Design And Analysis of Electric Car Safety

[1]Yashpal Aniruddha Gajbhiye, [2]Dr. Bharat Chede, [3]Prof. Swapnil Choudhary, [4]Dr. Somdatta Karanjekar
[1]*M-Tech (CAD/CAM) Wainganga College of Engineering and Management, Nagpur, India*
[2,3,4]*Corresponding Authors, Wainganga College of Engineering and Management, Nagpur, India*

Abstract: In comparison to internal combustion engines, electric vehicles represent an entirely new technology. This implies that there may be new safety risks, especially because of the features of high-power electric equipment.
The electric vehicle system must be built to function safely under all circumstances, and a number of specific issues will be addressed while focusing on various aspects of e-vehicle behavior. Standards and governmental regulations pertaining to electric road vehicles are currently not very well defined.
The current documentation and standards cover a vehicle that is undergoing full technical progress, but they are far from being harmonized. The design and study of e-vehicles with regard to increasing safety is a key factor.

Keywords—Redesigning the following measures will improve the safety of electric vehicles. The safety of electric systems, The safety of functional systems, The safety of battery charging system, Vehicle operation and accidental safety.

I. INTRODUCTION

Electric vehicles (EVs) originally appeared in the late 19th century when electricity was one of the preferred forms of motor vehicle power, offering a level of comfort and ease of use that petrol cars of the day were unable to match. For almost 100 years, internal combustion engines predominated as the primary means of propulsion for cars and trucks, but electric power remained prevalent in other vehicle types, such as trains and smaller vehicles of all kinds.
Due to technology advancements, a greater emphasis on renewable energy, and the possibility to lessen the impact of transportation on climate change, air pollution, and other environmental issues, EVs have had a comeback in the 21st century. Electric vehicles are ranked among the top 100 modern options to combating climate change by Project Drawdown.
Given that EVs have not been around for very long, it may be challenging to verify their safety profile with precise data and trustworthy information; as a result, we must make a thoughtful comparison with ICE vehicles. Additionally, because ICE vehicles have been in use for well over a century, a great deal is known about the fire risks they pose and how to reduce them.
This essay will look into electric vehicle safety, give an outline of it, and make some recommendations for its potential future growth.

II. OBJECTIVE

A. To enhance the electric car's safety features
The primary goal is to increase the safety of electric vehicles by taking into account their four primary systems, which are their electric, functional, charging, and operational systems

B. To recommend the ideal design for increased safety
Another goal is to make safer design recommendations for electric vehicles in order to increase their level of safety.

III. LITERATURE SURVEY

P. Van den Bossche, G. Maggetto. Safety characteristics of electric vehicles in city traffic. Second edition, CITELEC, Brussels, October 1993 [study report on behalf of the European Commission]

A. Regulations and safety-related activities::
Some potential electric car safety issues are covered in this section. As said, it wasn't the aim to indicate that electric vehicles are riskier than conventional automobiles or would put the public at greater risk. Instead, the emphasis was on a few common dangers and how they were handled by UN Regulations under the 1958 Agreement and EU type-approval.

B. Electrical safety in use:
The voltages used in electric vehicles are potentially very dangerous. However, a range of safety features are typically used to ensure the safety of occupants or other persons. Crucially, the high voltage circuit is isolated from the vehicle chassis (and any other conductors). This means that a person would need to touch both the positive and the negative sides of the circuit to receive an electric shock. This would require a loss of isolation

on both sides of the circuit (i.e. a double-fault). In fact, the ground-fault monitoring system would detect any leakage of current and would disconnect the high voltage system from the rechargeable energy storage system. Safety requirements for electrical power trains are set out in UN Regulation 100.

It includes requirements and test methods for four key areas, including hydrogen emissions measurement, rechargeable energy storage systems, functional safety, and electric shock protection.

When high voltage buses aren't connected to external high voltage supply, the rules for electric shock safety usually still apply to them. Protection against direct contact, protection against indirect contact with exposed conductive elements, and isolation resistance are the three key considerations.

To avoid the creation of harmful potentials, the law mandates that any exposed conductive components, such as barriers or enclosures, be connected to the chassis. The regulation also establishes a threshold of 0.1 ohm as the resistance between all exposed conductive components and the chassis when a current flow of at least 0.2 amperes is present.

IV. METHODOLOGY

Research methodology to be employed: -

A. Define:

The study that employs several conceptual frameworks and analytical techniques to enhance the safety of electric vehicles.

