Elektromobillarning turli tezliklarda harakatlanishi davomida sarflanadigan energiya qiymatini uning parametrlari asosida tahlil qilish

Xushnud B. Sapayev[1], Akbar Z. Jo‘raboyev[2a], Oybek O. Daminov[3]

[1)] DSc, prof., Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; khushnud.sapaev@mail.ru https://orcid.org/0000-0002-0486-3132
[2a)] tayanch doktorant (PhD), Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; akbar_universal@mail.ru https://orcid.org/0009-0008-2330-6324
[3)] PhD, dots., Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; oybek.daminov@tdtu.uz https://orcid.org/0000-0001-7876-1289

Dolzarbligi: xalqaro tashkilotlar hisobotlariga ko‘ra elektromobillardan foydalanuvchilar soni kun sayin ortib bormoqda. Xususan O‘zbekistonda ushbu tendensiya ham ro‘y bermoqda. Ushbu maqolada elektrmobillarning energetik qurilmalarini so‘ngra harakatlanish zaxirasiga asosiy ta’sir ko‘rsatuvchi faktorlarga bog‘liq bo‘lgan holatda turli yuklanganlik sharoitidagi xususiyatlarni o‘rganadi. Akkumulyator batareyasidagi quvvat va iste’mol qilininadigan quvvat o‘zaro bevosita bog‘liq bo‘lib, harakatlanish zaxirasi muvozanatni hosil qiladi. Bundan tashqari akkumulyator batareyasining vazni elektromobilning massaini oshirib yuborishi esa ortiqcha yuklanishga sabab bo‘lib, foydali ish ish bajarish holatini tushirib yuboradi. Shuning uchun ushbu bog‘liqlik muhim rol o‘ynaydi. Mazkur maqolada elektromobilning turli vazn bilan va turli tezliklarda tekislikda va qo‘shimcha yuklamalarsiz harakatlanayotganda talab qilinadigan quvvati tahlil qilinadi.
Maqsad: elektromobillarning uch xil vazn holatida turli tezlikda harakatlanoyotganda elektromobillarning energiya manbai hisoblangan akkumulyator batareyalaridan talab qilinadigan qiymatni aniqlash uslubini o‘rganib chiqishdan iborat.
Usullar: tadqiqot jarayonida akkumulyator batareyalaridan talab qilinadigan quvvatni tahlil qilish uchun o‘rta klassdagi elektromobillarning texnik xususiyatlarini o‘rgangan o‘rtacha qiymatlari hisobga olindi. Hisoblash dasturlari orqali avtomobillarga ta’sir etuvchi kuchlarni aniqlash uchun berilgan mexanik va aerodinamik formulalar yordamida qiymatlar hisoblangan va grafiklar qurildi. Elektromobillarning turli vaznlarda qancha harakat tezligiga bog‘liq holatda qanday quvvat talab qilinishi solishtirish usulubidan foydalanildi.
Natijalar: elektromobilning turli vaznlarda 0 dan 160 km/h tezlikda tekislikda harakatini hisoblash dasturida tadqiq qilish asosida, ta’sirini baholash grafik va jadvallar natijalari keltirilgan.
Kalit so'zlar: elektromobil, avtomobil vazni, harakat tezligi, energetika tizimi, akkumulyator batareyasi, qulaylik qurilmalari, talab.

Анализ энергопотребления электромобилей при различных скоростях на основе их параметров

Хушнуд Б. Сапаев[1], Акбар З. Журабоев[2a], Ойбек О. Даминов[3]

[1)] DSc, проф., Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; khushnud.sapaev@mail.ru https://orcid.org/ 0000-0002-0486-3132
[2a)] базовый докторант (PhD), Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; akbar_universal@mail.ru https://orcid.org/0009-0008-2330-6324
[3)] PhD, доц., Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; oybek.daminov@tdtu.uz https://orcid.org/0000-0001-7876-1289

