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DETERMINATION OF FIRE PROTECTION DISTANCES DURING A TESLA MODEL S FIRE IN A CLOSED PARKING LOT

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This study modelled an electric vehicle fire on the example of a Tesla Model S (USA) in a closed car park. Such fires pose an increased danger due to their rapid spread, the presence of a large number of vehicles, the release of toxic combustion products and heavy smoke. In fact, the rapid spread of a fire in a closed car park is caused by unreasonably small distances between vehicles. Thus, the purpose of the study was to determine the minimum fire protection distances due to an electric vehicle fire in a closed car park using the example of Tesla Model 3.

For this purpose, the objects and their physical characteristics were described, input and environmental parameters were set, and a mathematical model of the dynamics of fire development was formed. This made it possible to establish the minimum fire protection distance during the free development time of 610 s for an electric vehicle fire in a closed car park, which is 10 m along the flank and 6 m along the front. The difference in fire protection distances on the flank and front is explained by the design features of the electric vehicle. That is, the flank area of the flame will be larger than the front of the burning electric vehicle, and therefore the heat radiation power will also be greater. The actual heat radiation power is the key factor affecting fire protection distances.

The results of the study can be used in the design of various types of car parks and the safe placement of vehicles in them. Fire protection distances between cars in enclosed car parks can be taken into account by insurance companies when assessing the risk of damage to cars due to fires. And also by fire and rescue units involved in extinguishing such fires, to ensure the safety of rescuers

Keywords: fire protection distance in a car park, FDS modelling of Tesla Model 3 fire, electric vehicle fire

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1. Introduction

Various sources of electrical energy can be used to power electric motors: power storage batteries, fuel cells, supercapacitors, etc.

Among all types of batteries, namely lead-acid, nickel-metal hydride, nickel-cadmium, lithium-ion batteries (LIB) have become the most common in electric vehicles [1].

There are different types of lithium-ion batteries used in electric vehicles. The cathode of lithium-ion batteries can be made on the basis of: lithium-manganese oxide (LiMn2O4), lithium-nickel-cobalt-manganese oxide ($LiNiMnCoO_2$), lithium-nickel-cobalt-aluminum oxide ($LiNiCoAlO_2$), lithium-ferric-phosphate oxide (LiFePO4) [2].

LIBs are widely recognized as advanced energy storage systems due to their increased power, high charge-discharge efficiency, and increased lifetime [3]. However, chemical and electrochemical processes lead to an uncontrolled exothermic reaction. Such reactions lead to an uncontrolled increase in temperature, emission of harmful and dangerous gases, ignition, explosions, which is often accompanied by fire and causes not only material damage, but also human casualties [4].

In work [5] it is stated that in South Korea during 2018–2021 there were 6 electric vehicle fires in closed parking lots, and it was noted that such events were of a dangerous nature. The work [6] describes the features of the ignition of the Tesla Model S while driving on the highway. And during the fire of the electric bus, 5 passengers received burns [7].

The authors of the work [8] describe possible explosions of lithium-ion batteries under certain operating conditions. In the work [9] it is indicated that most explosions of lithium-ion batteries occur during their charging or excessive discharge. In [10], the influence of design parameters of batteries on the possibility of explosion due to their improper operation was investigated. The authors of the work [11] describe that fires and explosions of lithium-ion batteries occur not only in electric vehicles, but also in air transport.

The paper [12] emphasized the danger of not only fires, but also mechanical damage due to the movement of elements of lithium-ion batteries during an explosion.

Thus, the use of lithium-ion batteries creates a serious concern for the public and outlines new challenges for the scientific community.

Therefore, comprehensive studies of fires and other fire-hazardous situations of electric mobs are extremely important. Newly developed and researched safety approaches will create a basis for reducing material damage and human casualties due to electric vehicle fires.

2. Literature review and problem statement

In general, the global fleet of electric and hybrid vehicles by the end of 2022 is more than 27 million [13]. In 2022 alone, more than 10.5 million such cars were sold (which accounted for 10 % of the total number of cars sold), which is 55 % more than in 2021 [14]. The model range of electric cars is represented by 450 different models, which is 5 times more than in 2015. At the same time, a number of countries will abandon the production of cars with internal combustion engines by 2030 [15, 16].

