STM JOURNALS

Journal of
Industrial Safety Engineering

ISSN: 2395-6674
Volume 12, Issue 2, 2025
May–August
DOI (Journal): 10.37591/JoISE

https://journals.stmjournals.com/joise

Research JoISE

The Assessment of Electric Vehicle Fire Risk Using the Failure Tree Analysis

Gharat Aryan Prashant[1], Dhruv Singh[1], Ankush Singh[1], Aryan Vyas[1], Anuj Meena[1], Pravin Tathod[2,*]

Abstract

With the global shift toward sustainable transportation, the widespread adoption of electric vehicles (EVs) is rapidly becoming a reality, largely driven by growing environmental awareness and concerns over climate change. However, alongside this transition comes a set of emerging challenges, most notably, the increasing incidence of EV-related fire hazards, which have attracted significant public and media scrutiny. This situation highlights the urgent need for a detailed and systematic approach to assessing and managing fire risks associated with electric vehicles. In this study, five primary factors contributing to EV fire incidents were identified: human-related errors, vehicle design and component issues, operational and organizational shortcomings, environmental influences, and unidentified or unexplained causes. A weighted average technique was utilized to estimate the yearly incidence of electric vehicle fires across different countries. The analysis yielded an average annual EV fire occurrence rate of 2.44×10^{-4} fires per registered electric vehicle, offering a meaningful risk benchmark for industry and regulatory bodies. As the electric vehicle market continues to expand, this research highlights the importance of data-informed approaches for assessing fire risks and developing preventive strategies. It also emphasizes the need for agile and informed response plans, especially for emergency services and first responders facing the unique challenges of EV-related fire incidents. Ultimately, the findings of this study contribute significantly to the broader understanding of electric vehicle safety and lay the groundwork for enhanced policy development and future technological safeguards.

Keywords: Electric vehicles (EVs), fire risk, risk assessment, EV safety, fire hazards, sustainable transportation, emergency response, component failure, statistical analysis, preventive strategies

INTRODUCTION

The increasing adoption of electric vehicles (EVs) in India has been accompanied by a noticeable rise in fire-related incidents, sparking growing concerns about the safety and preparedness of the nation's EV infrastructure. While EVs represent a transformative leap in the automotive sector, their safe integration into the transportation ecosystem presents significant challenges. A key area of concern lies in the lithium-ion batteries that power most electric vehicles.

These batteries, while advantageous due to their high energy capacity and extended driving range, are prone to thermal runaway, an uncontrollable increase in temperature, which can lead to fires, especially when exposed to extreme conditions such as overheating, overcharging, or physical damage.

***Author for Correspondence**
Pravin Tathod
E-mail: pravintathod@ipsacademy.org

[1]Student, Department of Fire Technology and Safety Engineering, Indore Professional Studies Academy, Institute of Engineering & Science, Indore, Madhya Pradesh, India
[2]Assistant Professor, Department of Fire Technology and Safety Engineering, Indore Professional Studies Academy, Institute of Engineering & Science, Indore, Madhya Pradesh, India

Received Date: April 23, 2025
Accepted Date: April 30, 2025
Published Date: May 05, 2025

Citation: Gharat Aryan Prashant, Dhruv Singh, Ankush Singh, Aryan Vyas, Anuj Meena, Pravin Tathod. The Assessment of Electric Vehicle Fire Risk Using the Failure Tree Analysis. Journal of Industrial Safety Engineering. 2025; 12(2): 27–38p.

Figure 1. Images of electric vehicle fires in India.

Several contributing factors further elevate the risk of EV fires, including insufficient battery management systems, defects during battery production, and inadequate or poorly maintained charging stations. The situation is exacerbated by the lack of comprehensive, EV-specific safety regulations and enforcement mechanisms in India. Moreover, combating EV fires poses unique difficulties, as lithium-ion batteries can reignite after being extinguished, requiring specialized firefighting training and equipment.

To mitigate these risks, multiple initiatives are currently in progress. These include the development of stricter safety norms, advances in battery engineering, and the enhancement of emergency response protocols. Effective collaboration among government bodies, vehicle manufacturers, and key industry stakeholders is vital to creating robust safety standards for the production, operation, and maintenance of electric vehicles. Public awareness campaigns and education on EV safety practices also play a crucial role in fostering responsible usage.