Актуальность: по данным международных организаций, количество пользователей электромобилями растет с каждым днем. Эта тенденция наблюдается и в Узбекистане. В данной статье рассматриваются характеристики силовых установок электромобилей при различных условиях нагрузки, в зависимости от основных факторов, влияющих на запас хода. Заряд в аккумуляторе и потребляемая мощность напрямую связаны между собой, а запас хода устанавливает баланс. Кроме того, вес аккумулятора увеличивает массу электромобиля, что приводит к перегрузке и снижает эффективность полезной работы. Поэтому эта взаимосвязь играет важную роль. В данной статье анализируется мощность, необходимая электромобилю при движении с различным весом и скоростью по ровной поверхности без дополнительных нагрузок.
Цель: изучение метода определения требуемого значения срока службы аккумуляторных батарей, которые является источником энергии электромобилей, при движении с разными скоростями в трёх различных значениях веса электромобилей.
Методы: в процессе исследования были учтены средние значения исследуемых технических характеристик электромобилей среднего класса для анализа требуемой мощности от аккумуляторной батареи. Для определения мощности, необходимой в зависимости от скорости движения электромобилей различного веса, был использован метод сравнения.
Результаты: на основе исследования движения электромобиля в плоскости со скоростью 0-160 км/ч с различным весом в расчетной программе представлены график и таблица для оценки эффекта.
Ключевые слова: электромобиль, вес автомобиля, скорость движения, энергосистема, аккумуляторная батарея, устройства комфорта, спрос.

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Analysis of the energy consumption of electric vehicles at different speeds based on their parameters

Xushnud B. Sapaev[1], Akbar Z. Juraboev[2a], Oybek O. Daminov[3]

[1)] DSc, prof., Tashkent State Technical University, Tashkent, 100095, Uzbekistan; khushnud.sapaev@mail.ru https://orcid.org/0000-0002-0486-3132

[2a)] PhD researcher, Tashkent State Technical University, Tashkent, 100095, Uzbekistan; akbar_universal@mail.ru https://orcid.org/0009-0008-2330-6324

[3)] PhD, ass. prof., Tashkent State Technical University, Tashkent, 100095, Uzbekistan; oybek.daminov@tdtu.uz https://orcid.org/0000-0001-7876-1289

Relevance: according to reports from international organizations, the number of electric vehicle users is growing daily. This trend is also occurring in Uzbekistan. This article examines the characteristics of electric vehicle power systems under various load conditions, depending on the main factors that affect the driving range. The charge in the battery and the power consumed are directly related, and the driving range establishes the balance. Furthermore, the weight of the battery increases the mass of the electric vehicle, which leads to an overload and reduces the state of useful work. Therefore, this relationship plays an important role. This article analyzes the power required by an electric vehicle when moving at various weights and speeds on a flat surface without additional loads.

Aim: the purpose of this article is to study the method for determining the required value of battery life, which is the energy source of electric vehicles, when moving at different speeds in 3 different weight positions of electric vehicles.

Methods: in the research process, the average values of the studied technical characteristics of mid-class electric vehicles were taken into account to analyze the required power from the battery. The comparison method was used to determine the power required depending on the speed of movement of electric vehicles of different weights.

Results: based on the study of the motion of an electric vehicle in a plane at a speed of 0-160 km/h with different weights in a calculation program, a graph and a table for assessing the effect are presented.

Keywords: electric car, car weight, movement speed, power system, battery, comfort devices, demand.

1. Kirish (Introduction)

Dunyoda tobora ichki yonuv dvigatelli avtomobillar bilan bir ravishda elektromobillarga bo‘lgan talab oshib bormoqda. Elektromobillarning ko‘p qismlari oddiy avtomobillar bilan farq qilmaydi. Asosiy farq uning kuch agregati yoki energetik qismlarida hisoblanadi. Ushbu turdagi avtotransport vositasining energetik qismalariga qisqacha to‘xtalib o‘tamiz. Elektromobillarning umumiy energetik qismlari tuzilishi odatiy avtomobillardan qisman farq qiladi. Bunda elektromobillar ichki yonuv dvigateliga ega bo‘lgan avtomobillardan farqli o‘laroq, sodda konstruksiyaga ega bo‘lib, unda harakatlanuvchi qismlarning minimal soni bilan ajralib turadi, bu esa o‘z navbatida uning ishonchli ishlashiga ijobiy ta’sir ko‘rsatadi [1-2].