All these facts emphasize the prerequisites for the rapid development of electric cars. Fig. 1 shows the dynamics of the development of electric vehicles by region.

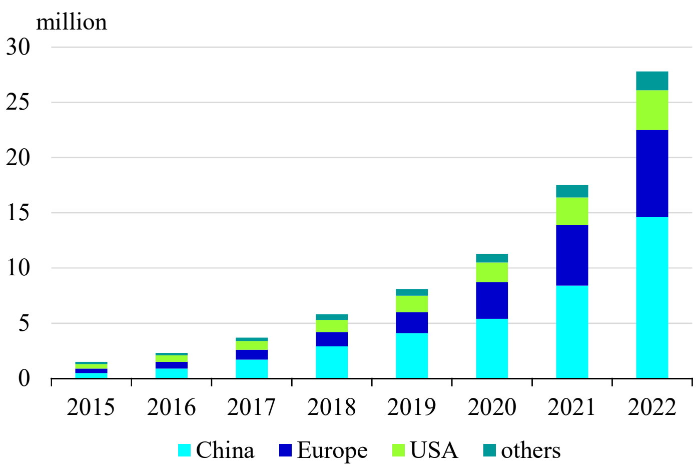


Fig. 1. Dynamics of the number of electric cars by world region

Most of such motor vehicles are concentrated in China, Europe and the USA, and among them passenger cars and buses are the most common.

According to studies [17, 18], the number of sales of electric cars in the European Union will increase to 7 million annually by 2030, and the world fleet will exceed 120 million such cars [14]. This will lead not only to an increase in the number of parking zones and closed parking lots, but also to an increase in the number of fires in electric vehicles and such facilities. It is often difficult to identify the cause that initiated the ignition of the vehicle [19].

Considering this trend, the world scientific community devotes a lot of research to the problem of electric vehicle fires, including in closed parking lots.

The paper [20] gives the results of studies of an electric car fire in a closed parking lot using the Fire Dynamic Simulator. The distribution of visibility at a height of 1.8 m above the floor of a closed parking lot, as well as the temperature distribution under the ceiling during an electric car fire, were actually investigated. However, the work did not investigate how the temperature fields spread in the horizontal direction, from which conclusions can be drawn about safe fire distances.

The authors of the paper [21] conducted an experimental study to determine the spread of fire from an electric vehicle to other vehicles placed in parallel. It was established that the jet flame from the burning electric car reached a length of more than 2.5 m. And already 94 minutes after the start of the fire test, the parallel parked car ignited. Such a long ignition time of the neighboring car can be explained by the fact that the experiment was conducted in an open area, and a lot of heat was dissipated into the environment. This work reveals the fire dynamics of parallel parked electric cars. It was established that the placement of the safety valve affects the duration and length of the jet flame, which is decisive when the fire spreads to nearby vehicles.

In [22], the factors affecting pedestrians during a fire of an electric vehicle in an open parking lot were investigated. However, in this study, it was assumed that the heat flow that was released was only 1/3 of the possible heat flow with a fully charged electric vehicle battery. Therefore, the safe distance for pedestrians is only 2.8 m from a burning electric car at a speed of air flows of 2.2 m/s. And the safe distance for parallel parked vehicles is 3 m, taking into account the above conditions.

The authors of the work [23] conducted full-scale fire tests of electric vehicle fires in road tunnels. This study is focused on the definition of harmful gases that are released as a result of a fire, as well as on methods of extinguishing such fires. It was established that hydrogen fluoride is the most dangerous combustion product resulting from electric vehicle fires. However, concentrations exceeding the threshold value for human health were found only in the smoke layer at relatively high altitudes. At a height of 1.6 m above the roadway, the recorded concentration levels remained below the threshold values. Fire protection distances under such conditions were not investigated, since there are no parking zones in road tunnels.

The paper [24] provides an assessment of the safety of a closed parking lot during an electric vehicle fire. It was established that already 80 seconds after the start of the fire, the cloud of combustion products has a size of more than 20 m in diameter. However, despite the cloud of combustion products, according to the authors, evacuation from a closed parking lot is possible.

The authors of the paper [25] investigated the impact of car fires on steel building structures of open parking lots. The work established that the location and number of burning cars affects the maximum heating temperature of metal building structures. However, the fire parameters of electric vehicles were not taken into account.

