Pertsev
Roman

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclaimer

The funder had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Contributors

The author contributed solely to the intellectual discussion underlying this paper, case-law exploration, writing and editing, and accept responsibility for the content and interpretation.

Declaration of Competing Interest

The author declare that they have no conflict of interest.

DOI: https://doi.org/10.32353/acfs.4.2021.04
UDC 343.983:614.841

Roman Pertsev,
Post-graduate student of the Department of Law-Enforcement and Anti-Corruption Activities (Educational and Scientific Institute of Law. Prince Vladimir the Great, IAPM, Kiev);Deputy Head of Investigative-Forensic Department of the Israel police in the Central District, Ramla, Israel.
ORCID: https://orcid.org/0000-0001-9471-2962
e -mail: romanpertsev82@gmail.com

Fire and Technical Aspects Related to Fire of Lithium-Ion Batteries

Lithium-ion batteries are becoming a universal phenomenon in modern society and are found in everywhere, from large-scale solar power storage system, as well as smaller devices such as laptops and phones to hybrid and electric vehicles.

According to the statistics, most fires of lithium-ion batteries arise in electric bicycles, and allowing for the fact that the electric bicycle is usually charged during the night inside apartments, when no one is watching the charging process, the fire can lead to serious consequences.

This article aims to understand how the lithium-ion battery technologies increases the risk of fire, the complexity of fact-finding and investigation of circumstances of the fire, and what can be done to prevent it at the legislative level.

Keywords: lithium-ion batteries, fire, electric bicycles, quality standard, fire investigation, seat of fire.

Introduction. Fires – calamity for people, both for partial and an irretrievable loss of property, and in many cases, human life.

In recent years one can notice the global transition to more environmentally friendly types of power, this is due, first of all, to air contamination, as well as to the search for a cheaper power resource for the transport system.

The rapid development of the given area was the use of the lithium-ion batteries as power sources. The annual average growth rate of the lithium-ion batteries market is expected to reach 22,58% during the projection period (2020-2025) . The lithium-ion batteries have a high capacity and power in a small overall size compared to other batteries. This is why, the lithium-ion batteries are one of the sources of increased fire risks.

For the past few years, numerous fires and explosives of the lithium-ion batteries have been reported in many countries resulting in property damage, bodily injuries and human losses.

The carrying out a fire and technical examination to establish the cause of fire can be difficult in many cases due to the very large area of the fire and damage caused by the fire, as well as the lack of expert methods for investigating these types of fires.

According to data of Singapore Civil Defence Force (SCDF), responsible for the fire extinguishing and investigation of fire cause, the batteries used in consumer products were the cause of approximately 53% of all battery fires in Singapore from 2008 to 2015. The lithium-ion batteries out of them, used in

© R. Pertsev, 2021

electric bicycles, consist of the most percentage of fires. Statistically, 50% of fires occurred while charging the electric bicycles batteries, and 31,3% of fires occurred when the electric bicycles were motionless and not in use .

Also, according to Israel Fire and Rescue Services, due to an increase in the use of lithium-ion batteries in everyday life, there is a growth of fires connected with lithium-ion batteries. In Israel, there are about 150 fires per year in apartments caused by the lithium-ion batteries used in electric bicycles .

The cause of this increase of lithium-ion batteries fires is associated with structural features of this battery, violation of safety rules while using it, storage, charging/discharging, as well as due to the potential failures of the battery or charger.

Analysis of Essential Researches and Publications. Lots of contemporary scientists such as Wáng Qiáng from University of Science and Technology of China, S. Y. Stoliarov and L. Kong from the University of Maryland and others are studying the problem of failure of the lithium-ion battery, methods of extinguishing fires associated with them.

National Fire Protection Association (NFPA) with a headquarter in the United States of America (hereinafter referred to as the USA) studies methods and the newest equipment to extinguish fires associated with lithium-ion batteries, as well as investigate these fires using special knowledge, methods and skills in order to study the causes of the fire and the mechanism of its progress.

Article Purpose. To determine the cause of fire or explosive of the lithium-ion batteries while using them, particularly in electric bicycles and scooters.

Main Content Presentation. The lithium-ion batteries (hereinafter referred to as LIB) are the most commonly used power source for modern electronic devices. Despite the practicality of these devices due to their high-power density, low maintenance, low self-discharge, fast charging and durability, their fire rules have become a matter of concern after reports of fires associated with them.

Lithium-ion batteries refer to a group of batteries that generate electrical power by converting chemical energy through redox reactions on active materials, that is, a negative anode and a positive electrode (cathode), in one or more electrically connected electrochemical cells .