Elektromobillarning asosiy energetik qismlariga quyidagilar kiradi: akkumulyator batareyalari, elektr dvigateli, transmissiya, bortli zaryadlovchi qurilma, DC/AC inverteri, DC/DC konvertori va elektron boshqaruv tizimi. Asosiy jihat shundaki bunda akkumlyator batareyasi quvvati elektr dvigatelining quvvatiga mos kelishi kerak [3] va bu qismni shunday tanlash kerakki, elektromobilni nafaqat harakatlanishini balki yetarlicha masofa bosib o‘tilishi ham ta’minlanishi kerak.

2. Materiallar va usullar (Methods and materials)

Ko‘pchilik holatlarda akkumulyator batareyalarida sarf qilinadigan energiya bilan harakatlanish masofasi o‘rtasidagi bog‘lanishi inobatga olib elektromobil ishlab chiqariladi. Bu masalani yechishda barcha parametrlar(avtomobil va ichki yuklarning og‘irligi, avtomobil profilini yuzasining qarshilik koeffitsiyenti, havoning zichligi va havoning harorati holati va boshqalar)ga nisbatan e’tibor berish muhim hisoblanadi.

1-jadval. Elektromobilning texnik xususiyatlari
Table 1. Technical specifications of the electric vehicle

№	Texnik ko‘rsatkich	Qiymati	Birligi / Izoh
1	Yuksiz to‘liq jihozlangan vazn	1340	kg
2	Elektromobilning haydovchi bilan vazni (m_1)	1400	kg
3	O‘rtacha yuklangan vazn (m_2)	1700	kg
4	To‘liq yuklangan vazn (m_3)	2000	kg
5	Elektromobilning old qismining o‘lchamlari: eni*balandligi	1750*1550	mm
6	Old yuza maydoni A	2.2	m^2
7	Aerodinamik koeffitsiyent C_d (ba’zi turdagi elektromobillarda)	0.21	

Bu masalani aniqlashda quyidagi texnik parametr(xususiyat)lardan foydalanamiz. Ushbu texnik parametrlar 1-jadvalda keltirib o‘tilgan [4 - 8].

Bu jadval asosida quyidagi hisoblashlar amalga oshirilgan.

• Elektromobilning turli vaznlari quyidagi formula bo‘yicha hisoblangan:

$$m_i = m_1 + m_{1+i}\ ; \quad (1)$$

bu yerda m_i – oldingi va keyingi vazn ko‘rsatkichlari.

Old yuza maydoni ushbu formula bo‘yicha hisoblangan:

$$A = k * b * h\ ; \quad (2)$$

bu yerda b – avtomobilning eni, 1750 mm; h – avtomobilning balandligi, 1550 mm; k – tuzatish koeffitsiyenti.

Energetik hisoblashlar quyidagi formulalar bo‘yicha amalga oshiriladi.

• Avtomobil va ichki yuklarning og‘irligi dumalash qarshiligini yuzaga keltiradi va natijada harakatlanishga qarshi kuch yuzaga keladi [9 - 11]. Bu kuch quyidagi formula yordamida aniqlanadi:

$$F_{rol} = m * g * f; \quad (3)$$

bu yerda F_{rol} – dumalash qarshiligi [N]; m – avtomobil massasi [kg]; g – erkin tushish tezlanishi; f – g‘ildirak ishqalanish koeffitsiyenti (0.01).

