**ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ
ҒЫЛЫМИ ЖУРНАЛЫ**

**НАУЧНЫЙ ЖУРНАЛ
ТОРАЙГЫРОВ УНИВЕРСИТЕТА**

ҚАЗАҚСТАН ҒЫЛЫМЫ МЕН ТЕХНИКАСЫ

2001 ЖЫЛДАН БАСТАП ШЫҒАДЫ

TORAIGHYROV UNIVERSITY

НАУКА И ТЕХНИКА КАЗАХСТАНА

ИЗДАЕТСЯ С 2001 ГОДА

ISSN 2788-8770

№ 2 (2022)

ПАВЛОДАР

НАУЧНЫЙ ЖУРНАЛ
ТОРАЙГЫРОВ УНИВЕРСИТЕТ
выходит 1 раз в квартал

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агенства и сетевого издания
№ KZ51VPY00036165

выдано
Министерством информации и общественного развития
Республики Казахстан

Тематическая направленность
Публикация научных исследований по широкому спектру проблем
в области металлургии, машиностроения, транспорта, строительства,
химической и нефтегазовой инженерии, производства продуктов питания

Подписной индекс – 76129

https://doi.org/10.48081/UIQR5237

Импакт-фактор РИНЦ – 0,342

SRSTI 73.31.85

https://doi.org/10.48081/BXTH2502

***S. B. Kokin**
Toraighyrov University,
Republic of Kazakhstan, Pavlodar

TRACTION BATTERIES OF MODERN ELECTRIC VEHICLES

The purposeful policy of developed countries to transform the global economy and form a new world order, an important feature of which will be an alternative fuel and energy balance, requires the reaction of all states, including Kazakhstan. Despite the rich reserves of hydrocarbon raw materials, Kazakhstan cannot ignore the fact that the main energy consumer – transport – has begun to actively gain momentum in the movement to reduce the consumption of fossil fuels. And the most important trigger of changes in this process was the increase in the production of electric vehicles, growing on high expectations of unsatisfied demand. The transformation will affect not only the transport industry, but also related segments of related industries. The adoption of carbon neutrality standards, as well as the integration of fundamentally new infrastructure and new modes of transport into everyday life will require the development of related technologies, deep modernization of existing and creation of new industries at all stages of the life cycle: extraction of raw materials for batteries, development and production of electric vehicles and components, charging stations and energy infrastructure, information infrastructure and cybersecurity, recycling and others.

Keywords: electric vehicle, traction battery, wiring diagrams, characteristics of traction batteries.

Introduction

Batteries are suitable energy storage systems in various types of cars, they play a key role in the case of electric vehicles. The technologies responsible for their operation are constantly evolving, and different types of batteries differ from each other in application and technical characteristics.

This article is devoted to the analysis of the characteristics of traction batteries used in the design of modern electric vehicles. Connection diagrams, advantages and disadvantages of various types of batteries are given and prospects for their further development are formulated.

The relevance of the work is due to the fact that one of the main problems of modern electric vehicles is the high cost and low performance of traction batteries. This problem is the main deterrent to the widespread adoption of electric vehicles [1–4].

Materials and methods

Comparative analysis of characteristics of traction batteries for modern electric vehicles

Electric vehicles have a number of advantages over cars with internal combustion engines (ICE). The advantages of electric vehicles include the following:

- absence of harmful exhaust emissions, which are one of the main sources of environmental pollution;
- significantly lower noise level;
- reliability and durability of the engine during its long-term operation;
- high efficiency of the electric motor (about 95 %).

Disadvantages of electric vehicles are:
- high cost of traction battery;
- significant influence of environmental conditions (temperature) on battery capacity;
- large mass of the vehicle;
- a relatively small power reserve on a single charge of the traction battery.

Two types of batteries are used in electric vehicles. The starter motor is used as an auxiliary energy source for starting the engine, lighting, heating and other purposes. Traction is the main source of electricity needed to power the electric motor. There are several main types of traction batteries:
- lead-acid;
- nickel-cadmium;
- nickel-metal hydride;
- lithium-ion [5–10].

The purpose of this article is a comparative analysis of the characteristics of the traction batteries used and the prospects for their development. Lead-acid ba tteries have become widespread due to their affordable cost and sufficient specific power. The principle of operation of these batteries is based on the chemical reaction of Pb (lead) and PbO_2 (lead dioxide) in an aqueous solution of H_2SO_4 (sulfuric acid).