Articles in magazines with headlines about underestimated dangers of the electric bicycle fires are increasingly seen on pages of printed publications and on the internet, as we do not expect the batteries that help us in our daily lives to harm us. With the increased maintenance of electric bicycles over the past few years, it is worth noting an increase in incidents related to them.

People, who use these products, should be aware of the risk-based maintenance of this product, dangers of storage in the home or in public places, only use the product from an official manufacturer, and follow the fire safety regulations.

Electric bicycles were the cause in more than 10,000 fires throughout the country from 2013 to 2017, according to the Ministry of Emergency Management of China, killing more than 200 people. In accordance with official information for 2008, over 200 million electric bicycles are used in China. In this regard, the Deputy Minister of Emergency Management of China made a comment. In his telling, some tragedies were due to the lack of quality in construction, illegal modifications such as the addition of heave supply batteries, and unsafe charging of electric bicycles, and he called for updating the national safety standard for manufacturing electric bikes .

R. Pertsev

FIRE AND TECHNICAL ASPECTS RELATED TO FIRE OF LITHIUM-ION BATTERIES.

In recent years, there has been a global transition to more environmentally friendly forms of energy, this is due, first of all, to atmospheric pollution, as well as to the search for a cheaper energy resource for the transportation system.

Lithium-ion batteries are becoming ubiquitous in today's society and are found in everything from large-scale solar energy storage systems to smaller devices such as laptops and phones and hybrid and electric vehicles.

This article aims to understand how lithium-ion battery technology increases the risk of fire due to fire or explosion of lithium-ion batteries when they are used, in particular, in electric bicycles, the difficulty of identifying and investigating the circumstances of this fire. What can be done to prevent fires at the legislative level.

The article provides an overview of the situation with fires caused by electric bicycles in China, Singapore, and Israel. Examples from countries (USA, European Union, Israel) that have adopted quality and safety standards related to the operation of e-bikes are given.

The detailed reasons for the occurrence of this problem are considered, the proposed possible legislative and scientific and technical actions for the prevention and investigation of this type of fires:

- it is necessary to strengthen state control over the production and the import of products with lithium-ion batteries, which must meet quality standards and undergo appropriate certification. Such actions should prevent possible technical problems that may arise with low-quality products;

- development and implementation of an expert methodology for investigating fires associated with the ignition of lithium-ion batteries in the expert and investigative departments of the police and other investigating authorities, will make it possible to establish the cause of the fire, the source of the fire and the mechanism of its course;

- development and implementation of effective materials and methods for extinguishing lithium batteries, will help to significantly reduce the time to extinguish a fire, prevent re-ignition, thereby preserving material property and human lives.

Key words: lithium-ion batteries, fire, electric bicycles, quality standard, fire investigation, fire site.

Р. Перцев

ПОЖАРНО-ТЕХНИЧЕСКИЕ АСПЕКТЫ, СВЯЗАННЫЕ С ВОЗГОРАНИЕМ ЛИТИЙ-ИОННЫХ АККУМУЛЯТОРНЫХ БАТЕРЕЙ

В последние годы наблюдается мировой переход на более экологичные виды энергии, связано это прежде всего с загрязнением атмосферы, а также с поиском более дешевого энергетического ресурса для транспортной системы.

Литий-ионные аккумуляторы становятся повсеместным явлением в современном обществе и присутствуют во всем: от крупномасштабных систем хранения солнечной энергии, а также устройств меньшего размера, таких как ноутбуки и телефоны, до гибридных и электрических транспортных средств.

Данная статья направлена на то, чтобы понять, как литий-ионные аккумуляторные технологии способствуют увеличению риска возникновения пожара в следствии возгорания или взрыва литий-ионных аккумуляторных батарей при их использовании, в частности, в электровелосипедах. В статье разобраны сложности выяснения и расследования обстоятельств данного возгорания и то, что можно сделать для его предотвращения на законодательном уровне.

В статье приведен обзор ситуации с пожарами, причиной которых являются электровелосипеды, в Китае, Сингапуре, а также Израиле. Приведены примеры стран Европейского Союза, а также США и Израиля, в которых были приняты стандарты качества и безопасности, относящиеся к эксплуатации электровелосипедов.

Рассмотрены подробные причины возникновения данной проблемы, предложены следующие возможные законодательные и научно-технические действия для предотвращения и расследования данного вида возгораний:

- усиление государственного контроля за производством и поставками продукции с литий-ионными аккумуляторными батареями, которые должны соответствовать стандартам качества и проходить соответствующую сертификацию. Такие действия должны предотвратить возможные технические проблемы, которые

According to the annual statistics published by Singapore Civil Defence Force (SCDF), for 2020 firefighters responded to a total of 1,877 calls, down 34.4% from the previous year, but on the other hand, there is an increase in twice of electric bicycle fires .

