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A Review on Fire Accidents in Electric Vehicles

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Abstract: *Electric vehicles are replacing internal combustion engines drastically because of high performance and efficiencies compared to internal combustion engines. Weight and cost of production are also very low compared to ICE's. Nowadays electric vehicle usage is high and some of the EVs are catching fire because of various external factors. In this study, we are going to identify the factors for fire accidents in Electric vehicles by following real-life case studies and discuss some safety measures to prevent the vehicles from catching fire.*

Keywords: *Electric vehicles, combustion engines, fire accidents.*

I. INTRODUCTION

An electric vehicle (EV) is a vehicle that uses one or more electric motors for propulsion. It can be powered by a collector system, with electricity from extravehicular sources, or it can be powered autonomously by a battery (sometimes charged by solar panels, or by converting fuel to electricity using fuel cells or a generator). EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft, and electric spacecraft.

EVs first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Internal combustion engines were the dominant propulsion method for cars and trucks for about 100 years, but electric power remained commonplace in other vehicle types, such as trains and smaller vehicles of all types. In the 21st century, EVs have seen a resurgence due to technological developments, an increased focus on renewable energy, and the potential reduction of transportation's impact on climate change, air pollution, and other environmental issues. Project Drawdown describes electric vehicles as one of the 100 best contemporary solutions for addressing climate change.

A. About Batteries

Most electric vehicles use lithium-ion batteries (Li-Ions or LIBs). Lithium-ion batteries have a higher energy density, longer life span, and higher power density than most other practical batteries. Complicating factors include safety, durability, thermal breakdown, and cost. Li-ion batteries should be used within safe temperature and voltage ranges to operate safely and efficiently.

Increasing the battery's lifespan decreases effective costs. One technique is to operate a subset of the battery cells at a time and switch these subsets. In the past, nickel-metal hydride battery batteries were used in some electric cars, such as those made by General Motors. These battery types are considered outdated due to their tendencies to self-discharge in the heat. Furthermore, a patent for this type of battery was held by Chevron, which created a problem for their widespread development. These factors, coupled with their high cost, have led to lithium-ion batteries leading as the predominant battery for EVs.

The prices of lithium-ion batteries are constantly decreasing, contributing to a reduction in the price of electric vehicles.

B. About Motors

The power of a vehicle's electric motor, as in other machines, is measured in kilowatts (kW). Electric motors can deliver their maximum torque over a wide RPM range. This means that the performance of a vehicle with a 100-kW electric motor exceeds that of a vehicle with a 100-kW internal combustion engine, which can only deliver its maximum torque within a limited range of engine speed. The efficiency of charging varies considerably depending on the type of charger, and energy is lost during the process of converting the electrical energy to mechanical energy.

Usually, direct current (DC) electricity is fed into a DC/AC inverter where it is converted to alternating current (AC) electricity, and this AC electricity is connected to a 3-phase AC motor.

For electric trains, forklift trucks, and some electric cars, DC motors are often used. In some cases, universal motors are used, and then AC or DC may be employed. In recent production vehicles, various motor types have been implemented; for instance, induction motors within Tesla Motor vehicles and permanent magnet machines in the Nissan Leaf and Chevrolet Bolt.

Fig (1) components in electric car

II. KEY COMPONENTS OF AN ALL-ELECTRIC CAR

- 1) *Battery (all-electric Auxiliary)*: The auxiliary battery provides electricity to power vehicle accessories in an electric drive vehicle.
- 2) *Charge Port*: The charge port allows the vehicle to connect to an external power supply to charge the traction battery pack.
- 3) *DC/DC Converter*: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
- 4) *Electric Traction Motor*: Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.
- 5) *Onboard Charger*: Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.
- 6) *Power Electronics Controller*: This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
- 7) *Thermal System (Cooling)*: This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
- 8) *Traction Battery Pack*: Stores electricity for use by the electric traction motor.
- 9) *Transmission (Electric)*: The transmission transfers mechanical power from the electric traction motor to drive the wheels.

III. FIRE ACCIDENTS IN THE RECENT ERA.

1) *Tesla Model S in Texas*

Tesla Model S dashed a tree that killed 2 occupants resulting in damage to the front of the car, The High voltage lithium-ion battery case caught fire and destroyed the car.

2) *Pure EV in Chennai*

In 2022, An electric scooter from Pure EV caught fire in the middle of the day in Chennai.

3) *OKINAWA in Tamil Nadu*

Scooters caught fire killing father and daughter and scooter makers blamed the user for negligence while charging the scooter.

4) *OLA Electric in Pune*

The scooter caught fire on its own. An investigation is going into this incident.

5) *The Battery Of A Brand-New Electric Scooter Explodes In Andhra Pradesh*

This event occurred in Vijayawada when the detachable battery of the vehicle was kept charging in his bedroom.

- 6) On April 7, at Machilipatnam in Krishna district, an electric scooter caught fire while charging. The explosion was so intense that it left the owner of the bike dead and three other family members severely injured.