Despite the outlined safety concerns, the push towards electric mobility remains strong, driven by the environmental advantages and technological progress that EVs offer. However, ensuring the safety, reliability, and public confidence in these vehicles is essential to unlocking their long-term viability as a sustainable transportation solution in India (Figure 1) [1–4].

LITERATURE REVIEW

A study published in Urban Science explored the multiple drivers influencing electric vehicle (EV) adoption across Australia. Using a descriptive analytical framework, it highlighted several crucial factors: supportive government policies and financial incentives, technological progress in EV systems, and public perception challenges such as range anxiety. Additionally, variables such as income disparities, urban versus rural location, environmental consciousness, availability of charging stations, and competitive pricing of EV models were identified as influential. The findings offer valuable insights for stakeholders aiming to accelerate sustainable transportation initiatives.

Another study focused on the safety risks associated with lithium-ion batteries used in electric and hybrid vehicles. It analyzed past incidents involving battery fires and investigated the chemical properties contributing to such hazards. The research examined safety protocols, international regulations, and protective technologies integrated by manufacturers. It emphasized the importance of proper fire prevention mechanisms, effective response strategies, and the necessity of training emergency responders to handle high-risk EV fire scenarios.

Further research addressed the prediction of thermal runaway, a critical failure mode in lithium-ion batteries. This study reviewed current battery technologies and outlined conditions that can trigger this hazardous event. A model was introduced to forecast potential thermal runaway situations, contributing to early detection systems and improved battery management strategies for electric vehicles.

SCOPE

This research project broadly investigates the causes, prevention strategies, and mitigation measures related to battery fires in electric vehicles. The key focus areas include:

Battery Chemistry and Design

- Studying different battery types such as lithium-ion and solid-state to evaluate their safety profiles.
- Enhancing battery architecture to reduce the probability of thermal runaway.
- Analyzing how aging and degradation impact battery fire susceptibility.

Thermal Management Systems

- Developing effective thermal regulation mechanisms to avoid overheating.
- Implementing cutting-edge cooling solutions for maintaining optimal battery temperatures.

Fire Detection and Suppression

- Designing systems to detect early signs of battery malfunction that could lead to fires.
- Researching fire suppression systems tailored to the unique characteristics of EV fires.
- Comparing various fire extinguishing materials and technologies for effectiveness.

Standards and Regulations

Supporting the formulation and refinement of national and international safety standards for electric vehicles.

Consumer Education and Awareness

- Promoting public knowledge about safe usage, charging, and maintenance practices.
- Providing clear safety guidelines and encouraging the use of certified service centers.
- Increasing consumer literacy on recognizing early signs of battery failure.

NOTABLE FIRE INCIDENTS INVOLVING ELECTRIC VEHICLES IN INDIA

This section outlines several reported EV fire incidents across different parts of India in 2022, reflecting the need for stronger safety mechanisms and oversight:

Ola S1 Pro: March 2022, Pune, Maharashtra

An Ola electric scooter burst into flames while parked. The company labeled the occurrence as an isolated thermal event.

Pure EV: April 2022, Chennai, Tamil Nadu

An electric scooter caught fire during operation. Though the rider remained safe, Pure EV launched a probe into the incident.

Okinawa: April 2022, Vellore, Tamil Nadu

A tragic incident where a scooter ignited while charging at home, resulting in two fatalities. Over 3,000 units were recalled to address battery concerns.

Jitendra EV: April 2022, Nashik, Maharashtra

A fire broke out in a transportation truck carrying electric scooters, likely due to a short circuit. Several units were damaged.

Gemopai: May 2022, Gujarat

A charging scooter ignited without causing injury. The manufacturer began an internal investigation to determine the cause.

Hero Electric: June 2022, Jaipur, Rajasthan

A Hero scooter caught fire while parked. The company responded by inspecting the case and categorizing it as an isolated event.

Tata Nexon EV: June 2022, Mumbai, Maharashtra

A parked Nexon EV ignited while charging. Tata Motors attributed the incident to an external electrical fault rather than a vehicle defect.

Mahindra e-Verito: August 2022, Delhi

An e-Verito vehicle from a government fleet caught fire while stationary. Mahindra assured the public of vehicle safety while investigating the cause (Figure 2).