B. Measure:

a. Electric system safety
b. Functional system safety
c. Battery charging safety
d. Vehicle operation and accidental safety

a. Electric system safety: -

Security from electric shocks Voltages seen within electric cars:

The following voltage ranges are typical for electric vehicles:

- 48-400 V for compact vehicles
- 96-800 V for standard vehicles

Higher voltage levels are utilised for AC drives, which are becoming more and more prevalent; It is possible for little vehicles to experience 200 V or more. Even on little automobiles, more might be seen. These voltage levels should be compared to the safety voltage limits, which are 25 V for AC and 60 V for DC in a typical electric vehicle environment marked by low skin resistance (wet skin is likely) (BB2) and contact with conductive objects (BC3). As a result, safety precautions should be taken to avoid electrocution from direct or indirect contact with the voltages utilised in electric cars.

Protection against direct contact:

Electric traction system live components should be shielded from direct touch by anyone inside or outside the vehicle via insulation or by positioning them in an inaccessible location. Insulation that isn't necessary for protection against direct touches, such as varnish, enamel, coatings, etc. Only tools or keys shall be used to remove safety barriers and open doors, lids, and bonnets allowing access to live electrical equipment. It is important to uphold the standard protection degrees (IPXXB or IPXXD).

Protection against indirect contact:

The issue of frame faults and the issue of indirect contacts are closely related.

A flaw is considered to exist whenever there is an erroneous connection between the traction circuit and the vehicle frame. Frame errors can result in the following dangers:

- short circuits
- electrocution
- uncontrolled operation

To prevent these risks, the following steps should be taken:

• A fuse should be built inside the battery pack, preferably in the battery's electrical centre.

• The vehicle structure must not be a component of the power electrical circuit and must be disconnected from the traction circuit.

• frame fault leakage detection shall be included in routine maintenance; permanent frame fault monitoring is required for some vehicles.

• all conductive parts of the vehicle, particularly accessible parts or parts adjacent to electrical equipment, shall be connected with an equipotential connection.

b. Functional system safety: -

The traction system for electric vehicles must guarantee the vehicle's dependability and safety. In order to minimise or prevent harmful activities, certain precautions need be taken because the topology of the traction system in an electric vehicle differs significantly from that of vehicles with IC engines.

System activation warning:
Most of the time, an electric car is entirely silent while it is stopped. A warning device must be present to stop movement caused by accidental traction circuit activation.

Power on procedure:
The power-on procedure must be properly organized to prevent potential damage from excessive torque, overcurrent, or violent accelerations: it must be impossible to activate the controller while depressing the accelerator, and any unintentional movement of the vehicle during start-up must be avoided.

Emergency disconnect device:
Electricians and automakers use different approaches to this issue: • Emergency switches are not seen necessary by automakers, and they try to avoid using them (thermal vehicles don't have them). • Emergency switches are necessary, according to electrical manufacturers (they can be found on each industrial electric device). There are various versions of emergency switches: connections for batteries Direct-acting and indirect-acting emergency buttons are available. It is advised that the disconnect action be straightforward. Additionally, it must not harm the controller in any way whilst in operation.

Fail-safe operation- Power surge prevention:
Power surge control fail-safe circuitry must be used to stop unintentional acceleration brought on by malfunctions in electronic traction controllers. A standing, unbraked vehicle cannot move more than 0.01 metres as a result of any failure.

Fail-safe operation - Frame faults:
Uncontrolled operation can also result from frame faults and stray currents: a few A of fault current in a controller can discharge hundreds of Amps in the motor!
Galvanically isolating traction and auxiliary circuits is required. Water condensation and infiltration must be prevented.

Fail-safe-operation-Electromagnetic compatibility:
The operation of the controller must not be harmed by electromagnetic interference that is produced either externally or by the controller itself. The controller must be built into the rest of the vehicle in a way that prevents the production of harmful radiations.

The auxiliary network:
For lighting, windscreen wipers and other comparable demands, the auxiliary network is employed. Through a DC/DC converter, which should be built with galvanic isolation, the traction battery is used to power it. The majority of cars additionally have an auxiliary battery. If the DC/DC converter is strong and trustworthy, it can replace the auxiliary battery and assure the safe operation of the auxiliary loads—especially lighting—under any circumstances.