According to official data from Israel Fire and Rescue Services, about 60,000 fires were reported in 2019. It was found that 25% of the fires were caused by a malfunction of electric equipment.

For the period from 2015 to 2019, there has been a sharp increase in the use of electric bicycles with LIB in Israel, and in proportion to this, the number of fires in apartments, associated with them, increases . In such a way, in accordance with Israel Fire and Rescue Services, in 2015 one case of the fire was recorded, related to the malfunctions of the electric bicycle's battery, in 2017, 76 cases were already recorded, in 2019, 144 cases of fires were recorded. Thus, it's an obvious point that as the use of electric bicycles increases, there is also an increase in the number of fires associated with them.

The problem of fire safety of LIB is an important obstacle to the growth of the market and their sales. Let us consider the main reasons that can lead to their fire.

When stored and maintained within the norms and rules recommended by the manufacturer, the failure rate of LIB is estimated at 1 out of 40 million. However, unpredictable circumstances, such as overcharging the battery, external heating, and mechanical damage, can significantly enhance the likelihood of battery failure and, as a result, its fire .

The fire hazard of lithium-ion battery is a major concern due to its poor thermal stability and due to the presence of a cathode made from lithium cobalt oxide (LiCoO2). With a sufficiently low heating (no more than 90oC) LiCoO2 begins to decompose with the oxygen precipitation which oxidizes the polymeric electrolyte. A gradual increase in temperature occurs, thereby starting the process in neighboring battery cells. A chain reaction occurs (this process is called the battery thermal dispersal) which continues until the battery is completely burned out . This heating can be caused by a short circuit inside the electrochemical cell, as well as by improper charging/discharging of the battery or by external heating.

The LIB mechanical damage can also lead to its fire. Such damages can be seen with daily use of the electric bicycle. If the battery is not sealed properly, oxygen and water vapor from the environment enter the body and react with the cathode and electrolyte materials. Consequently, the battery heats up and explodes .

Another cause of fire may be the use of a non-original charger or the battery itself. Devices that do not pass proper quality control and do not meet the fire safety regulations can lead to short circuits or overcharging of the battery.

All these reasons can lead to the battery fire and even to its explosion, and if we take into account that usually batteries of electric bicycles are charged indoors, the consequences of this fire can lead to severe fire and human losses.

During the fire, occurred in 2021, in one of the apartments in Israel, several people were injured, one of them was in serious condition, and later died in hospital. As reported by the investigator of fire investigation of Israel Fire and Rescue Services, the fire occurred due to the malfunction of the electric bicycle that was in the apartment . There are more headlines like this

in the news about electric bicycle fires in apartments. The consequences of these fires lead to the loss of not only property, but also to human life.

On figure 1 the consequences of the fire in the apartment, caused by ignition of LIB are shown.