PROBLEM FORMULATION AND METHODOLOGY

Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) is a hierarchical method that begins with a specific failure event and systematically examines the contributing factors that could lead to it. This graphical technique enables engineers and safety analysts to visualize the pathways that can lead to a particular undesired event, known as the "top event". By systematically tracing the logical relationships between various subsystems and components, FTA provides a comprehensive overview of how and why failures might occur [5–9]. FTA is especially valuable in areas such as risk assessment, system reliability evaluation, and safety engineering. It is frequently used to:

- Determine the root causes of critical system failures;
- Estimate the likelihood of specific adverse events;
- Enhance system design by identifying weak points; and
- Support decision-making in safety-critical industries like automotive, aerospace, and manufacturing.

The FTA process typically involves the following key steps:

- *Defining the top event:* This is the main failure or hazardous outcome under investigation (e.g., an electric vehicle battery fire).

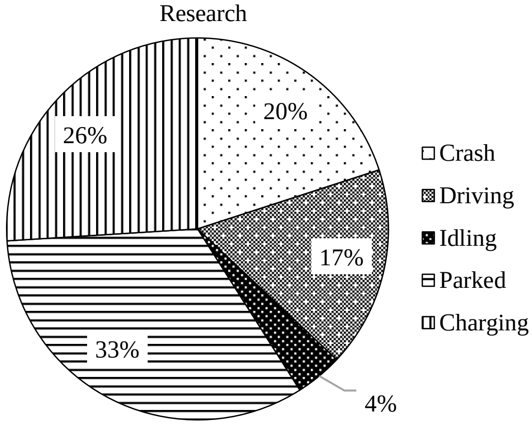

Figure 2. Situation when EV fire occurred.

- *Constructing the fault tree:* A logic-based diagram is built using gates (AND, OR, etc.) to connect various basic and intermediate events that could contribute to the top event.
- *Probability analysis:* With known probabilities for basic failures or faults, the overall likelihood of the top event can be calculated using Boolean logic and statistical methods.

Unlike bottom-up approaches such as Failure Modes and Effects Analysis (FMEA), which begin with individual component failures, FTA starts at the system-level failure and works downward. This allows FTA to account for complex interactions among components and helps identify combinations of failures that might otherwise go unnoticed.

In the context of electric vehicles, FTA can play a critical role in pre-emptively identifying scenarios that might lead to fire incidents. This approach allows designers and authorities to introduce effective safety enhancements or preventive actions, thereby minimizing the likelihood of widespread failures and costly recalls [10–13].

FTA Analysis

This risk assessment is based on the Fault Tree Analysis (FTA) methodology and covers qualitative, quantitative, and control aspects. In this study, the term "risk" specifically refers to the likelihood of vehicle fires and the potential spread of such fires across multiple vehicles (Figure 3). The evaluation is grounded in a thorough literature review and includes the following sources:

- Reports and case studies of significant EV fire incidents.
- Research on the characteristics and intensity of fires in both electric and internal combustion engine (ICE) vehicles.
- Data on fire occurrence rates in car parks for EVs, EV charging infrastructure, and ICE vehicles.
- Fire safety standards applicable to car parks and vehicles.
- Protocols for Fire Brigade interventions in car park fires.

The literature review involved examining publicly available sources and fire safety research but was constrained by the limited timeframe of the study. The intention was not to conduct an exhaustive or cutting-edge review. The study applied a systematic literature review methodology to ensure a structured, transparent, and replicable process for gathering and analysing the relevant research. This approach primarily relied on secondary data from sources such as conference proceedings, journal articles, books, and scientific reports (Figure 4).

EV Numbers in India

Graphical representations of the growth in EV numbers in India, based on digitalized vehicle records from the centralized Vahan-4 system, are depicted in Figure 5. The data illustrate a significant increase in EV numbers, rising from 124,681 in 2020 to 1,433,545 EVs in 2023. Additionally, Figure 5 highlights the changing ratio of EVs to total vehicles in India, which escalates from 0.0067 in 2020 to 0.0631 in 2023. However, it is noteworthy that the proportion of electric vehicles remains relatively low compared to petrol and diesel vehicles. This is attributed to factors such as the availability of less efficient batteries in India and recent fire incidents (Figure 5).