In work [26], a study was conducted using CFD modeling to determine the amount of combustion products, as well as the heat released as a result of a fire in a closed parking lot. The source of the fire was modeled as spilled fuel measuring 3 m by 1.5 m and having a power of 5 MW. It was established that in order to ensure a visibility of 15 m behind a closed parking lot during a fire, it is necessary to provide an air exchange of 300,000 m^3/h at a speed of 1.1 m/s. Moreover, due to the presence of longitudinal beams, the air exchange should be increased by 20 % in a loft with a flat ceiling.

The study [27] concerned the fire of e-bikes in the basement of a multi-story building, which is similar to a closed parking lot. As a result of the CFD modeling, it was determined that the combustion products of the fire from the five e-bikes, which were located in the basement, would reach the 10^{th} floor of the building. However, fire protection distances were not investigated in this scientific work.

In work [28], a study of the development of a fire in an underground parking lot was conducted. However, this study is focused on determining the concentration of harmful gases released as a result of a fire, as well as the evacuation time from an underground parking lot. On the basis of modeling, it was established that in case of a fire at a distance of 5 m from the escape exit, the visibility decreases to 2 m in just 15 s, and the concentration of CO, which is fatal for a person, is reached in 240 s.

In the work [29], the dangers of fire development in a closed underground parking lot are thoroughly described. The Fire Dynamics Simulator program was used for calculations. In this study, it was established that secondary hydrogen poses a particular danger during a fire of electric vehicles in a closed underground parking lot. Under such conditions, the concentration of secondary hydrogen can exceed the lethal concentration for humans by 2 times.

As the analysis of scientific works shows, insufficient attention is paid to the study of fire protection distances in closed parking lots in the event of an electric vehicle fire. This gives grounds for asserting the expediency of conducting research of this kind.

3. The aim and objectives of the study

The aim of the study is to determine the minimum fire protection distances due to an electric car fire in a closed parking lot using the Tesla Model 3 as an example. This will provide an opportunity to create an idea of the spread of such fires in closed parking lots, as well as to minimize damage from them.

To achieve the aim, the following objectives were solved:

– to describe the dynamics and peculiarities of the development of electric vehicle fires;

– to simulate a Tesla Model 3 electric car and conduct a study of the temperature field in a closed parking lot, which will cause it to catch fire.

4. Materials and methods of research

4. 1. The object and hypothesis of the study

The object of this study is the fire of a Tesla Model 3 electric car in a closed parking lot.

The hypothesis of the research consisted in the simulated fire of an electric car according to the scenario where the fire develops freely during the entire simulation time (610 s).

The main task during the development of a mathematical model is the maximum approximation of the parameters of the model to the conditions of the process under investigation.

During the mathematical description of the geometric boundary conditions, the shape and linear dimensions of the electric vehicle were set to the scale of the relevant local conditions and the distance between the objects was observed.

The following assumptions were made during the evaluation of fire protection distances using calculation methods:

– the temperature of the flame is assumed to be the same over the entire surface;

– the temperature of substances or materials that perceive heat from a fire in an adjacent object is assumed to be equal to 20 °C at the initial moment of calculation;

The following environmental conditions are accepted:

– air temperature 20 °C, atmospheric pressure 1 atm, wind speed 0 m/s;

– the thermal effect of a fire on an adjacent object is determined due to thermal radiation, the convective component is not taken into account;

– in the absence of data, the degree of blackness of the flame (εf) is taken as equal to (εf)=1, and the degree of blackness of the surface of the material or substance that perceives heat from the fire is taken as equal to εm=0.8;

– the cause of the fire is not considered.

During the simulation, the wind effect is not taken into account, as it creates a decrease in the density and uniformity of the heat flow and reduces the height of the fire flame.

The minimum duration of the simulation (610 s) is based on the arrival time of the fire-rescue units at the scene of the fire (500 s), as well as taking into account the additional time (110 s) conditionally necessary for the deployment of the forces and means of the fire-rescue unit.