The operating temperature of the battery has a fairly wide range: from -40 to +40 ° C. When the ambient temperature decreases, their parameters deteriorate: the batteries do not ensure the reliability of starting the engine and are not able to take charge from the generator. The main condition of operation is not to allow the battery to be discharged below 50% of its capacity, as this significantly reduces its service life. One of the main disadvantages of these batteries is that they occupy 25... 50 % of the total mass of the vehicle. Nickel-cadmium batteries have a significant advantage over lead-acid batteries – a longer service life (with proper operation, 100–900 charge-discharge cycles, which is about 20–25 years). The chemical current source is Ni(OH)2 (hydrate of nickel oxide) with graphite powder (5...8 %). The principle of operation is based on a reversible chemical reaction.

The operating temperature has a larger range than that of lead-acid batteries from -50 to +40 °C. The main advantage of these batteries is that they can be stored in a discharged state, unlike nickel-salt and nickel-metal hydride batteries, for which it is necessary to maintain a charged state. As well as lead-acid, they have a low cost. One of the disadvantages is the so-called «memory effect». This process manifests itself when the battery is charged before it has had time to discharge. In this case, an «extra» electrical layer appears in the electrochemical system of the battery, which reduces the voltage by 0.1 V. Currently, the use of the batteries in question is limited, as they have a negative impact on the environment (the toxicity of the materials used significantly exceeds the norms). The nickel-metal hydride battery was designed to replace the nickel-cadmium one. It has a larger capacity (by about 20%), but a shorter service life (300–500 charge-discharge cycles). The advantage of the considered batteries is a much smaller «memory effect». This means that it is possible to charge an incompletely discharged battery, while the formation of «extra» layers is excluded. The chemical current source is a reversible reaction of nickel-lanthanum or nickel-lithium hydride. The charge occurs in a direct reaction from right to left, the discharge occurs in the opposite direction: Ni(OH)2 + M ↔ NiOOH + MH.

Nickel-metal hydride batteries are the most environmentally friendly, as they do not have toxic components. They have good performance at low temperatures. Operating temperature range from -40°C to +55 °C. At a negative temperature, the power loss is no more than 1-2%, while other batteries have 20–30 %. The disadvantages include poor tolerance of high temperatures (20–30 °C), high cost compared to nickel-cadmium batteries, the amount of self-discharge, which is 1.5 times higher than that of other batteries [11, 12].

Lithium-ion batteries are widely used in laptops, phones and other devices. Recently, these batteries have been gaining popularity in the modern electric vehicle industry. Such batteries have a high specific energy (from 200 Wh / kg) and charge efficiency. The service life of lithium-ion batteries is higher than that of the rest – at least 1000 charge-discharge cycles (or at least 10 years). The advantages of this type of battery are considered to be minimal self-discharge (no more than 3 %), no need for additional maintenance and low weight compared to other batteries. The disadvantages of this type of battery do not allow you to take a leading position in the market. This is the operating temperature from -20°C to +50°C and high sensitivity to changes in ambient temperature. When the temperature drops, the battery's ability to release energy sharply decreases, in this they are inferior to lead-acid batteries. It is not recommended to charge them at temperatures below 0 °C. At temperatures above 60°C, overheating occurs, which can lead to an explosion and fire. Every year, the popularity of electric vehicles is gaining momentum, so the issue of improving batteries is becoming more relevant. The choice of the type of traction battery for electric transport depends on its technical characteristics: voltage, capacity, mass, strength of charging and discharge currents and efficiency. The table shows the comparative characteristics of various types of traction batteries for electric vehicles.

Table 1 – Comparative characteristics of traction batteries

Characteristic	Lead-acid	Lead-acid	Nickel-metal hydride	Lithium-ion
Internal resistance	Very low	Very low	Low	Low
Number of charge/ discharge cycles	300-500	100-900	300-500	800-1500
Self-discharge per month	5 %	20 %	30 %	до 5 %
Permissible ambient temperature during charging	From -20 °C to 50 °C	From 0 °C to 45 °C	From 0°C to 45 °C	

Operating temperature	-20 … 50 °C	-50 … 40 °C	-40 … 55 °C	-20 … 50 °C
Toxicity	Very high	Very high	Low	-
Service	+	+	–	–
Memory Effect	–	+	–	–
Cost	Low	Moderate	High	High

The batteries used on electric vehicles consist of a number of connected elements (cans) that have a voltage multiple of two. Taking into account the variety of designs of modern electric vehicles, it is necessary to have different combinations of characteristics of the batteries used. This is achieved by serial and parallel connection of batteries. Serial connection is applicable in cases where it is necessary to obtain a higher voltage with a constant battery capacity. Individual elements (banks) are connected alternately (the positive terminal of one battery with the negative terminal of the other). The total voltage can be calculated by the formula: Uc = Ueln, where Uel is the voltage at the element clamp; n is the number of elements.

Parallel connection is applicable in cases where it is necessary to obtain a large battery capacity at constant voltage. In this case, all the positive terminals are connected together, forming a positive charge, the negative terminals are connected in the same way.