• Avtomobil profilini yuzasining qarshilik koeffitsiyenti, havoning zichligi va havoning harorati holati aerodinamik kuchni hosil qiladi [9 - 12]. Ushbu formula quyidagicha aniqlanadi:

$$F_{air} = \frac{\rho * v^2 * C_d * A}{2}; \quad (4)$$

bu yerda, F_d – aerodinamik kuch [N]; ρ – havoning zichligi 15^0 C haroratda va 1 atmosfera bosimida – 1,29 kg/m^3 ga teng; v^2 – avtomobil harakat tezligi [m/s]; C_d – aerodinamik qarshilik koeffitsiyenti (0,21); A – avtomobilning old yuzasi [m^2].

• Jami elektromobilning harakatlanishda yuzaga keladigan kuchlari ushbu formula asosida hisoblanadi:

$$F_{um} = F_{rol} +. \quad (5)$$

• Elektromobilning harakalanishi uchun jami quvvat sarfini quyidagi formula yordamida hisoblanadi [9 – 11,13]:

$$P = \frac{(F_{air} + F_{rol}) * v}{1000 * \eta}; \quad (6)$$

bu yerda P – elektrodvigatel quvvati [kVt]; η – elektrodvigatel va transmissiya FIK odatda 83-92% bo‘ladi [10].

Akkumulyator batareyalaridan talab qilinadigan quvvatni tahlil qilish uchun yuqorida keltirilgan o‘rta klassdagi elektromobillarning texnik xususiyatlarini o‘rgangan holatda hisoblash dasturlari orqali elektromobilga ta’sir etuvchi kuchlarni aniqlash uchun avtomobillarga ta’sir etuvchi mexanik va aerodinamik kuchlarni hisoblash uchun berilgan formulalar yordamida qiymatlar aniqlanadi. Hisoblash dasturi yordamida jadval va grafiklar qurilgan. Elektromobillarning turli vaznlarda qancha harakat tezligiga bog‘liq holatda qanday quvvat talab qilinishi ushbu natijalarni solishtirish usulubi tahlil qilinadi.

3. Natijalar (Results)

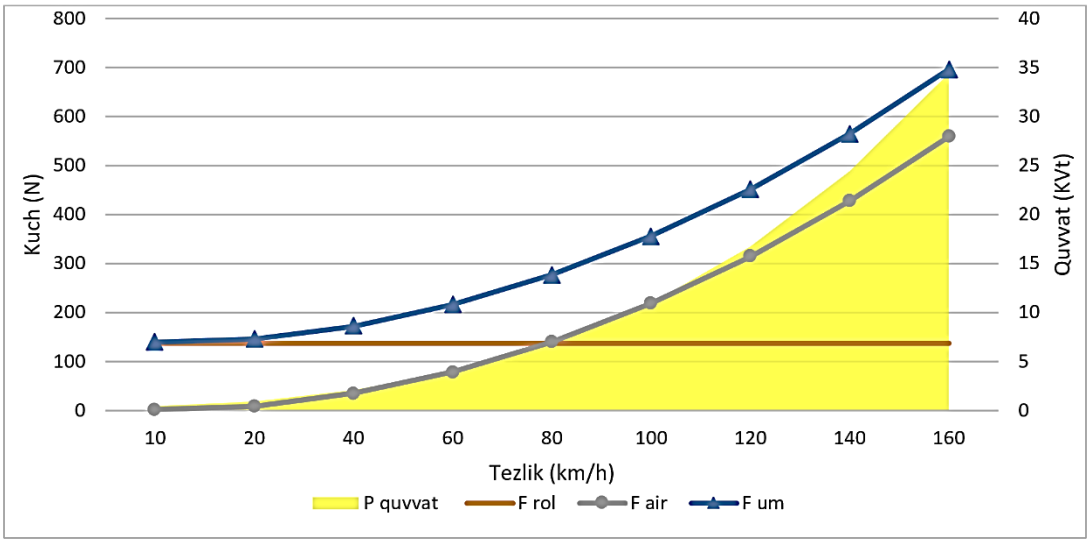
Ushbu qiymat va yuqoridagi formulalar asosida elektromobilni quvvat sarfining harakatlanishiga qarshilik kuchlari va tezlikka bog‘liq xarakteristikasi 1400 kg vazn uchun hisoblanib, 2-jadvalda natijalari va 1-rasmda grafigi keltirib o‘tilgan.