(ALL THE ABOVE INFORMATION IS TAKEN FROM GOOGLE)

IV. DISCUSSIONS

Several factors are associated with the above fire accidents but the major identification is the thermal runaway and position of the battery in the EV. A thermal runaway occurs when one exothermal event sets off a chain reaction that results in an uncontrollable temperature rise. This can lead to the battery being destroyed or, in the worst-case scenario, a fire. Thermal runaways have been documented in lead-acid batteries, particularly VRLA batteries when improper charging and supervision procedures are applied. During constant voltage charging, there is a possibility of thermal runaway. Gases recombine internally to water in VRLA batteries, and the energy required for the electrolysis process is released as heat again inside the cell. Because the gases are expelled from the cell in flooded batteries, they also transfer the energy required for the electrolysis process. However, with VRLA batteries, the released energy causes an increase in cell temperature. As a result, the electrolyte's resistance and overpotentials, as well as electrochemical processes, are minimized. The charger boosts the float current to the battery to maintain the cell voltage constant. This increased current causes electrolysis and recombination within the cell in fully charged batteries.

In practice, this can cause the battery cells to reach temperatures of over 100 °C. As a result, water and electrolytes are lost through the vent, causing the cell to dry out. Because the heat stays inside the battery because no gases are released as long as the temperature is within normal ranges and because VRLA batteries have a substantially lower heat capacity than flooded electrolyte batteries, they are more vulnerable to thermal runaway. VRLA batteries have less electrolyte than flooded batteries, and the electrolyte dominates the heat capacity of lead-acid batteries.

Mechanical Impact: Without the protection of an EV frame and/or a battery module and pack enclosure, most commercial LIB cells are relatively fragile. An EV, like any other conventional vehicle, may be involved in a traffic collision over its lifetime. Nonetheless, thanks to contemporary LIB and EV design, the vast majority of crashes will not affect the battery. LIB packs are typically placed into heavily reinforced portions of the vehicle to reduce the danger of being penetrated during a collision. However, at high speeds, which some EVs can achieve in a matter of seconds, even the best level of protection is insufficient to consistently prevent fire.

Thermal runaway in a lithium-ion battery can cause significant injury to the car's occupants as well as damage to the battery pack and the vehicle itself. A thermal runaway happens when a lithium-ion battery overheats, which can be caused by a short circuit, overcharging, or other cell stress. The extra heat in the cell sets off a chain reaction that produces gas. If not addressed, the problem can spread throughout the battery pack, causing additional cells to overheat and degrade. As the runaway takes hold and the battery cells break down, combustible gases are released, such as:

Hydrogen.

Flammable hydrocarbons.

Carbon monoxide is a poisonous gas.

During a thermal runaway, other dangerous gases are emitted, including:

Fluoride of Hydrogen.

Dimethyl carbonate is a compound made up of carbon dioxide and dimethyl carbonate.

Acetonitrile.

It's difficult to stop a thermal runaway once it starts since its chain reaction can cascade across a battery pack, creating smoke and flames. A thermal runaway's influence on a battery pack, as well as the rest of the vehicle, can be limited with rapid intervention. While many of the elements employed in the pack are intended to decrease the chance of fire spreading, if a cell vents gas, a hazardous condition exists within the battery pack that must be discovered and addressed to avoid the risk of fire.

A. Thermal Runaway Prevention Management

To prevent thermal runaway in EVs and HEVs, a three-pronged approach is required:

Keeping the runaway from getting started in the first place

Detecting whether or not a cell is experiencing a thermal runaway.

preventing the battery packs from spreading to other elements.

In any case, there are two ways to stop a battery thermal event: active and passive thermal management systems.

B. Active Thermal Management

Cooling systems are used in active thermal management to keep a battery pack at the right temperature.

An active thermal management system drains heat from the cells utilizing air or cooling plates with traditional automotive coolants or even refrigerants to bring temperatures back down when the cells begin to heat up during charge or discharge. It's similar to how a radiator regulates temperature in an internal combustion engine.

C. Thermal Management In The Passive Mode

Passive thermal management systems are mainly concerned with preventing thermal runaway in the later stages. A passive system, such as a heat shield or insulation, prevents excessive heat from flowing from a single cell to the remainder of the battery pack and perpetuates the chain reaction.

Passive thermal management systems are related to compartmentalization as a type of building fire safety. A fire that is contained in a certain region does not spread to other portions of the structure.

D. Thermal Runaway Prevention & Sensor Technology

Maintaining peak performance in an EV or HEV requires constant monitoring of its systems, just as it does in any other vehicle. That's why electric cars, trucks, and buses have sensors and electronic controls that constantly monitor the battery condition and automatically provide appropriate cooling or heating as needed. Sensors are crucial in preventing a thermal runaway from spreading, regardless of an EV's thermal management system for its battery pack. Sensors were used to measure heat, which was an instant and clear symptom of a thermal battery event in the early days of lithium-ion battery pack thermal management. Sensor technology is now taking a more scientific approach to thermal management by monitoring for the gas escape of a venting cell, which is the prelude to thermal management.

The position of the battery plays a key role in EVs to prevent fire hazards when the vehicle hits an obstacle.

The battery should keep away from high-impact zones and be surrounded by a high protective casing,

The position to set up any battery in cars is the middle of the vehicle because the impact zone is far. After all, the front and back part of the vehicle has a high impact when the vehicle collides with an obstacle.

V. CONCLUSION

Electric Vehicles industries have great growth in upcoming years because of huge demand. Because of more demand, the companies have to supply according to the demand. So their quality is reduced because of fast and mass manufacturing. Because of poor quality and poor design, electric vehicles catch fire quickly, to minimize these fire accidents the monitoring bodies have to be strict, and the quality control department has to take care more. by taking proper quality control precautions and research and development we can minimize these accidents and we can able to minimize global air pollution.

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