Results and discussion

The largest manufacturers of batteries for electric vehicles

According to SNE Research analysts, in 2021, the share of South Korean companies in the global market of batteries for electric vehicles was 30.4 %, which is 4.3 percentage points less than in 2020. The study was published in February 2022.

Since 2017, CATL has become the world’s largest manufacturer of batteries for electric vehicles in 2021, according to SNE Research, a market research firm. With an installed capacity of 96.7 GWh, CATL gained a 32.6 % share of the global lithium-ion car battery market in 2021. LG Energy Solution is the second leader in the production of batteries for electric vehicles with a market share of 20.3 % and a total capacity of 60.2 GWh, according to an estimate, Panasonic ranks third with an installed capacity of 36.1 GWh and a market share of 12.2 %.

Among the largest manufacturers of batteries for electric vehicles: CATL, LG Energy Solution, Panasonic

However, this also means that the top three already have a combined market share of 65.1 % with 193 GWh of installed capacity. According to SNE Research, the total market volume at the end of the year was 296.8 GWh, which is twice as much as in 2020. In particular, the growth was 102.3 %.

The following is a list of companies producing batteries for electric vehicles and their share in global production:

- CATL 96.7 GWH 32.6 %
- LG Energy Solution 60.2 GWh 20.3 %
- Panasonic 36.1 GWH 12.2 %
- BYD 26.3 GWH 8.8 %
- SK On 16.7 GWh 5.6 %
- Samsung SDI GWh 13.2 4.5 %

- CALB 7.9 GWh 2.7 %
- Gotion High-Tech 6.4 GWh 2.1 %
- AESC 4.2 GWh 1.4 %
- SVOLT 3.1 GWh 1.0 %

The fastest growth was recorded in SVOLT, whose turnover increased more than fivefold in 2021. However, the largest increase in capacity can be attributed to CATL and BYD, which in 2021 increased the installed production capacity by 2.5 times. CALB and Gotion still have a factor of 2.

Among Korean manufacturers, LGES was able to increase by 70 %, according to the Pulse News portal, also thanks to the active sales of the Tesla Model Y and VW ID.4. However, as the market grew faster, LGES lost market share. SK On was able to double its capacity and took fifth place in the ranking with a market share of 5.6 %. Samsung SDI was able to increase its capacity by only 50 % to 13.2 GWh and took sixth place with a market share of 4.5 %.

Another Japanese manufacturer, AESC, entered the top ten in ninth place with a market share of 4.2 GWh or 1.4 %. Compared to 2020, AESC was able to increase its production capacity by 0.3 GWh. However, major projects have been announced in England and France, which should increase the company's capacity from 2022 to 2024.

Conclusions

Based on the comparative analysis of traction batteries, the following conclusions can be drawn:

- lead-acid batteries have the lowest cost, have large overall dimensions and require maintenance every 3 to 6 months;

- nickel-cadmium batteries have a large number of charge/discharge cycles, are resistant to low temperatures, but have a negative «memory effect»;

- nickel-metal hydride batteries have a greater self-discharge value than nickel-cadmium batteries and do not tolerate low temperatures; lithium-ion batteries are the most promising of the considered batteries, since they have a high energy consumption, a large number of charge/discharge cycles and are the most environmentally friendly.

REFERENCES

1 **Gorelov V. P., Danilov G. A**. Power supply of transport facilities. – Moscow : Transport, 2016. – 379 p.

2 **Ashley Vance.** Elon Musk. Tesla, SpaceX and the road to the future. – Moscow : Business and Management, 2021. – 440 p.

3 **Drobov A. V., Galushko V. N.** Electric machines: textbook. – Moscow : Transport, 2015. – 292 p.

4 **Timatkov V. V.** Electric transport as a part of the electric world. Facts and forecasts. – Moscow : ID Energia , 2015. – 48 p.

5 **Kashkarov A. P.** Modern electric vehicles. Device, differences. – Moscow : Transport, 2017. – 92 p.

6 **Zaripov R. Yu., Ivashko V. S., Sembayev N. S. [et al.]** On the issue of introduction of electric buses in the transport system of the city // Science and Technology of Kazakhstan. – 2019. – № 4. – P. 50-63.

7 LLP «Research INSTITUTE OF TC». Methodology of passenger traffic survey in the public urban passenger transport system. – Moscow : Transport, 2014. – 37 p.

8 **Karamyan O. Yu., Chebanov K. A., Solovieva Zh. A.** Electric vehicle and prospects for its development // Fundamental Research, 2015. No. 15. – 696 p.

9 **Balgabekov T. K., Aidarbek A. O., Kongkybayeva A. N., et al.** The problems of urban transport in major cities / // Science and Technology of Kazakhstan. – 2021. – No 1. – P. 75–85. – DOI 10.48081/AEWB5483.