Electrical regenerative braking:
On this item, a few special safety concerns should be made:

- regenerative braking works through the drive train, on one axle only
- regenerative braking does not work at very low speeds or at standstill
- in most cases, the rate of deceleration is limited and not sufficient for an emergency stop
- on slippery surfaces, high levels of regenerative braking may cause loss of adhesion
- torque inversions add wear and tear to the mechanical drive system
- the effect of regenerative braking may be impaired when the battery is fully charged; the latter may even be overcharged.

The vehicle should always be able to stop using the primary friction brake system.
The braking torque must be gradually adjustable and coasting must continue to be an option in order to guarantee safe operation and optimal efficiency. Given the importance of energy-efficient driving, the last characteristic.

Over-speeding:
The vehicle should always be able to stop using the primary friction brake system.
The braking torque must be gradually adjustable and coasting must continue to be an option in order to guarantee safe operation and optimal efficiency. Given the importance of energy-efficient driving, the last characteristic.

c. Battery charging safety:

The electric car's battery is the most important component. It represents a number of possible dangers:

- electrical
- mechanical
- chemical
- explosion hazard

Electrical aspects :-

• To prevent electrocution, the standard enclosures must be used as necessary.

• Short-circuit prevention: Traction batteries often have a very high short-circuit current. Protective devices (fuse links) must be planned for, preferably at the battery's electrical core. Additional fuse links must be provided when using several battery packs. To reduce the chance of an explosion, attention must be used while choosing the type and location of these fuse linkages.

• The battery compartment's layout must also be logically planned to prevent any unintended direct contact or short-circuit.

• Creepage distances between live parts must be followed in order to minimise leakage currents, especially when vented batteries are utilised.

Mechanical aspects: -

The traction battery is a heavy item (especially the Lead-Acid battery); its location on the vehicle must be determined to prevent instability of the vehicle, the battery must be restrained to prevent injury in the event of an accident, and the location of the battery should be particularly observed when existing thermal vehicles are converted to electric traction since an adequate battery compartment is typically not available in this situation.

Chemical aspects:-

Lead-Acid batteries:

The electrolyte (sulphuric acid), which is found in lead-acid batteries, poses the greatest chemical risk. Maintenance should be done with discretion. Electrolyte should not be spilled on other people or on the vehicle's occupants in the event of an accident. Only after the battery's disposal and recycling processes does the lead metal in the battery leak out.

Nickel-Cadmium batteries:

A lye solution (potassium hydroxide) serves as the electrolyte. Precautions that apply to sulfuric acid also apply here. Tools for handling and maintenance must be carefully segregated when Lead-Acid and Nickel-Cadmium batteries are used in the same fleet. The battery contains cadmium metal, which is only released during recycling and disposal.

Sodium-Sulphur batteries:

These batteries are totally sealed. The reagents (molten sodium and sulphur) are securely contained within the thermal envelope. The battery also has a large number of tiny cells, which limits the amount of active material that can be released in an accident. Thermal runaway issues plagued the early prototypes of this battery.

Sodium-Nickel Chloride batteries:

These are comparable to sodium-sulfur, although sulphate is a more reactive salt than nickel chloride. batteries containing zinc and bromine. The battery's internal bromine complex solution is toxic yet exhibits little reactivity, providing it a high level of inherent safety. Inhaling bromine and bromine-related compounds that are released in the case of a fire is the main risk connected with this battery.

Explosion hazards:

Hydrogen is produced through the electrolysis of aqueous electrolytes in batteries. At the conclusion of the charge, this is especially true. In order to reduce the risk of an explosion, specific precautions must be followed. For example, the hydrogen concentration in any given area of the vehicle must never increase from 0,8% during normal operation to 3,5% in the event of a failure (the explosion limit is 4%).

•Contactors, switches, connectors, light bulbs, braking pathways, etc. should not be placed near areas where it's possible for air/gas mixes to become explosive. • The passenger compartment must always be aired and never open to battery fumes.

• When using valve-regulated lead-acid batteries (sometimes referred to as "sealed" or "maintenance-free" batteries), it is important to remember that these batteries have the potential to release hydrogen gas in the event of an overcharge. Safety in battery charging The electric car is connected to the mains distribution network for battery recharging, so appropriate safety precautions must be made to prevent electrocution risk.