EV Fires in India

The rise in electric vehicle (EV) fires in India has raised safety concerns, particularly with recent high-profile incidents. For example, a high-end Volvo C40 Recharge SUV caught fire while traveling on a highway in Chhattisgarh (Economic Times), and a compact electric car, possibly a Mahindra E20, erupted in flames on the streets of Bengaluru (The Times of India). Additionally, the Tata Nexon EV experienced its first fire incident (The Times of India), and the battery of an electric two-wheeler exploded while charging in Delhi. These incidents highlight the urgent need for stricter safety regulations and improved safety protocols for EVs in India.

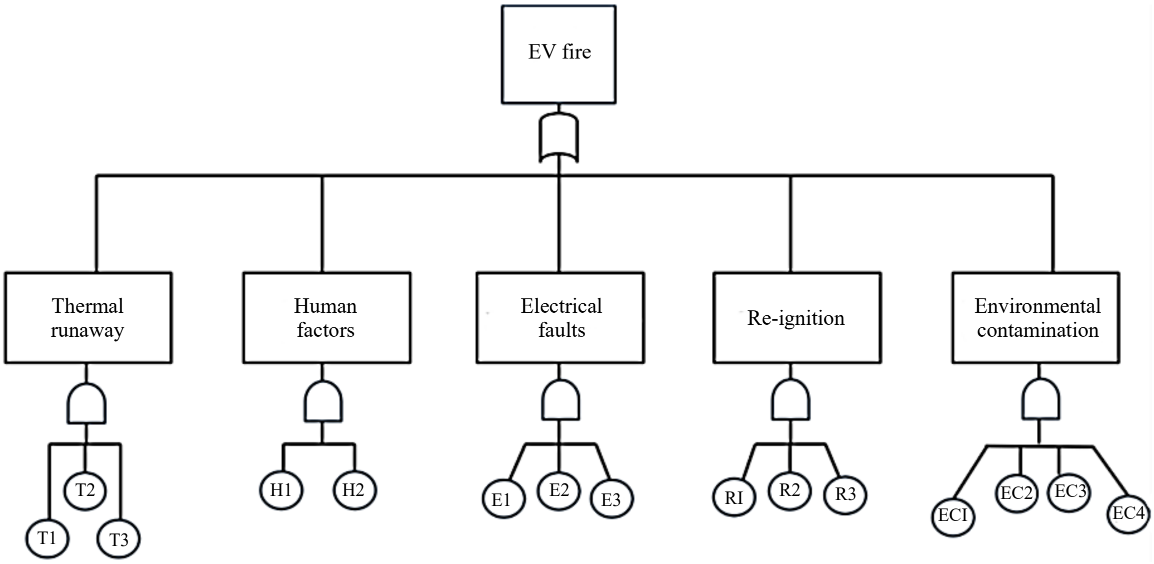

Figure 3. Fault tree analysis of EV vehicles fire.

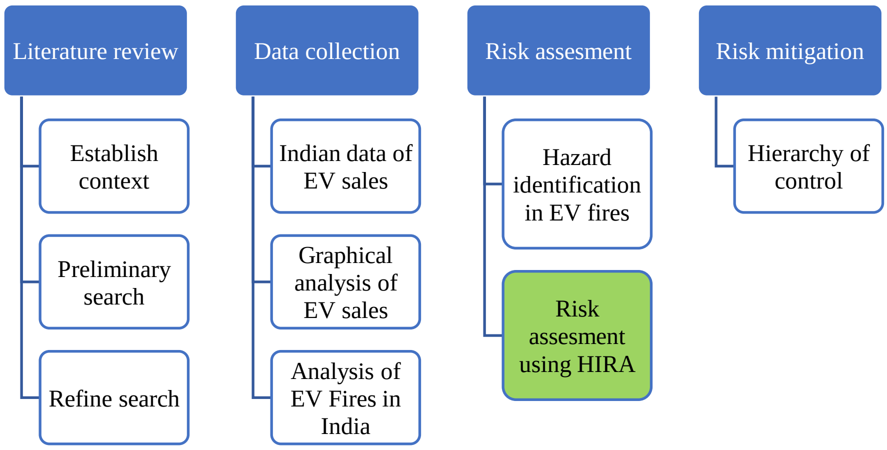

Figure 4. Steps of mitigation framework.