During the creation of the computer model of the electric car, the model of the Tesla Model S electric car was taken as a basis, with dimensions of 4976×1963×1435 mm (length, width, height), with a total weight of 2100 kg. The choice of this type of electric vehicle is due to the large capacity of the traction battery, currently used among passenger electric vehicles. The analysis of technical reports [30, 31] showed that it is extremely difficult to reproduce the complete design of lithium-ion batteries using FDS simulation. However, knowing the main components of the components of the combustion reaction of cathode materials, it is possible to reproduce the temperature regime of the combustion reaction.

4. 2. Methods of research

Simulation of the dynamics of fire development is carried out using the FDS (Fire Dynamics Simulator) computer program developed by the National Institute of Standards and Technology (NIST, USA) [32, 33].

The FDS program simulates fire scenarios using a computational fluid dynamics (CFD) model optimized for low-velocity temperature-dependent flows. This approach is very flexible and can be applied to a variety of fires, ranging from furnace fires to oil tanker fires. FDS implements a Computational Fluid Dynamics (CFD) model of heat and mass transfer during combustion, numerically solves the Navier-Stokes equation for low-speed temperature-dependent flows, with a special focus on smoke propagation and heat transfer during a fire. The main algorithm is a certain scheme of the predictor-corrector method of the second order of accuracy in terms of coordinates and time. Turbulence is performed using the Smagorinsky Large Eddy Simulation (LES) model. Direct Numerical Simulation (DNS) can be performed if the underlying grid is sufficiently accurate. Large-scale eddy simulation is the default mode.

In most cases, FDS uses a one-step chemical reaction, the results of which are transmitted through a two-parameter mixture fraction model. "Mixture fractions" as used herein is a scalar quantity that gives the mass fraction of one or more gas components at a given point in the flow. By default, two components of the mixture are calculated: the mass fraction of unburned fuel and the mass fraction of burned fuel (that is, combustion products). A two-stage chemical reaction with a three-parameter decomposition of a particle in a mixture is decomposed into one-stage reactions – oxidation of fuel to carbon monoxide and oxidation of monoxyl to dioxide. The three components in this case are the unburned fuel, the mass of fuel that completed the first step of the reaction, and the mass of fuel that completed the second step of the reaction. The mass concentration of all major reactants and products can be obtained using the "state ratio". A multistep reaction with a finite flow rate can also be used.

During the formation of the mathematical model of the dynamics of fire development, the following mathematical dependencies were used. In its usual form, the system of Navier-Stokes equations [34] consists of two equations: the equation of motion and the equation of continuity.

In vector form for an incompressible fluid, they are written as follows:

$$\frac{\partial \rho}{\partial t}+\nabla(\rho V)=0, \tag{1}$$

$$\frac{\partial}{\partial t}(\rho V)+\nabla[\rho V \otimes V]== -\nabla p+\nabla\left[(\mu+\mu_t)\left(\nabla V+(\nabla V)^T\right)\right]+S, \tag{2}$$

$$\frac{\partial}{\partial t}(\rho h)+\nabla(\rho V h)=\nabla\left(\left(\frac{\lambda}{c_p}+\frac{\mu_t}{\Pr_t}\right)\nabla h\right)+Q_{rad}, \tag{3}$$

$$\frac{\partial}{\partial t}(\rho Y_k)+\nabla(\rho V Y_k)=\nabla\left(\left(\frac{\mu}{\mathrm{Sc}}+\frac{\mu_t}{\mathrm{Sc}_t}\right)\nabla Y_k\right)+Q_k. \tag{4}$$

where t – time; ρ – density; V – relative velocity vector; p – relative pressure; μ – molecular dynamic viscosity; μ_t – turbulent dynamic viscosity; λ – thermal conductivity coefficient of the mixture; $\Pr_t$ – turbulent Prandtl number; Sc – Schmidt number; Sc_t – turbulent Schmidt number; Y_k – concentration of the k-th component of the combustion reaction.

4. 3. Establishing criteria for evaluating results

For calculations, a fire scenario was determined, namely, the ignition of an electric vehicle in a closed parking lot.

The minimum permissible height of the parking floor is adopted, which is 2.7 m. The walls and ceiling of the parking lot are made of monolithic concrete, there are no light openings and activation of fire protection systems in the room. The main task of the study is to determine the safe fire distances to cars located next to each other in the volume of a closed parking lot.

The criterion for acceptance of the calculated fire distance (R) is the condition that the calculated temperature (T_c) from the fire does not exceed the permissible temperature (T_p), i.e. $T_c \leq T_p$.