2-jadval. Elektromobilning turli tezliklarda harakatlanishi davomida hosil bo‘ladigan kuchlar va quvvat sarfi

Table 2. Forces and power consumption during the movement of an electric vehicle at various speeds

T/r	v	F_{rol}	F_{air}	F_{um}	P
1	0	0	0	0	0
2	10	137.34	2.18	139.52	0.43
3	20	137.34	8.73	146.07	0.90
4	40	137.34	34.94	172.28	2.13
5	60	137.34	78.60	215.94	4.00
6	80	137.34	139.74	277.08	6.84
7	100	137.34	218.34	355.68	10.98
8	120	137.34	314.42	451.76	16.73
9	140	137.34	427.96	565.30	24.43
10	160	137.34	558.96	696.30	34.39

Keyingi qadamda elektromobilning turli vazn yuklanishlaridagi xususan P_1 – 1400 kg, P_2 – 1700 kg P_3 – 2000 kg vaznlarda harakat tezligiga bog‘liq ravishda talab etiladigan quvvat bog‘liqliklari dumalash ishqalanish kuchini o‘zgarmas qiymatda olinib hisoblanib, 3-jadval aniqlangan qiymatlar keltirib o‘tilgan.

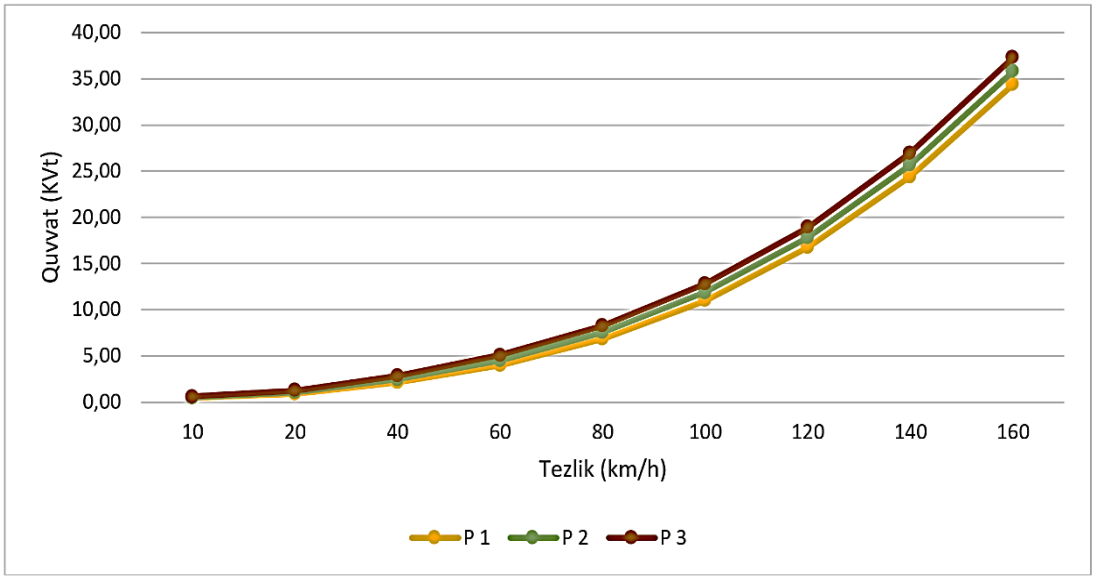


1-rasm. Elektromobilning qarshilik kuchlari, quvvat va tezlik o‘rtasidagi bo‘gliqlik grafikasi
Fig.1. Graph of the relationship between resistance forces, power, and speed of an electric vehicle

3-jadval. Elektromobilning turli vazn yuklanishlari va tezlikda talab etiladigan dvigatelning quvvati bo‘gliqligi
Table 3. Required Engine Power of an Electric Vehicle at Various Weight Loads and Speeds