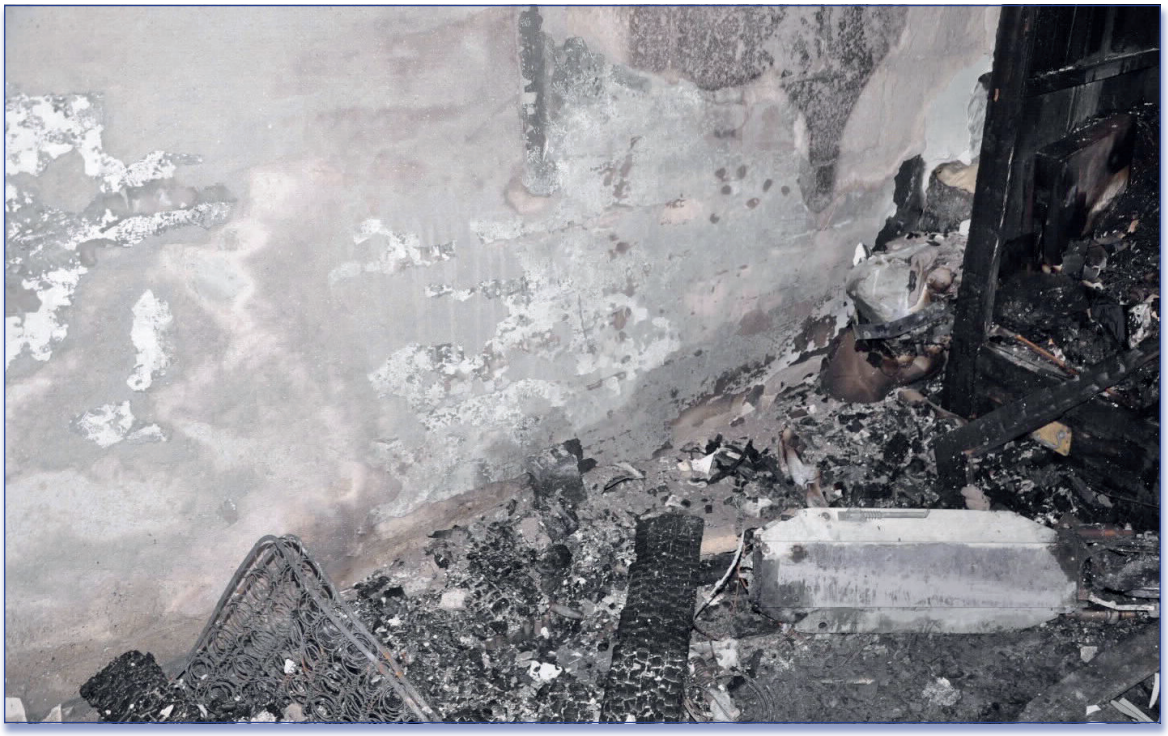

Figure 1. Consequences of the fire in the apartment caused by ignition of the lithium-ion batteries of the electric bicycle (LIB is highlighted in a red circle).

The carrying out the fire and technical examination in order to establish the source of the fire, as well as the circumstances that led to the fire, can be significantly complicated due to the complexity of establishing the facts and mechanisms of its course, as well as in the absence of expert methods and practice in the investigation of this type of fire.

The electric bicycle battery is an electrical and mechanical combination of separate electrochemical cells to produce a higher voltage or more power. Electric bicycles typically use 18,650 cells in a battery configuration to get 48 volts .

The lithium-ion battery may provoke the fire caused both internal and external heating of the battery, thereby serving as a secondary ignition source (power source).

The complexity of fire investigation also consists of the preservation of material evidence at the scene until the forensic expert's arrival, due to the fragile state of LIB and its elements after the fire and explosion. In some cases, the study of these elements may indicate thermal phenomena that happened before the fire. Thus, the prompt implementation of the fire and technical examination at the fire site provides the best chances to determine the cause of the fire associated with the lithium-ion batteries.

могут возникнуть с некачественной продукцией;

- разработка и внедрение экспертной методики расследования пожаров, связанных с возгоранием литий-ионных аккумуляторных батарей, в экспертных и следственных подразделениях полиции и МЧС позволят устанавливать причину возгорания, очаг пожара и механизм его протекания;

- разработка и внедрение эффективных материалов и методов тушения литиевых аккумуляторов помогут в значительной мере уменьшить время тушение пожара, не допустить повторного возгорания, тем самым сохранить материальное имущество и человеческие жизни.

Ключевые слова: литий-ионные аккумуляторы, возгорание, электровелосипеды, стандарт качества, расследование пожаров, очаг пожара.

On figure 2 the scatter of the electric bicycle battery elements after the fire is shown.