10 **Ivanov S. A., Asadov D. G.** Market analysis and development trends of lithium-ion batteries and electric vehicles // International Technical and Economic Journal. 2011. – No. 1. – P. 119–122.

11 **Ospanbekov B. K.** Optimization of resource-determining operational modes of traction batteries of electric vehicles. – Moscow, 2017. – 170 p.

12 **Nusupbek Zh. T., Zharkenov N. B., Kongkybayeva A. N. [et al.]** Ensuring the safety of vehicles // Science and Technology of Kazakhstan. – 2022. – No 1. – P. 178-186. – DOI 10.48081/UQZS8247.

Material received on 06.06.22.

***С. Б. Кокин**

Торайғыров университеті,
Қазақстан Республикасы, Павлодар қ.
Материал 06.06.22 баспаға түсті.

ҚАЗІРГІ ЗАМАН КӨЛІКТЕРІНЕ АРНАЛҒАН ТАРТҚЫШ АККУМУЛЯТОРЛАР

Дамыған елдердің жаһандық экономиканы түрлендіру және жаңа әлемдік тәртіпті қалыптастыру жөніндегі мақсатқа барлық мемлекеттердің, соның ішінде Қазақстанның да ден қоюын талап етеді. Оның маңызды белгісі - баламалы отын-энергетикалық теңгерім болмақ, Көмірсутектердің бай қорына қарамастан, Қазақстан энергияның негізгі тұтынушысы – көліктің қазба отын тұтынуын азайту қозғалысының белсенді қарқын ала бастағанын назардан тыс қалдыра алмайды. Бұл процестегі өзгерістердің ең маңызды қозғаушы күші сұраныстың жоғарылауына байланысты өскен электр көліктерінің өндірісінің артуы болды. Трансформация тек көлік саласына ғана емес, сонымен қатар аралас салалардың сабақтас салаларына да әсер етеді. Көміртегі бейтараптығы стандарттарын қабылдау, сондай-ақ күнделікті өмірге түбегейлі жаңа инфрақұрылым мен көліктің жаңа түрлерін біріктіру байланысты технологияларды дамытуды, қолданыстағыларды терең жаңғыртуды және жаңа өндірістерді құруды . өмірлік цикл үдірісінде талап етеді: аккумуляторларға арналған шикізатты өндіру, электрлі көліктер мен бөлшектерді әзірлеу және өндіру, қуаттандыру станциялары *мен энергетикалық инфрақұрылым, ақпараттық инфрақұрылым және киберқауіпсіздік, қайта өңдеу және т.б.*

Кілтті сөздер: электрокөлік, тартқыш аккумулятор, қосу сұлбалары, тартқыш аккумуляторлардың сипаттамалары.

***С. Б. Кокин**
Торайгыров университет,
Республика Казахстан, г. Павлодар.
Материал поступил в редакцию 06.06.22.

ТЯГОВЫЕ АККУМУЛЯТОРЫ СОВРЕМЕННЫХ ЭЛЕКТРОМОБИЛЕЙ

Целенаправленная политика развитых стран по трансформации глобальной экономики и формированию нового мироустройства, важной особенностью которого станет альтернативный топливно-энергетический баланс, требует реакции всех государств, включая Казахстан. Несмотря на богатые запасы углеводородного сырья, Казахстан не может игнорировать тот факт, что основной потребитель энергии – транспорт – начал активно набирать обороты в движении по сокращению потребления ископаемого топлива. И важнейшим триггером изменений в этом процессе стало увеличение производства электромобилей, растущего на больших ожиданиях неудовлетворенного спроса. Трансформация затронет не только отрасль транспорта, но и связанные с ней сегменты смежных отраслей. Принятие стандартов углеродной нейтральности, а также интеграция принципиально новой инфраструктуры и новых видов транспорта в повседневную жизнь потребуют развития сопутствующих технологий, глубокой модернизации существующих и создания новых производств на всех стадиях жизненного цикла: добыча сырья для батарей, разработка и производство электротранспорта и компонентов, зарядные станции и энергетическая инфраструктура, информационная инфраструктура и кибербезопасность, утилизация и др.

Ключевые слова: электромобиль, тяговая аккумуляторная батарея, схемы подключения, характеристики тяговых аккумуляторов.

Теруге 06.06.22 ж. жіберілді. Басуға 30.06.22 ж. қол қойылды.
Электрондық баспа
8,9 Mb RAM
Шартты баспа табағы 12,4. Таралымы 300 дана.
Бағасы келісім бойынша.
Компьютерде беттеген: З. С. Искакова
Корректор: А. Р. Омарова

Тапсырыс № 3964

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов көш., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69

e-mail: kereku@tou.edu.kz
https://vestnik.tou.edu.kz/
http://stk.tou.edu.kz/