The critical material that is irradiated by the fire torch and is an indicator of the spread of the fire is plastic products of cars, namely the design of the bumper with a flash temperature T_p of 220 °C [26, 35].

Thus, the limit value of the temperature in the space, which should not exceed 220 °C, is adopted as a criterion for the calculated fire scenario.

5. Research results of the peculiarities of the development of electric vehicle fires and the determination of the minimum fire protection distances

5. 1. Results of data analysis of electric vehicle fires

It is obvious that fires in electric cars are of a different nature than fires in cars with internal combustion engines. This is due to the lack of fuels and lubricants such as gasoline, diesel, or LPG, as well as various types of combustible lubricants and other materials.

An electric car uses a number of systems that ensure the safety of the power battery and the car as a whole. This is the power battery management system (BSM), (charge/discharge control (SOC), battery capacity (SOH) and temperature (SOT) control), thermal fuses, as well as vent fuses to release excess pressure from the battery cell. Despite this, malfunctions often occur that cause an irreversible exothermic reaction that ends in a fire or even an explosion [36].

During an exothermic reaction, a large amount of heat, smoke, and harmful and flammable gases are released, including hydrogen peroxide, methane, ethane, and hydrogen [37–39].

Electric vehicle fires are capable of releasing more than 8 GJ of heat energy, and the power of heat release is about 7–8 MW. The specific heat of combustion for EVs is more than 30 MJ/kg, and for lithium-ion batteries this indicator is 45.9 MJ/kg, which is equivalent to the heat of combustion of flammable liquids such as gasoline and diesel fuel [40].

If to compare the fires of two vehicles with the most similar technical characteristics, one of which will be equipped with an internal combustion engine, and the other with an electric engine, then the power of heat generation during a fire of an electric car is up to 2 times higher than the power of heat generation of a car equipped with an internal combustion engine. At the same time, the time to reach the maximum power of heat generation for electric cars is 15–20 % shorter, compared to cars equipped with internal combustion engines. This indicates a more dynamic development of fires in electric vehicles [23].

5. 2. Modeling of the Tesla Model 3 electric car and investigation of the temperature field in a closed parking lot, which will cause it to catch fire

Fig. 2 shows a fragment of a closed parking lot, a created model of the Tesla Model 3 electric car and the location of other vehicles, to which the value of the safe fire distance is determined.

Based on the result of the fire simulation, temperature distributions and heat exchange between adjacent objects during an electric vehicle fire are determined. Based on the data [41], the average rate of heat release during the burning of lithium ion batteries is about 3 MW.

In addition to the battery, the fire load is: rubber – 118.4 kg (lower heat of combustion 33.52 MJ/kg); lubricants – 8.4 kg (lower heat of combustion 41.87 MJ/kg). And also finishing materials: polymer materials – 49.7 kg (lower heat of combustion 24.3 MJ/kg); Polyurethane foam – 32.6 kg (lower heat of combustion 47.14 MJ/kg); cellulose products – 6.1 kg (lower heat of combustion 13.4 MJ/kg); artificial leather – 14.2 kg lower heat of combustion (17.76 MJ/kg).

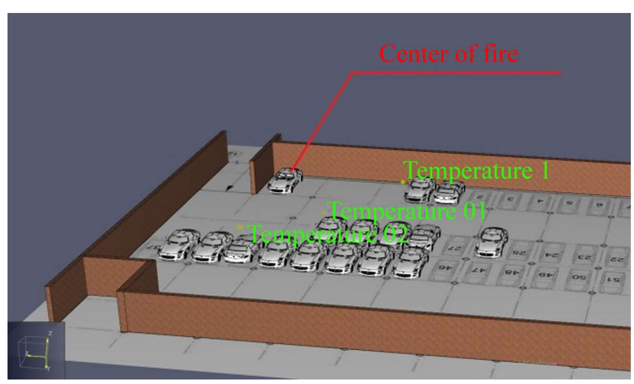


Fig. 2. A fragment of the created model of a closed parking lot and other vehicles placed in it

The initial chemical reaction of combustion consists of: C (carbon atoms) – 1.9; H (hydrogen atoms) – 40.0; O (oxygen atoms) – 2.6. CO emission is 0.015 and soot is 0.098. There is no reduction in burning intensity (self-extinguishing). The linear speed of flame propagation is 0.21 m/s.