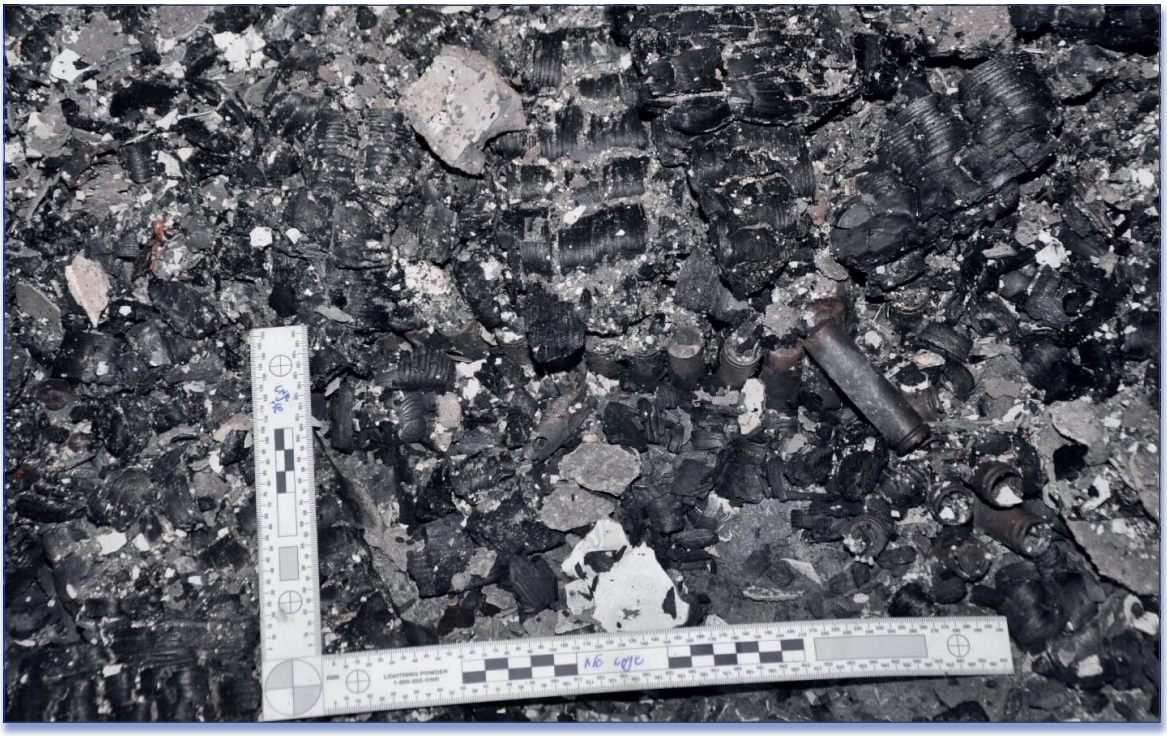

Figure 2. Parts of the lithium-ion battery of the electric bicycle after its fire and explosion.

One of the main problems in the struggle against the fire of LIB is the problem of extinguishing these fires.

In accordance with National Fire Protection Association (NEPA), fires fall into several categories. The fire classification of lithium-ion batteries varies. The LIB is used as an energy source, and a fire may occur due to a malfunction of the electrical device (charger). In such cases, the fire caused by the lithium-ion battery can spread and ignite nearby materials and cause enormous damage.

Extinguishing fire, caused by the lithium-ion battery fire, refers to both extinguishing an open flame and reducing the temperature of the battery. If the battery temperature is high enough after extinguishing the open flame, there is still a chance that the battery could ignite again .

In 2013, the Fire Protection Research Foundation (USA), tested LIB ignition on full-scale model cars. In one of the tests, the battery re-ignited 22 hours after extinguishing the open flame .

There are four main approaches to extinguishing the typical fire: isolation method, suffocation method, cooling method, and chemical suppression method. The fire caused by the lithium-ion battery is not a typical fire because at least part of it consists of direct reactions between the battery and its constituents. These reactions do not require external oxygen.

Although the extinguishing this type of fire with water at the moment is the main method of extinguishing, since water also extinguishes the

Р. Перцев

ПОЖЕЖНО-ТЕХНІЧНІ АСПЕКТИ, ПОВ'ЯЗАНІ ІЗ ЗАЙМАННЯМ ЛІТІЙ-ІОННИХ АКУМУЛЯТОРНИХ БАТАРЕЙ

Останніми роками спостерігається світовий перехід на більш екологічні різновиди енергії, пов'язано це передусім із забрудненням атмосфери, а також із пошуком дешевшого енергетичного ресурсу транспортної системи.

Літій-іонні акумулятори стають повсюдним явищем у сучасному суспільстві та присутні у всьому: від великомасштабних систем зберігання сонячної енергії, а також пристроїв меншого розміру, як-от ноутбуки та телефони, до гібридних та електричних транспортних засобів.

Ця стаття спрямована на те, щоби зрозуміти, як літій-іонні акумуляторні технології сприяють збільшенню ризику виникнення пожежі через займання або вибух літій-іонних акумуляторних батарей у разі їхнього використання, зокрема, в електровелосипедах. У статті розібрані складнощі з'ясування та розслідування обставин цього займання та те, що можна зробити для його запобігання на законодавчому рівні.

open flame and cools the battery cells, thereby preventing re-ignition from happening. But we should not forget that to extinguish this type of fire with water takes much more water and time than conventional fire extinguishing, not connected with LIB, and also the water is a good electricity conductor, which is also should be taken into account.

The search for an optimal reagent for fire extinguishing of the lithium-ion batteries, which does not emit gases harmful to humans during the extinguishing process, and does not allow the resumption of re-ignition, will require further research efforts .

Another significant factor, which leads to the LIB fire, is the absence in many countries, of the specific government quality and safety standards of these products manufacturing and inspection, as well as its certification.

At the current time, citizens, who want to reduce the cost of buying battery or a charger, buy it via the Internet or try to put the LIB together for the electric bicycle by their own efforts. In many cases, such products may not meet quality and fire safety standards.

In such a way, in the USA, since 2020, the voluntary ANSI / CAN / 2849 safety standard for electric bicycles. The Standard UL 2849 is the national standard, accredited by the American National Standards Institute (ANSI) and Standards Council of Canada (SCC) in the USA and Canada . This standard proposes certification for the electrical and fire safety of electric bicycles by examining the combinations of an electric drive system, the battery system, and the charger system.