Tr	**v**	**P_1**	**P_2**	**P_3**
1	0	0	0	0
2	10	0.43	0.52	0.61
3	20	0.90	1.08	1.27
4	40	2.13	2.49	2.85
5	60	4.00	4.54	5.09
6	80	6.84	7.57	8.29
7	100	10.98	11.89	12.79
8	120	16.73	17.82	18.91
9	140	24.43	25.70	26.97
10	160	34.39	35.84	37.29

Ushbu qiymatlar asosida 2-rasmda elektromobilning 3 xil vazn bilan turli tezliklarda harakat qilganida yuzaga keladigan qarshilik kuchlarining elektromobil talab qiladigan quvvatga bog‘liq xarakteristikasi olingan.



2-rasm. Elektromobil vaznining quvvatga ta’siri
Fig.2. Effect of electric vehicle weight on power

Yuqoridagi barcha hisoblashlar elektromobilning akkumulyator batareyasidan talab qilinadigan quvvat bo‘lib [15], avtotransport vositasi hech qanday ortiqcha tezlanishlarsiz, qo‘zg‘alishlarsiz ya’ni tekis harakati davomida, qiyalik va balandlikka harakatlanmayotgan, havo harorati va bosimining o‘zgarishi bo‘lmagan, shamol tezligi natijasida hosil bo‘ladigan kuchlar ta’sir etmayotganida, elektromobil foydalanuvchilarining qulaylik talab va istaklarini amalga oshiruvchi qurilmalar misol uchun rul istishi, audiotizim va hokazolarni ishchi holatida bo‘lmagan, issiq yoki sovuq ob-havo sharoitida konditsioner tizimi ishlamoyotgani kabi bir qancha faktorlarni hisobga olmagan holati uchun hisoblangan. Agarda shu kabi faktorlarni hisobga olgan holatda elektromobil harakatlansa hisobiy grafik va jadval qiymatlari o‘zgaradi. Misol tariqasida shuni ilova qilishimiz mumkinki, konditsioner tizimi bilan jihozlangan avtotransport vositalarida ushbu tizim qo‘shimcha ravishda 2-3 kvt*soat energiya sarf qilishi turli adabiyot va manbalarda keltirib o‘tilgan [15]. Demak nafaqat ushbu tizim balki yuqoridagi kabi faktorlar akkumulyator batareyalaridan energiya qo‘shimcha energiya talab qiladi va shu bilan bir qatorda sarflanishiga, natijada esa harakatlanish zaxirasi o‘zgarishiga sabab bo‘ladi.

4. Xulosa (Conclusion)

Ushbu grafiklar elektromobil harakati dinamikasi davomida ta’sir etuvchi kuchlar va talaba etiladigan quvvat sarfi bo‘yicha quyidagi muhim xulosalarni beradi:

1. Havo qarshiligini elektromobilning tezligi ortishi bilan kvadratik bo‘gliqlikda o‘sib boradi, taxminan 80 km/h tezlikdan so‘ng, havo qarshiligi asosiy harakatlanish uchun to‘sqinlik qiluvchi kuchga aylanadi.
2. Elektomobil massasing ta’sir harakatlanish past rejimlarda ya’ni 80 km/h dan ortiq bo‘lmagan, yoki shahar rejimida 1400 kg dan 2000 kg gacha o‘zgarishi talab etiladigan quvvat katta farq qilmasada, yuqori tezliklarda asosiy energiya havo qarshiligini yengib o‘tishga sarflanadi.
3. Yuqori tezlikda harakatlangan elektromobil o‘z akkumulyator batareyasi zaxirasini bir necha barobar tezlikda yo‘qotadi.
4. Turli iqlim sharoitlarda qo‘shimcha faktorlar masalan issiq iqlim mintaqsida uzoq vaqt harakatlangan elektromobillarda konditsioner tizimi akkumulyator batareyalarida qo‘shimcha yuklama hosil qiladi.

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