Thus, the created model made it possible to reproduce the rate of heat release during the study of the combustion processes of lithium ion batteries in electric vehicles, which is shown in the graph of Fig. 3.

The results of a fire simulation in the event of an electric car catching fire in a closed parking lot were carried out in stages with an increase in the fire-fighting distance from the electric car to adjacent cars in steps of 0.5 m. The critical temperature value was determined based on the indicator of the flash temperature of the car bumper design with a value of 220 °C.

Based on the results of the simulation, a visualization of the distribution of temperature fields from an electric car fire in the middle of the parking lot during 480 seconds of the fire was obtained, which is shown in Fig. 4.

Starting from 300 s, the fire of the electric car begins to develop rapidly, the flame becomes clearly visible, the size of which increases. The temperature begins to rise rapidly, and the heat flow affects adjacent objects. 8 minutes (420 seconds) from the start of the fire test, the electric car is completely engulfed in flames.

At the time of the arrival of the fire and rescue units and their supply of fire extinguishing agents to extinguish the fire (610 s), the flame had already covered the nearby transport vehicle, which is located at a distance of 9.83 m (Fig. 5).

Based on the results of the simulation, it was established that the flank spread of the critical temperature of 220 °C as a result of an electric car fire under the given modeling conditions extends to a distance of up to 10 m. The frontal spread of temperature distributions within the range of up to 220 °C is up to 6 m. Taking into account that car parking can be both longitudinal and transverse, it is advisable to take the largest value of the fire protection distance, namely 10 m.

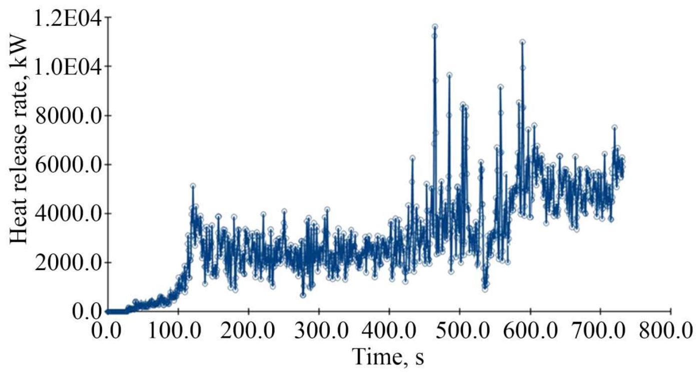
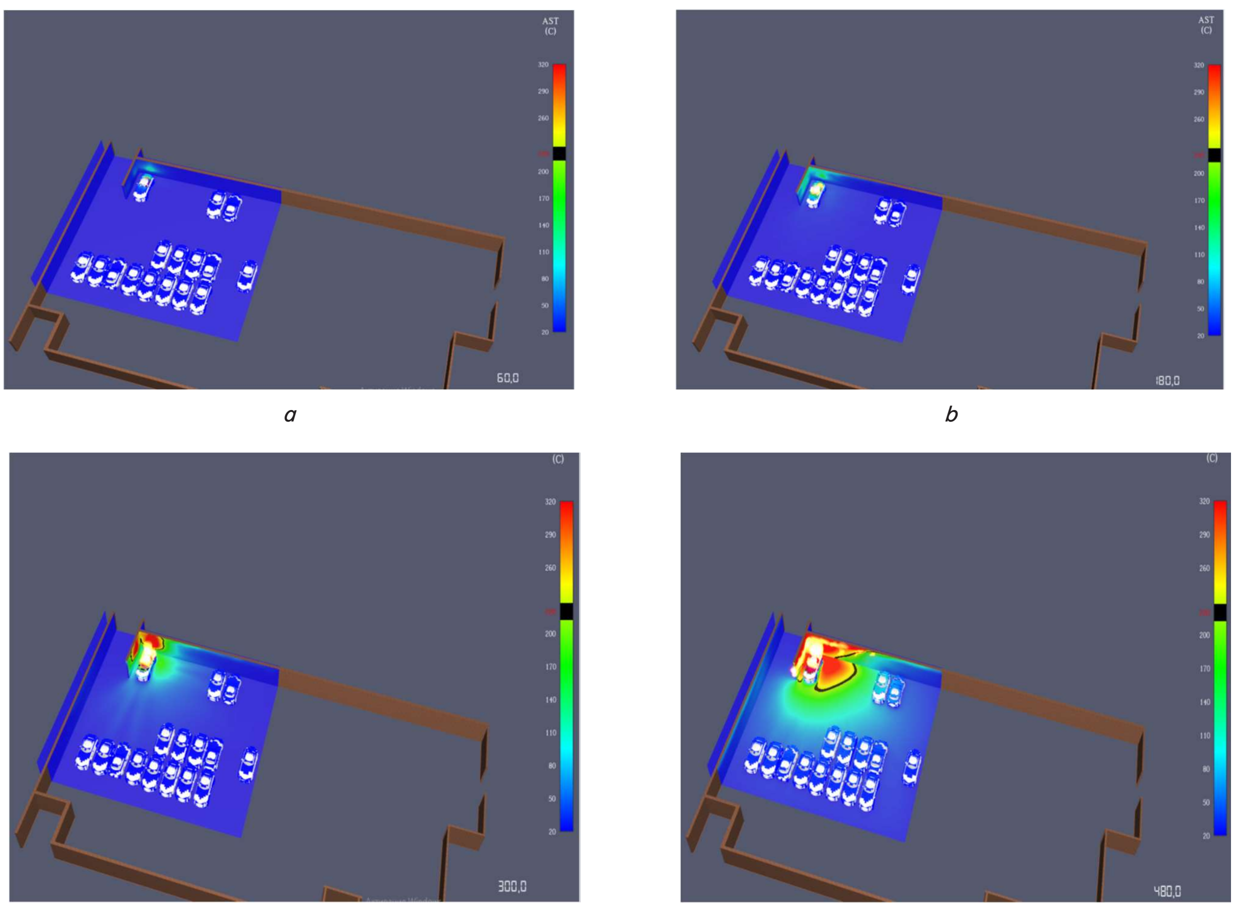


