatda 50 A beradi. Oqim ko‘rsatkichi bundan tashqari akkumulyator batareyasidan unga zarar yetkazmasdan ya’ni degradatsiyaga uchartmasdan energiya olish imkoniyatini ko‘rsatadi. [18][19][20][21]

Issiq iqlim sharoitda bu ko‘rsatkichlar ortiqcha qizishga sabab bo‘ladi va salbiy oqibatlarga olib keladi.

Elektr yuritmali avtotransport vositalarida qo‘llaniladigan elektrodvigatellar turlari quyidagilar bo‘lib 4-rasmda ko‘rsatib o‘tilgan.



4-rasm. Elektromobillarning va gibrid elektromobillarda qo‘llaniladigan elektrodvigatellar. [25]

ISSN 3030-3907

1. Brushed DC Motor - Cho'tkali o'zgarmas tok dvigateli
2. Brushless DC motor — Cho'tkasiz o'zgarmas tok dvigateli.
3. PMSM (Permanent Magnet Synchronous Motor) — Doimiy magnitli sinxron dvigatel. – byd, tesla
4. Induction Motor (IM) — Asinxron dvigatel
5. SRM (Switched Reluctance Motor) — Ventilli reaktiv dvigatel
6. SyRM (Synchronous Reluctance Motor) — Sinxron reaktiv dvigatel
7. AFIPM (Axial Flux Interior Permanent Magnet motor) — Aksial oqimli ichki doimiy magnitli motor [22][23][24][25]

Elektrodvigatellarning asosiy ustunliklaridan biri bo‘lib uning harakatlanayotganida zaharli va zararli gazlar ishlab chiqarmasligini ko‘rsatishimiz mumkin. Shu bilan birga ortiqcha shovqinning yo‘qligi osoyishta harakatini ta’minlashi ularning ichki yonuv dvigatelli avtomobillardan muhim jihatidir. [26] [27][28]

TADQIQOT NATIJALARI

Tadqiqotchilarning tahllilariga asosan elektromobillarda ko‘p hollarda quyidagi muammolardan ma’lum turlari hisobida ularning qo‘llanilgan akkumlyator batareyalarining o‘z xususiyatiga ko‘ra energiya zaxirasi bilan bog‘liqligi tufayli yuzaga kelishi keltirib o‘tilgan. Bu esa o‘z navbatida ularning energiya saqlash va energiyani maqbul ishlatish holatlariga bo‘lgan talabni oshirishga e`tibor qaratishimizni taqozo etadi. Yer yuzida iqlim sharoiti bir xil taqsimlanmaganligi uchun bu aynan bir mintaqada foydalanilayotgan avtotransport vositlarini boshqa mintaqada ekspluatatsiya qilishdan oldin turli tahlillar olib boorish ushbu sabablarni kamaytirish yo‘llaridan biri bo‘ladi. Zero elektr energiyasi, qo‘llanilgan materiallar ichki qarshiligi issiq iqlimga ega mintaqalarda yo‘qotilishi mo‘tadil ob – havoda harakatlanayotgan ellaridan farq qilishi tabiiy holdir. Demak yuqori samardorlikka erishish uchun foydalaniladigan materiallar xususiyati, sovutish tizimi, boshqaruv qurilmalari ustida izlanishlar olib borish zarur omillardan biri hisoblanadi. [17][28][29][30][31]

Akkumulyator batareyalari bloki barcha asosiy va yordamchi qurilmalarni elektr energiyasi bilan doimiy o‘zgarmas yetkazib berishdan tashqari, haydovchi tomonidan beriladigan turli yuklamalar, yo‘lda avtomobil harakati ta’sirida duch keladigan barqarorlik va o‘zgaruvchanlikni yengib o‘tish uchun elektrodvigatel kuchlanishini qabul qiladi. Bu kuchlar doimiy nafaqat sinxron balki turlicha bo‘lib, har xil miqdorda elektr energiyasi sarf bo‘lishiga sabab bo‘ladi. Natijada qo‘zg‘alish harakati tez – tez takrorlanadigan triband shahar sharoitlarida energiya sarfi ma’lum miqdorda yuqori bo‘ladi. Shuning uchun Turli nagruzkalarda Issiq iqlim sharoitida sovutish tizimi barqaror ishlashi yoki akkumulyator batareyalarini

ISSN 3030-3907

eng maqbuldan foydalanish quvvat zaxirasini oshirishga xizmat qiladi. [32][33][33][34]

Elektrmobillarda Li ion tipidagi akkumlyator batareyalaridan kengroq foydalaniladi.[35][36] Bunday turdagi akkumulyator batareyalari normal hotada ishlashi uchun o‘rta hsobdagi harorat kengliklariga ega, issiq yoki sovuq harorat oqimi uning natijalariga ta’sir qilishi tahlillar ko‘rsatadi. Razryad samaradorligi va sikl davomiyligini hisobga olgan holda, litiy-ionli batareyalarning ishchi harorati 10-30 °C atrofida bo‘ladi.[37][38][39]. Elektr dvigatellarining ish rejimlari 40 °C haroratda barqaror ishlashi ko‘rsatib o‘tilgan.[40][41]

Litiy cobalt oksidli akkumulyator batareyalari energiya saqlash sig‘imi harorat oshib borganida ham energiya sig‘imi juda katta bo‘lmagan ko‘rsatkichlar asosida o‘zgarib boradi, 60 °C haroratda ham nominal ko‘rsatkichlarga yaqin bo‘ladi.

Elektr yuritmali transport vositasi zaryad rejimida akkumulyatorlar batareyalari blokining harorati bir necha ko‘rsatkichga oshishi [42][43][44][45][46] davomida yuqoridagi batareya turidan foydalanish energiya sig‘imini oshirishga xizmat qilishi ehtimoilini oshiradi.

XULOSA

Olib borilgan tadqiqotlar shuni ko‘rsatadiki elektr yuritmali transport vositalaridan issiq iqlim sharoitda foydalanishda ularning harakatlanish zaxirasini oshirish uchun quyidagi vazifalarni amalga oshirishimiz zarur

1. Issiq iqlim uchun maqbul bo‘lgan akkumulyator batareyalar turlarini aniqlash;
2. Sovutish tizimini tadqiq etish va nominal harorat rejimini ishlab chiqish;
3. Akkumulyator batareyalarini turli tezda o‘zgarib turuvchi yuklanishlarga bardoshligini qo‘llash;
4. Elektrodvigatellarining qizib ketishi mumkinligini inobatga olgan holda qo‘shimcha qurilmalar yoki sovutish yo‘llarini takomillashtirish.
5. Elektrodvigatellarning boshqaruv tzizimini takomillashtirish

Ushbu natijalarni aniqlashtirish orqali biz amaldagi quvvat holatini optimallashtirishimiz mumkin.

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