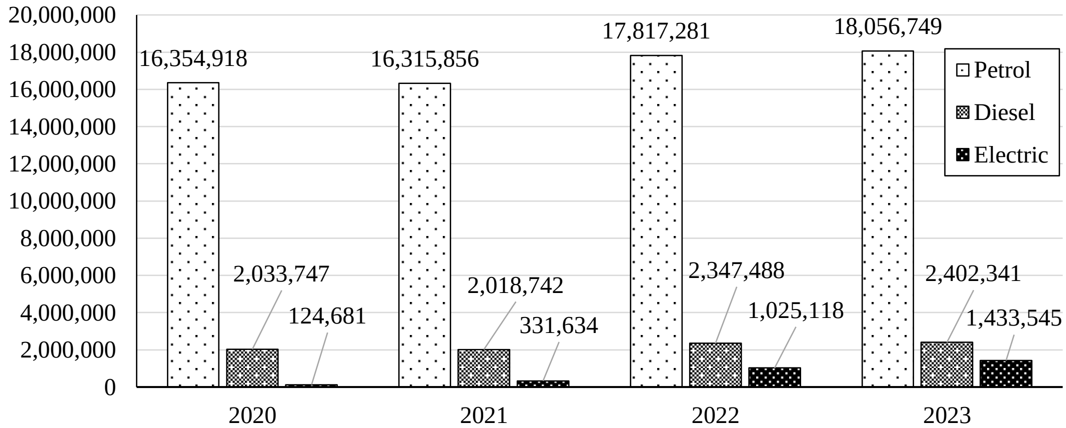

Figure 5. Vehicle registered during calendars years -2020 to 2023.

The Defence Research and Development Organisation (DRDO), tasked by the Ministry of Road Transport and Highways to investigate EV fire incidents, has identified significant issues in the design of the batteries. Investigators suggest that defects in battery packs and modules, potentially linked to cost-cutting measures by manufacturers, are contributing to these incidents. Companies such as Okinawa

Auto Tech, Pure EV, Jitendra Electric Vehicles, Ola Electric, and Boom Motors have been cited as possible sources of these substandard designs due to the use of lower-quality materials (India TV). Potential causes of EV fires include:

1. *Poor battery quality:* Defective battery cells significantly increase the risk of fires.
2. *Battery design issues:* Flaws in design may lead to overheating and fires.
3. *Inadequate battery management system (BMS):* A malfunctioning BMS could fail to regulate battery temperature and voltage, leading to overheating.

Although these incidents attract considerable attention, EV fires remain rare compared to fires in conventional gasoline-powered vehicles. Nevertheless, they pose serious safety concerns for India's rapidly growing EV industry.

HIERARCHY OF CONTROL

Preventing repeated accidents should be a primary focus during safety inspections and investigations. The Hierarchy of Controls offers a systematic approach to identifying and applying the most effective safety measures.

- *Elimination controls:* This strategy involves completely removing the risk of EV fires, ensuring the highest level of safety. For instance, removing faulty EV charging stations would eliminate a significant risk.
- *Engineering controls:* Engineering controls reduce fire risks by modifying the vehicle or infrastructure systems. For example, classifying EV charging stations in buildings as “Special Hazard” zones in accordance with building codes, with features like fire compartments or suppression systems, would enhance safety.
- *Administrative controls:* These measures depend on human actions and decisions, including supervisory oversight. While these are valuable, they are typically less effective when used alone. For example, emergency planning and operational protocols fall under this category.

OBSERVATION

During the risk assessment of fire hazards in electric vehicles (EVs), several critical observations were made to identify potential risks and develop effective strategies for their mitigation. The key areas of focus are outlined below.

Battery Risk Factors

- *Thermal runaway:* Evaluate the likelihood of thermal runaway, a process where a battery cell overheats uncontrollably, leading to potential fires or explosions.
- *Battery chemistry:* Assess the fire risks associated with the type of battery used (e.g., lithium-ion, solid-state). Lithium-ion batteries, in particular, are more susceptible to thermal runaway.
- *Cell defects:* Inspect the battery cells for defects or damage that could escalate the risk of fire.
- *Battery aging:* Consider how the aging process of the battery impacts its fire risk, as older batteries are more prone to failure.

Charging Infrastructure

- *Overcharging risks:* Evaluate the risk posed by overcharging, which can lead to excessive heat generation and possible fires.
- *Charger compatibility:* Ensure that the charging system is compatible with the EV to prevent electrical faults.
- *Electrical overload:* Assess the risk of electrical overloads in the charging system, which could potentially lead to fires.