Fig. 3. Reproduced mode of heat release rate during the study of combustion processes of lithium ion batteries



a *b* *c* *d*

Fig. 4. Distribution of temperature fields from an electric car fire in a closed parking lot from the beginning of the test: *a* — 60 s; *b* — 180 s; *c* — 300 s; *d* — 480 s

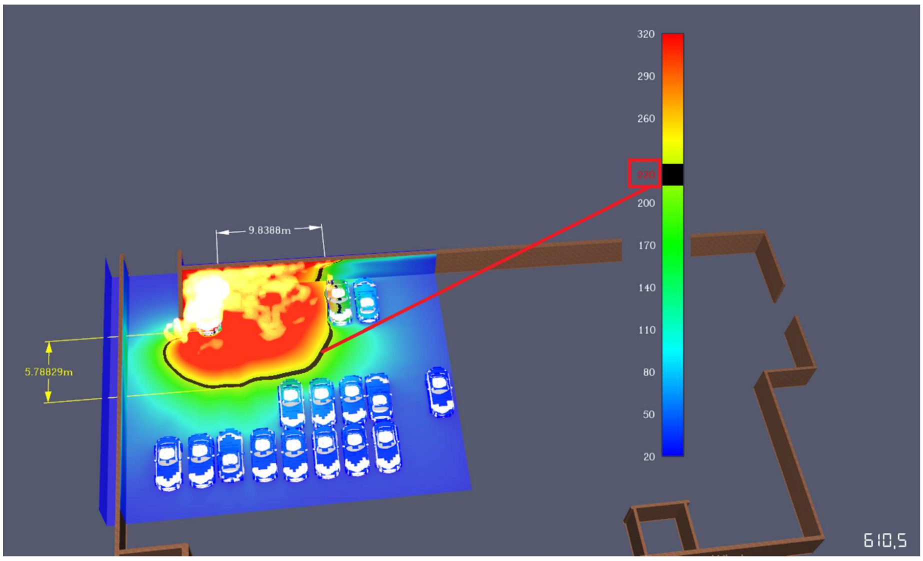


Fig. 5. Distribution of temperature fields from an electric car fire in a closed parking lot at 610 seconds

6. Discussion of the research results of the peculiarities of the development of electric vehicle fires and the determination of the minimum fire protection distances

According to the results of the study of data on electric vehicle fires, there are reasons to assert that electric vehicle fires are of a much more dangerous nature, compared to cars equipped with internal combustion engines. This is caused by a greater power of heat release, a more dynamic process of fire development, as well as the release of poisonous and explosive gases such as hydrogen fluoride, methane and hydrogen. Moreover, due to the formation of explosive gases due to the ignition of an electric car, an explosion may occur, with further consequences from it.