The European Union also has a quality standard for electric bicycles EN15194. The European standard applies to electric bicycles for private and commercial use, with the exception of electric bicycles that are rented from an automatic station. The standard specifies the requirements and test methods for engine power control systems, electrical circuits, including a charging system, for the design and assembly of electric bicycles and assembly units for systems with rated voltages up to 48 V .

The Standards Institution of Israel also uses the European Union Quality Standard EN15194, which establishes safety requirements and test methods for evaluating the design and assembly of bicycles with a supporting electric motor and additional rules for battery-powered systems .

Conclusions. The aforementioned indicates that with the increased use of the lithium-ion batteries in daily life, there is a sharp increase in the number of fires and ignitions associated with their use.

In this regard, supervisory authorities should develop and adopt legislative and regulatory and technical standards to counter this type of fire:

- it is necessary to strengthen state control over the production and supply of products with lithium-ion batteries, which have to meet quality standards and undergo appropriate certification. Such actions should prevent possible technical problems that may arise in low-quality products;

- development and implementation of the expert methodology for investigating fires associated with the ignition of lithium-ion batteries in the expert and investigative departments of the police and the Ministry of Emergency Situations will make it possible to establish the cause of the fire, the source of the fire and the mechanism of its process;

- development and implementation of effective materials and methods for extinguishing lithium batteries will help to significantly reduce the time taken to extinguish the fire, prevent re-ignition, thereby preserving material property and human lives loss;

Summing up, it is worth noting that with the increase in use of hybrid and electric vehicles, the environmental situation also improves, but the use of low-quality products and non-compliance with fire safety rules can lead to serious consequences.

У статті наведено огляд ситуації з пожежами, причиною яких є електровелосипеди, у Китаї, Сінгапурі, а також Ізраїлі. Наведено приклади країн Європейського Союзу, а також США та Ізраїлю, у яких були прийняті стандарти якості та безпеки щодо експлуатації електровелосипедів.

Розглянуті докладні причини виникнення цієї проблеми, запропоновані такі можливі законодавчі та науково-технічні дії для запобігання та розслідування цього різновиду займань:

- посилення державного контролю за виробництвом та постачанням продукції з літій-іонними акумуляторними батареями, які мають відповідати стандартам якості та проходити відповідну сертифікацію. Такі дії мають запобігти можливим технічним проблемам, які можуть виникнути з неякісною продукцією;

- розроблення та впровадження експертної методики розслідування пожеж, пов'язаних із займанням літій-іонних акумуляторних батарей, в експертних та слідчих підрозділах поліції та МНС, дадуть змогу встановлювати причину займання, осередок пожежі та механізм його протікання;

- розроблення та впровадження ефективних матеріалів та методів гасіння літієвих акумуляторів допоможуть значною мірою зменшити час гасіння пожежі, не допустити повторного займання, тим самим зберегти матеріальне майно та людські життя.

Ключові слова: літій-іонні акумулятори, займання, електровелосипеди, стандарт якості, розслідування пожеж, осередок пожежі.

R. Pertsev

BRANDTECHNISCHE ASPEKTE, DIE MIT DEM ENTZÜNDEN VON LITHIUM-IONEN-AKKUMULATOREN-BATTERIEN VERBUNDEN SIND

In den letzten Jahren hat sich weltweit eine Umstellung auf umweltfreundlichere Energieformen vollzogen, das ist vor allem mit der Luftverschmutzung sowie der Suche nach billigeren Energieressourcen des Verkehrssystems verbunden.

Lithium-Ionen-Akkumulatoren werden in der modernen Gesellschaft allgegenwärtig und sind in allen Bereichen vorhanden: von großen Solarspeichersystemen sowie kleineren Geräten wie Laptops und Telefonen bis hin zu Hybrid- und Elektrofahrzeugen.

Dieser Artikel zielt darauf ab, zu verstehen, wie Lithium-Ionen-Akku-Technologien die Brandgefahr durch Entzündung oder Explosion von Lithium-Ionen-Akkumulatoren erhöhen, wenn sie insbesondere in Elektrofahrrädern verwendet werden. Schwierigkeiten, die Umstände dieses Brandes herauszufinden und zu untersuchen und was auf gesetzgeberischer Ebene getan werden kann, um ihn

zu verhindern. Die Schwierigkeiten, die Umstände dieses Entzündens herauszufinden und zu untersuchen, und was auf gesetzgebender Ebene getan werden kann, um es zu verhindern, werden erörtert.

Der Artikel gibt einen Überblick über die Situation bei Bränden durch Elektrofahrräder in China, Singapur und Israel. Es werden Beispiele für Länder Europäische Union, USA, und Israel gegeben, in denen Qualitäts- und Sicherheitsstandards für die Nutzung von Elektrofahrrädern angenommen wurden.