Vehicle Design and Engineering

- *Battery placement:* Consider the location of the battery pack within the vehicle and its exposure to potential impacts or environmental conditions.

- *Cooling systems:* Evaluate the effectiveness of the vehicle's cooling systems in preventing battery overheating.
- *Material flammability:* Assess the flammability of materials used in the vehicle's construction, particularly those near the battery pack.
- *Structural integrity:* Review the vehicle's structural design to ensure it can protect the battery during a crash or collision.

Environmental and External Factors
- *Extreme temperatures:* Assess the vehicle's vulnerability to extreme temperatures, which can increase the risk of thermal runaway.
- *Water ingress:* Evaluate the risk of water entering the battery pack, potentially causing short circuits and fires.
- *Collision and impact:* Examine the risk of fires resulting from vehicle collisions, especially if the battery is compromised.

Operational and Usage Patterns
- *Driving habits:* Consider aggressive driving behaviours that may generate excessive heat in the battery, increasing the risk of fire.
- *Frequent fast charging:* Assess how frequent use of fast charging stations could impact battery health and contribute to fire risks.
- *Maintenance practices:* Evaluate the adequacy of vehicle maintenance practices in preventing conditions that could lead to fire hazards.

Regulatory Compliance and Safety Standards
- *Adherence to standards:* Review the vehicle's compliance with international safety standards concerning battery safety and fire prevention.
- *Testing protocols:* Ensure the vehicle has undergone rigorous testing under various conditions to identify potential fire hazards.

Emergency Response and Containment
- *Fire suppression systems:* Evaluate the effectiveness of onboard fire suppression systems.
- *Emergency response plans:* Consider the availability and adequacy of emergency response plans, including evacuation procedures and first responder training.
- *Containment measures:* Assess the design of measures intended to contain a fire within the battery pack, preventing it from spreading to other vehicle components.

Incident History and Data Analysis
- *Historical data:* Review historical data on EV fires to identify recurring causes and risk factors.
- *Incident reporting:* Analyse past incidents involving the specific EV model to detect recurring design issues or flaws.
- *Root cause analysis:* Conduct thorough root cause analysis for any past fires to determine underlying factors and develop preventive measures for the future.

Risk Analysis and Categorization

Risk analysis was performed after identifying the hazards associated with various activities. These activities were classified into categories such as Extreme, High, Medium, or Low, based on the likelihood of occurrence and potential consequences. These categories are visually represented in below, with specific colour codes for clarity:
- *Extreme risk (red):* Activities that fall into the red category are considered unacceptable and require immediate action.
- *High risk (orange):* Activities marked in orange need to be thoroughly analysed, and strategies must be DEVELOPED to mitigate the risks.

- *Medium risk (Yellow):* These risks are tolerable but require efforts to reduce them without incurring disproportionate costs.
- *Low risk (green):* Risks in this category are minimal, requiring no further action to reduce them.

For orange-marked risks, a detailed analysis and the creation of a risk-reduction plan are essential. Yellow-marked risks should be addressed with minor adjustments, taking care to avoid excessive expenditure for benefits that may not justify the cost. Green-marked risks have minimal impact and do not require additional measures to reduce their severity.

RESULT AND INTERPRETATION

Various activities related to fire hazards in electric vehicles (EVs) were identified, such as charging, parking, driving, and maintenance, each with its associated potential risks. These risks were evaluated as follows.

Charging Risks

- *Thermal runaway:* A significant hazard during charging, potentially leading to fire explosions and toxic emissions, putting both passengers and first responders at risk. The use of an advanced Battery Management System (BMS) and thermal sensors is crucial to mitigate these risks.
- *Electric shock:* A risk of electric shock exists due to high-voltage batteries and faulty charging points. This risk can be minimized by avoiding defective charging points and preventing direct contact with the battery.
- *Explosion:* Overcharging or using non-original chargers increases the risk of battery explosions, which could lead to severe injuries or fatalities. Implementing advanced BMS, early detection sensors, and automated shutdown features can significantly reduce these risks.

Parking Risks

- *Overheating:* Overheating can cause fires or personnel injuries and is a leading cause of thermal runaway in EVs, especially in hot weather. To reduce this risk, avoid open parking during the summer months and implement advanced battery management systems and early detection sensors.