Based on the results of modeling the distribution of temperature fields in the closed parking lot due to the fire of the Tesla Model 3 electric car (Fig. 4), it was established that the critical temperature of 220 °C spreads to a distance of up to 10 m along the flank and 6 m along the front of the burning electric car at the time of arrival fire and rescue unit (Fig. 5). The difference in fire protection distances along the flank and front is explained by the design features of the electric vehicle. That is, from the side of the flank, the area of the flame will be larger than from the side of the front of the burning electric vehicle, which means that the power of thermal radiation will also be greater. This is due to the fact that the distance between vehicles in closed parking lots is within 0.5–0.8 m, which creates conditions for the fire to quickly and successfully spread to other vehicles even before the arrival of the fire and rescue unit.

Such values of the obtained results of fire-fighting distances are explained by the presence of a power battery, the capacity of which can reach 100 kWh or more, which creates a different nature of fire development compared to other similar vehicles equipped with internal combustion engines. This causes an increase in the power of heat radiation and the total energy of heat release due to fires of this kind.

It is obvious that the fire safety distances obtained in the study are not observed in closed parking lots. This is caused by a large number of vehicles, insufficient number of parking lots, including closed ones. This is especially true for large cities. At the same time, the security fundamentals take a backseat to commercial interests, but this can be costly in the long run. Thus, understanding the dynamics of the development and spread of fires of electric vehicles in a closed parking lot, as well as the provision of fire protection distances, will create a safe basis for everyone who uses such vehicles and eliminates events involving them.

The research results can be used in the design of various types of parking lots and for the safe placement of vehicles in them. Fire safety distances between cars in closed parking lots may be taken into account by insurance companies when assessing the risk of damage to cars due to fires. They should also be taken into account by fire and rescue units, which are involved in extinguishing such fires, to ensure the safety of rescuers.

This study covers the simulation of a Tesla Model 3 electric car fire in a closed parking lot. However, the fire of another electric vehicle with a different battery capacity will obviously give different thermal characteristics of the fire. This means that fire protection distances will be different. However, it is difficult to derive an average value for the thermal characteristics of electric vehicle fires. This is due to the wide variety of model series of electric cars, as well as the different origin of power battery components. Moreover, fuel cell electric vehicles use hydrogen, which creates yet another scenario for the development of such vehicle fires. Therefore, such features make it difficult to take into account all the factors that affect the dynamics of development and thermal characteristics of a fire.

Further research should be directed to deriving the correlation between factors such as: capacity of the power battery, its type, state of charge, type of vehicle, etc., on the power of heat generation and total heat generation due to electric vehicle fires.

7. Conclusions

1. The peculiarities of the development of fires in electric cars, which differ from fires in cars with internal combustion engines, are described. During a fire of an electric car, the power of heat release is up to 2 times higher than the power of heat release of a car equipped with an internal combustion

engine. The total heat release energy is 20 % higher. At the same time, the time to reach the maximum power of heat generation for electric cars is 15–20 % shorter, compared to cars equipped with internal combustion engines. This indicates a more dynamic development of fires in electric vehicles.

2. Using the Fire Dynamics Simulator, an EV fire simulation was carried out using the Tesla Model S car as an example. The criterion of not exceeding the maximum temperature value of 220 °C, which is the flash point of the car's plastic bumper, was adopted. On the basis of modeling, it was determined that the minimum fire-fighting distance during the time of free development of 610 s for an electric car fire in a closed parking lot is 10 m on the flank, and 6 m on the front. Taking into account that car parking can be both longitudinal and transverse, it is advisable to take the largest the value of the fire protection distance, i.e. 10 m.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other, that could affect the study and its results presented in this article.

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Data availability

The manuscript has no associated data.

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