Several instances can be seen: chargers for batteries off-board Off-board battery chargers are typically utilised for quick charging particularly with large cars. It is crucial to link the car body to the earth while charging with off-board chargers. In the event of a fault, potentially dangerous circumstances may arise. battery chargers on board The vehicle body must be linked to the earth while utilising on-board battery chargers, with the exception of Class II (double insulated) equipment. It is advised to use an earth-loop monitor to assess the stability of the earth. The traction battery needs to be insulated from the vehicle body when the charger has no electrical separation, isolation monitoring is crucial, and both are required. Chargers for batteries onboard only partially Inductive energy transfer is the foundation of partially on-board chargers. Their electrical safety is quite high because there is no electrical contact between the car and the mains network. The mechanical dangers are also decreased by the lack of a cord. These chargers' electromagnetic environment's peculiarities are being taken into account.

d. Vehicle maintenance, operation.

Maintenance:

First-line maintenance: by the user Example: vehicle washing, windscreen top-up The ordinary user is not a trained electrician, and must be protected against all risks of direct contact.

Second-line maintenance: In the workshop Example: battery top-up, routine mechanical maintenance, controller replacement. The servicemen must be thoroughly trained for safe maintenance action when servicing electric vehicles. The battery should be disconnected before any intervention is done.

Third-line maintenance: in the manufacturer’s workshop Example: major electrical repairs. This is to be done by trained personnel only.

Maintenance for safe operation:

In addition to ordinary mechanical maintenance, some electrical maintenance is required for safe operation and must be carried out at scheduled service intervals:

• test of insulation resistance and earth leakage
• controller operation
• battery condition, maintenance and cleaning

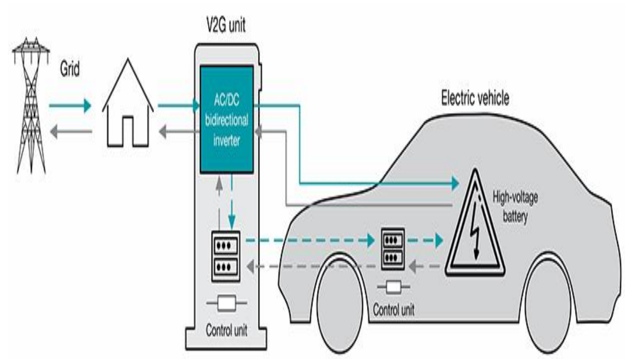
The validation of these items might be tested on licenced vehicles.

Driver training:

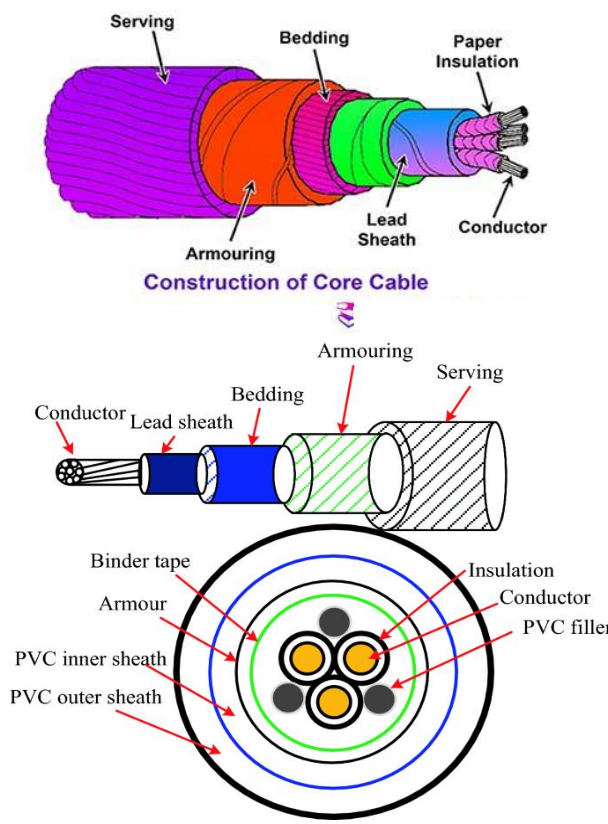
An electric car is neither a petrol, diesel or even an LPG or CNG vehicle. It's electrifying! When compared to IC engines, the torque and power characteristics of an electric motor are very different. Driving an electric vehicle safely and efficiently demands the right abilities. The careless driving style so common in the world of petrol vehicles has no place in the world of electric vehicles. Battery charging in particular needs to be done correctly and with the necessary restraint. Through the dealer network, the relevant information must be given to buyers of electric vehicles..