Driving Risks

- *Impact:* Collisions can damage the battery and cause explosions, leading to permanent disability or death. To reduce this risk, using crash-resistant battery enclosures is essential.
- *Battery leakage:* Battery leakage during driving can damage the battery system and pose hazardous risks. Preventive measures include the use of crash-resistant enclosures and personal protective equipment (PPE) during maintenance.
- *Mechanical impact and rapture:* Accidents involving mechanical impacts or off-road driving can lead to battery rupture or explosions, presenting high risks.

Maintenance Risks

- *Electric shock:* High-voltage batteries and faulty charging sockets can cause electric shocks during maintenance. This risk can be mitigated by using proper PPE and avoiding direct handling of batteries.
- *Environmental contamination:* Battery or fuel cell leakage during maintenance can lead to environmental contamination, posing health risks and contributing to water and air pollution. Proper disposal methods and prevention measures are necessary to avoid these risks.

RECOMMENDATIONS

Enhanced Battery Safety

- *Advanced battery chemistry:* Research and develop safer battery chemistries, such as solid-state batteries, which offer better thermal stability and lower fire risks.
- *Improved battery management systems (BMS):* Implement sophisticated BMS capable of accurately monitoring and predicting thermal runaway and taking proactive steps to prevent it.

- *Robust battery design:* Focus on designing battery packs with enhanced thermal management systems, including better cooling and insulation features.

Charging Infrastructure Safety

- *Safe charging systems:* Design charging systems with built-in safety features to prevent overcharging, overheating, and electrical faults.
- *Infrastructure monitoring:* Implement monitoring systems to detect potential hazards in the charging infrastructure and trigger alerts when necessary.

Vehicle Design and Safety Systems

- *Improved crash protection:* Design vehicles with structures that protect the battery packs from impact damage during collisions.
- *Fire suppression systems:* Integrate onboard fire suppression systems that can rapidly contain and extinguish battery fires.
- *Early warning systems:* Develop advanced sensors and algorithms that can detect early signs of thermal runaway and alert drivers accordingly.

Emergency Response Training

- *Specialized training:* Provide specialized training for firefighters and emergency responders on how to manage EV fires.
- *Standardized procedures:* Establish standardized procedures for extinguishing EV fires, including the use of appropriate extinguishing agents and techniques.

Regulatory Frameworks

- *Stricter regulations:* Enforce more stringent regulations for EV battery safety and fire prevention to ensure compliance and reduce fire risks.
- *Regular inspections:* Conduct frequent inspections of both EV batteries and charging infrastructure to ensure safety standards are maintained.

These recommendations aim to address the identified risks and enhance the safety of electric vehicles in India. Implementing these measures can significantly reduce the likelihood of fire-related incidents, protecting both individuals and property.

CONCLUSION

This study has provided valuable insights into the fault tree analysis of electric vehicles (EVs) in India. Several areas present opportunities for future research to improve EV fire safety in the country. Potential directions for future studies include:

Advanced Battery Design and Management

- *Solid-state batteries:* Research into safer battery chemistries, such as solid-state batteries, that offer better thermal stability and lower fire risks.
- *Battery management systems (BMS):* Development of more advanced BMS that can effectively monitor and manage battery conditions to prevent overheating and potential fire hazards.
- *Thermal management:* Enhancement of battery thermal management systems to ensure that batteries remain within safe operating temperatures.
- *Redundant safety mechanisms:* Implementation of backup safety systems to ensure that, in the event of failure, secondary mechanisms can mitigate risks like thermal runaway.

Vehicle Design and Engineering Enhancements

- *Crash-resistant enclosures:* Design improvements for vehicle structures to prevent battery damage during collisions and impacts.
- *Reinforced battery casings:* Development of stronger, more resilient battery casings to protect batteries from external damage.

- *Strategic battery placement:* Optimizing battery placement within the vehicle to minimize the risk of damage during a crash or mechanical failure.
- *Fire-resistant materials:* Using materials that are resistant to ignition and can contain fires, preventing them from spreading.
- *Integrated fire suppression systems:* Embedding fire suppression technology into vehicles that can quickly extinguish fires before they escalate.

Enhanced Charging Safety

- *Smart charging systems:* Development of charging systems with intelligent monitoring and control features to prevent overcharging, overheating, and electrical faults.
- *Temperature control during charging:* Incorporating temperature control measures to monitor and adjust charging rates in real-time, preventing excessive heat buildup.
- *Standardized charging protocols:* Creating standardized protocols for charging stations and equipment to ensure consistent safety measures are applied.