Die detaillierten Ursachen dieses Problems werden betrachtet, die folgenden möglichen gesetzgebenden und wissenschaftlich-technischen Maßnahmen zur Vorbeugung und Untersuchung dieser Art vom Entzünden werden angeboten:

- Stärkung der staatlichen Kontrolle über die Herstellung und Lieferung von Produkten mit Lithium-Ionen-Akku-Batterien, die Qualitätsstandards erfüllen und eine entsprechende Zertifizierung durchlaufen müssen. Solche Maßnahmen sollten mögliche technische Probleme verhindern, die mit minderwertigen Produkten auftreten können;
- Entwicklung und Einsatz der Expertenmethodik zur Brandermittlung im Zusammenhang mit der Entzündung von Lithium-Ionen-Akku-Batterien in Experten- und Ermittlungseinheiten der Polizei und des Katastrophenschutzministeriums ermöglichen es, die Brandursache, den Brandherd und den Mechanismus seines Ablaufs zu ermitteln;
- Entwicklung und Einsatz wirksamer Materialien und Methoden zur Löschung von Lithiumakkumulatoren helfen die Dauer der Brandbekämpfung erheblich verkürzen, Neuzündungen verhindern und dadurch Sachwerte und Menschenleben retten.

Schlüsselwörter: Lithium-Ionen-Akkumulatoren, Entzünden, Elektrofahrräder, Standard der Qualität, Brandermittlung, Brandherd.

R. Pertsev

INCENDIE ET ASPECTS TECHNIQUES LIÉS À L'ALLUMAGE DES BATTERIES LITHIUM-ION.

Ces dernières années, il y a eu une évolution mondiale vers des types d'énergie plus respectueux de l'environnement, principalement en raison de la pollution de l'air, ainsi que de la recherche de ressources énergétiques moins chères pour le système de transport.

Les batteries lithium-ion deviennent omniprésentes dans la société moderne et sont présentes dans tout, des systèmes de stockage solaire à grande échelle aux appa-

References

Mordor Intelligence, Lithium-ion battery market - Growth, Trends, Covid-19 Impact, and Forecasts (2021-2026). URL: https://www.mordorintelligence.com/industry-reports/lithium-ion-battery-market [in English].

Fire Analysis Report, Fires Involving Batteries of Electric Bicycles, Personal Mobility Devices, Powerbanks and Laptops (2008 – 2015), Volume 2, Issue 1 / August 2016. URL: https://www.scdf.gov.sg/docs/default-source/scdf-library/far-issue-3---21-feb-2017.pdf [in English].

Israel Fire and Rescue Service, Charging an unattended lithium battery is dangerous. URL: https://www.gov.il/he/departments/general/lithium_batteries [in Hebrew].

E-Lyte Innovations 2021, The working principle of the lithium-ion battery. URL: https://e-lyte-innovations.de/working-principle-lithium-ion-battery/ [in English].

Bike Europe, Jack Oortwijn. Underrated E-Bike Battery Fire Hazards Call for Attention on Safe Storage, 6 Feb 2018. URL: https://www.bike-eu.com/home/nieuws/2018/02/underrated-e-bike-battery-fire-hazards-call-for-attention-on-safe-storage-10132804 [in English].

London Fire Brigade, Safety warnings, Fire investigators issue urgent warning over fires involving e-bike batterie, sLast updated: 1.07.21. URL: https://www.london-fire.gov.uk/news/2021-news/july/fire-investigators-issue-urgent-warning-over-fires-involving-e-bike-batteries/ [in English].

China Daily, Hou Liqiang. Official calls for upgrade on electric bike standards, Updated: May 19, 2018. URL: http://english.www.gov.cn/state_council/ministries/2018/05/19/content_281476152688088.htm [in English].

Singapore Civil Defence Force, Fire, Emergency Medical Services and Fire Safety Enforcement Statistics 2020. URL: https://www.scdf.gov.sg/docs/default-source/scdf-library/amb-fire-inspection-statistics/scdf_annual_statistics_2020.pdf [in English].

Firefighting and Rescue Service of Israel. How to conduct a fire investigation. URL: https://www.gov.il/he/departments/guides/investigation_procedure?chapterIndex=3 [in Hebrew].

Wang Q., Mao B., Stoliarov S., Sun J. A review of lithium-ion battery failure mechanisms and fire prevention strategies, Progress in Energy and Combustion Science Volume 73, July 2019, Pages 95-131. doi.org/10.1016/j.pecs.2019.03.002 [in English].