V. DESIGNS

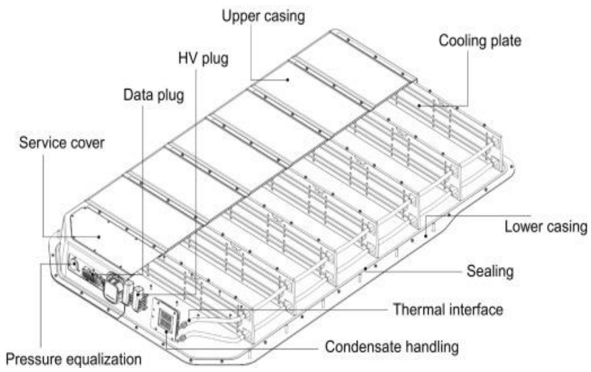
a. Design concept of safe electric car charging:



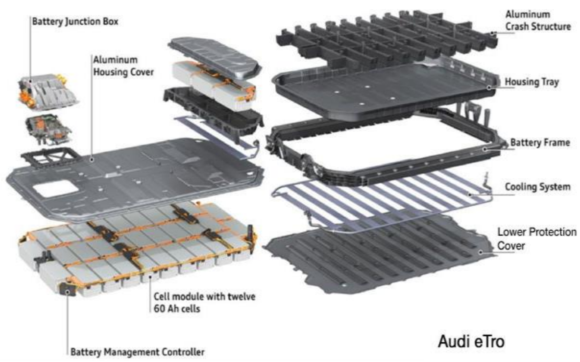
b. Improved High voltage cable designs:



c. Improved design of high voltage battery pack:



d. Improved battery shell design:



VI. CONCLUSION

The use of electric vehicles will require adherence to the safety regulations unique to electric traction. The electric car will afterward become a safe and dependable mode of transportation that will enable the improvement of traffic and environmental conditions in tomorrow's cities if proper risk assessment and common sense prevail in this situation.

REFERENCES

[1]. Hanumant Yaragudri, Mohan Narayana K, Ravikumar M, Design and analysis of heat exchanger for battery thermal management system, volume (5) 2018.

[2]. Hamidreza behi, Danial Karimi, Mohammadreza Behi, Joris Jaguemont, Morteza Ghanbarpour, Masud Behnia, Maitane Berecibar, joeri Van Mierlo, Journal of energy storage (32) 2020.

[3]. Linpei, Zhu, Fei Xiong, Hu Chen, Dan Wei, Gang Li, Chenzhi Ouyang, International journal of heat and mass transfer (163) 2020.

[4]. Hsiu-Ying Hwang, Yi-shin Chen, and Jia- Shiun Chen, Optimising the heat dissipation of an electric vehicle battery pack.

[5]. Guiying Zhang, Fei Qin, Huiming Zou, Changqing Tian, Experimental study on a dual parallel evaporator heat pump system for thermal management of electric vehicles.

[6]. Huiming Zou, Bin Jiang, Qian Wang, Changqin Tian, Yuying Yan, Performance analysis of a heat pump air conditioning system coupling with battery cooling for electric vehicles. © 2021 JETIR March 2021, Volume 8, Issue 3 www.jetir.org (ISSN-2349-5162) JETIR2103088 Journal of Emerging Technologies and Innovative Research (JETIR) www.jetir.org 644

[7]. Z. Lu, X.Z. Meng, L.C. Wei, W.Y. Hu, L.Y. Zhang, L.W. Jin, Thermal management of densely packed EV battery with forced air cooling strategies.

[8]. A.A. Pesaran, “Battery thermal management in EVs and HEVs: issues and solutions,” in proceedings of the advanced automotive battery conference, Las Vegas, Nev, USA, February 2001.

[9]. Z. Rao, S. Wang, A review of power battery thermal energy management, Renew. Sustain. Energy Rev.(15) 2011.

[10]. S..C. Chen, C.C. Wan, Y.Y. Wang, Thermal analysis of lithium ion batteries, J. Power sources (140) 2005.

[11]. A. Jarrett, I.Y. Kim, Design optimization of electric vehicles battery cooling plates for thermal performance

[12]. Y. Wei, M. Agelin Chaab, Experimental investigation of a novel hybrid cooling method for Lithium ion batteries, Applied thermal engineering 2018.

[13]. Yunus A. Cengel., Heat transfer A practical approach 2017.

[14]. K. Li, J. Yan, H. Chen, Q. Wang, water cooling based strategy for lithium ion battery pack dynamic cycling for thermal management system, applied thermal engineering 2017.