Stringent Testing and Quality Control

- *Rigorous testing standards:* Establishment of strict testing standards for both EVs and their components, especially batteries, to ensure they meet safety requirements.
- *Quality assurance in manufacturing:* Strengthening quality control practices during the manufacturing process to detect and eliminate any potential defects in EV components.
- *Regular safety audits:* Conducting frequent safety audits of EVs, batteries, and charging infrastructure to identify and address any potential risks.

Regulatory and Industry Standards

- *Mandatory safety certifications:* Enforcing mandatory safety certifications for all EVs and related components to ensure compliance with safety standards.
- *Continuous update of standards:* Regular updates to safety regulations and standards based on evolving technology and emerging risks.
- *Regulatory oversight:* Strengthening regulatory bodies and ensuring more stringent oversight of the EV industry to enforce compliance and encourage innovation in safety.

Emergency Response Preparedness

- *Training for first responders:* Providing specialized training for emergency responders on how to handle EV-related fires and accidents effectively.
- *Guidelines for safe disposal:* Developing comprehensive guidelines for the safe disposal of EV batteries and other components that may present risks during decommissioning or accidents.

REFERENCES

1. Meng Luhan. Research and analysis of electric vehicle fire accidents and review of lithium-ion battery thermal runaway mechanism. International Journal of New Developments in Engineering and Society (IJNDES). 2022; 6(2): 6–14.
2. Mohamed CH, Gerutu GB, Chombo PV. Risk assessment for battery electric vehicles' occupants during fire accident. J Logist Manag Eng Sci. 2021;3(2):1–10.
3. Alanazi F. Electric vehicles: Benefits, challenges, and potential solutions for widespread adaptation. Appl Sci. 2023;13(10):6016. doi:10.3390/app13106016.
4. Mohd Tohir MZ, Martín-Gómez C. Electric vehicle fire risk assessment framework using Fault Tree Analysis. Open Res Eur. 2023 Oct 18; 3: 178.
5. Zhang Xingping, Liang Yanni, Yu Enhai, Rao Rao, Xie Jian. Review of electric vehicle policies in China: Content summary and effect analysis. Renew Sustain Energy Rev. 2017; 70: 698–714.
6. Christensen Paul A, Anderson Paul A, Harper Gavin DJ, Lambert Simon M, Mrozik Wojciech, Rajaeifar Mohammad Ali, Wise Malcolm S, Heidrich Oliver. Risk management over the life cycle of lithium-ion batteries in electric vehicles. Elsevier: Renew Sustain Energy Rev. 2021; 148: 111240.

7. Diaz Laura K, Xuanze He, Zhenwen Hu, Francesco Restuccia, Monica Marinescu, Jorge Varela Barreras. Meta-Review of Fire Safety of Lithium-Ion Batteries: Industry Challenges and Research Contributions. *J Electrochem Soc.* 2020 Aug; 167(9): 090559.
8. Kirkels AF, Bleker J, Romijn HA. Ready for the Road? A Socio-Technical Investigation of Fire Safety Improvement Options for Lithium-Ion Traction Batteries. Energies. 2022; 15(9): 3323.
9. Zermane A, Mohd Tohir MZ, Baharudin MR, Yusoff HM. Risk assessment of fatal accidents due to work at heights activities using fault tree analysis: case study in Malaysia. Saf Sci. 2022;151:105724. doi:10.1016/j.ssci.2022.105724.
10. Feng X, Ouyang M, Liu X, Lu L, Xia Y, He X. Thermal runaway mechanism of lithium-ion battery for electric vehicles: A review. Energy Storage Mater. 2018; 10: 246–67.
11. Offer GJ. Automated vehicles and electrification of transport. Energy Environ Sci. 2015; 8(1): 26–30.
12. Capuder T, Sprˇci´c DM, Zoriˇci´c D, Pandži´c H. Review of challenges and assessment of electric vehicles integration policy goals: Integrated risk analysis approach. Int J Electr Power Energy Syst. 2020; 119: 105894.
13. Ouyang D, Chen M, Huang Q, Weng J, Wang Z, Wang J. A Review on the thermal hazards of the lithium-ion battery and the corresponding countermeasures. Appl Sci. 2019; 9(12): 2483.