Yezheleva E.E., Melnik A.A., Eliseev Yu. N., 2021. Investigation of fires associated with the ignition of lithium-ion storage batteries in transport // Scientific and analytical journal: "Siberian fire and rescue bulletin" № 1 (20). doi: 10.34987/vestnik.sibpsa.2021.20.1.008 [in Russian].

Logunovic D., Auto. Onliner, Experts told why electric bicycles light up, 25.06.21. URL: https://auto.onliner.by/2021/06/25/eksperty-rasskazali-iz-za-chego-zagorayutsya-elektrovelosipedy [in Russian].

Skrader Y., Mivzak Leyv-news: An apartment in Beer Ya'akov burned down due to a malfunction of an electric bike, a person was seriously injured, 11.07.21. URL: https://www.mivzaklive.co.il/archives/457655 [in Hebrew].

Grewal D., PhD, P.E. Rechargeable lithium battery fire risks, Fathom Engineering, Jan. 14, 2020, Marin Water. UPL: https://www.marinwater.org/search/content?keys=Rechargeable+lithium+battery+fire+risks [in English].

Kong L., Li Ch, Jiang J. and M.l G., 2018. Pecht Li-Ion Battery Fire Hazards and Safety Strategies, Energies, 11, 2191; doi:10.3390/en11092191 [in English].

Long, R.T.; Blum, A.F.; Bress, T.J.; Cotts, B.R., 2013. Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results; National Fire Protection Research Foundation: Quincy, MA, USA. URL: https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Electrical/EV-BatteriesPart-1.ashx [in English].

Wang Q., Mao B, Stoliarov S., Sun J. A review of lithium-ion battery failure mechanisms and fire prevention strategies, Progress in Energy and Combustion Science Volume 73, July 2019, Pages 95-131. doi.org/10.1016/j.pecs.2019.03.002 [in English].

Evaluating the safety of next generation micromobility. e-Bikes Certification – UL 2849. URL: https://www.ul.com/services/e-bikes-certification-ul-2849 [in English].

Cycles - Electrically power assisted cycles - EPAC Bicycles,4-OCT-2017, EN 15194:2017. URL: https://standards.iteh.ai/catalog/standards/cen/c9b5ac0f-0728-4674-b9ab-73f4bb33f932/en-15194-2017 [in English].

The Standards Institution of Israel, Bicycles: Electrically Power Assisted Bicycles-(EPAC Bicycles) - Safety Requirements and test Methods, EN 15194. URL: https://www.sii.org.il/he/bicycles [in Hebrew].

Received by Editorial Board: 16.09.2021

Suggested Citation:

Pertsev, R., (2021). Fire and Technical Aspects Related to Fire of Lithium-Ion Batteries. Archives of Criminology and Forensic Sciences. 2(4). 52-59. DOI: https://doi.org/10.32353/acfs.4.2021.04

reils plus petits tels que les ordinateurs portables et les téléphones en passant par les véhicules hybrides et électriques.

Cet article vise à comprendre comment les technologies rechargeables lithium-ion augmentent le risque d'incendie dû au feu ou à l'explosion des batteries lithium-ion lorsqu'elles sont utilisées, notamment, dans les vélos électriques. Difficultés à connaître et à enquêter sur les circonstances de cet incendie et ce qui peut être fait pour l'empêcher au niveau législatif.

L'article donne un aperçu de la situation des incendies causés par les vélos électriques en Chine, à Singapour et en Israël. Des exemples sont donnés de pays (États-Unis, Union européenne et Israël) dans lesquels des normes de qualité et de sécurité liées au fonctionnement des vélos électriques ont été adoptées.

Les causes détaillées de ce problème sont examinées, des actions législatives, scientifiques et techniques possibles pour la prévention et l'investigation de ce type d'incendies sont proposées:

– il est nécessaire de renforcer le contrôle de l'État sur la production et la fourniture de produits avec des batteries lithium-ion, qui doivent répondre à des normes de qualité et faire l'objet d'une certification appropriée. De telles actions devraient éviter d'éventuels problèmes techniques pouvant survenir avec des produits de qualité inférieure;

– élaboration et la mise en œuvre de méthodes d'expertise pour enquêter sur les incendies liés à l'allumage de batteries lithium-ion dans les unités d'expertise et d'enquête de la police et du ministère des Urgences, établiront la cause de l'incendie, la source de l'incendie et son mécanisme ;

– développement et l'introduction de matériaux et de méthodes efficaces d'extinction des batteries au lithium permettront de réduire considérablement le temps d'extinction des incendies, de ne pas tolérer les allumages répétés, ce qui permettra de sauver des biens matériels et des vies humaines.

Mots-clés: batteries ion-ion, incendie, vélos électriques, norme de qualité, enquête incendie, incendie.