SAFETY OF ELECTRICAL COMPONENTS IN HYBRID AND ELECTRIC VEHICLES: A REVIEW

K Abhijith,
Department of Mechanical Engineering,
Nehru College of Engineering and Research Centre,
Thrissur, India
abhijithabhik2003@gmail.com

Lt. Sanoj Thonakkot,
Department of Mechanical Engineering,
Nehru College of Engineering and Research Centre,
Thrissur, India
sanoj.thonakkot@gmail.com

Abstract: The quick coordination of electrical parts in crossover and electric vehicles (HEVs) has changed the car business, yet it presents novel wellbeing concerns. This paper investigates the security perspectives encompassing HEV electrical frameworks, digging into difficulties emerging from high-voltage parts, warm administration, and multifaceted vehicle design. The paper underscores progressions in wellbeing conventions, protection materials, and safeguard systems to moderate dangers to travelers and specialists on call. Also, this paper explores issue identification systems in power gadgets and the convergence of jolt with independent driving. Advancements in materials, testing strategies, and prescient examination are featured as means to upgrade part security. By looking at the two difficulties and arrangements, this diary adds to the continuous exchange on getting the solid and safe activity of electrical parts in HEVs.

Keywords: Battery, HEVs, Recycling, Management

I. INTRODUCTION

The shift towards crossover and electric vehicles (HEVs) addresses a vital headway in the car business, lining up with worldwide endeavors to moderate fossil fuel byproducts. HEVs offer predominant proficiency, yet their complex electrical parts present exceptional wellbeing concerns. This paper tends to the security of HEV electrical frameworks as well as the basic parts of reusing and the board. As the reception of HEVs increments, dealing with the finish of-life stage becomes central. This work investigates the wellbeing challenges presented by high-voltage parts and looks at imaginative techniques for their reusing and dependable administration, adding to an extensive comprehension of both security and supportability in HEV innovation.

II. PRIMARY ATTRIBUTES OF HALF BREED AND ELECTRIC VEHICLES WITH RESPECT TO SAFETY

T A Stevan Kjosevski MSc et al. (2017) discussed about electric and half vehicles which addresses a very surprising innovation contrasted with gas powered motors. This means that new dangers are primarily associated with high voltage electrical equipment

present in the vehicle. Guidelines as of now exist for the development of such vehicles regarding lessening likely gamble towards the travelers and the salvage group who could be uncovered to risks like destructive synthetic substances, poisonous gases, fire and electric shock. There are various aspects of electrical wellness that should be considered in electric vehicles:
- The electrical framework's health;
- The capability of wellbeing in the frameworks;
- While charging batteries, you can enjoy your well-being;
-Vehicle maintenance and activities, as well as planning.
Following that is a more detailed depiction of the relevance of the terms mentioned.

III. SECURITY OF THE ELECTRICAL FRAMEWORK

T A Stevan Kjosevski MSc et al. (2017) discussed that the security of the electrical framework or the insurance against electric shocks includes levels of voltage in electric vehicles, assurance against immediate and roundabout contact. Regular degrees of voltage for vehicles and little vans changes from 48V to 120V, for huge vans from 96V to 240V and transports from 300V to 600V. For drives with AC utilizing higher voltage, 200V or on the other hand more can be tracked down even in little vehicles. These voltage levels ought to be contrasted with safe voltage levels. Voltages utilized in electric vehicles are possibly perilous and ought to hence be taken to forestall electric shock in immediate or backhanded contact. Electric drivetrain components that are under voltage should be kept out of reach or in a protected area to prevent direct contact with passengers or pedestrians. Removal of security devices and opening of doors or protective coverings where there is access to electrical equipment under voltage should only be possible with tools or keys. Aberrant contact is a problem that is closely related to the vehicle body's mistakes. Any auxiliary connection between the driving circuit and the car is thought to be a mistake. Accidental damage to the vehicle's body can result in dangers like electric shock, short circuit, or uncontrolled activity.

IV. BATTERY WELLBEING

Wojciech Zakrzewicz et al. (2020) said through his framework that the most fundamental component of an electric car is the battery. It provides several potential concerns, including electrical, mechanical, chemical, and blast risk. Security against electric shock and short circuits is included in the electrical concepts. As a result, battery breakers and other defensive devices should be accommodated. Using various batteries should result in more locking relationships. The division that contains the batteries should also be designed to avoid any unintentional direct contact or cutoff. Regarding mechanical considerations, the battery should not be fixed in place because it is a significant component of the vehicle's design and should be constrained to prevent damage in the event of an accident. The risks from synthetic viewpoint rely upon the kind of battery furthermore, on every one of the sorts recommended approach to taking care of and reusing. Batteries with watery electrolyte transmit hydrogen because of electrolysis. This particularly happens toward the finish of charging and ought to subsequently be gone to under specific lengths to stay away from the gamble of blast. During the method involved with charging the battery, electric vehicle is associated with the primary appropriation organization and ought to play it safe to stay away from hazard of electric shock. They should consider a few scenarios. Large cars and quick charging frequently use "off-board" battery chargers. With these chargers, it is essential to tether the vehicle to the ground while it is fully charged because doing otherwise can put you at risk in an emergency. When using "on-board" battery chargers, the vehicle should always be grounded, with the exception of when Gear Class II (two-protection) is used. It is prescribed to check the rightness of ground through a control gadget for establishing. When the charger lacks an electrical division, it is crucial to examine the drive battery's seclusion and it should be kept away from the body of the car. Inductive power transmission is a need for incomplete "on-board" chargers. They have very good electrical safety because there is no electrical contact between the vehicle and the power system. The shortfall of link likewise diminishes mechanical dangers. Nonetheless, the attributes of the electromagnetic climate in these chargers are still getting looked at.

V. UPKEEP

Wojciech Zakrzewicz et al. (2020) also said that in the primary line of keeping up with is the client. Customary purchaser is certainly not a prepared circuit repairman and must consequently be safeguarded against all dangers of direct contact. The second column in the upkeep is the studios. Representatives at studio (administration) should be entirely prepared in the protected upkeep activities in overhauling of electric vehicles. The battery ought to be detached prior to any sort of mediation. Third line are holding studios producer and incorporate the super electrical fixes. It would be ideal for this to be done exclusively via prepared staff. Other than upkeep of mechanical parts, it is important to have electrical and routine upkeep for safe activity. These incorporate testing the obstruction of protection and earth spillage working regulator, battery status as well as its upkeep and cleaning. The electric vehicle isn't like petroleum, diesel and other sort of vehicles. The electric engine has the attributes of force and power that are very not the same as the gas-powered motors. Safe and energy effective electric driving vehicle requires proper abilities. For electric vehicles there is no space for ordinary driving style all things considered with petroleum vehicles. Particularly the charging ought to be done appropriately and with the essential discipline. Consequently, purchasers of electric vehicles should be given the fundamental data through the dealer.

VI. WELLBEING IN REGARDS TO THE WORKING OF FRAMEWORK

Wojciech Zakrzewicz et al. (2020) also developed a framework discussing on the electric vehicle's drive configuration should ensure reliable and secure operation of the vehicle. Because the geography of the drive framework in an electric car differs significantly from that of gas-powered vehicles, specific precautions must be taken to avoid or stop potentially hazardous behaviour. At the point when the electric vehicle remains set up it is totally quiet. To forestall coincidental development through enactment of the drive circuit there should be an admonition gadget. Methodology access should be appropriately coordinated to stay away from conceivable mischief through inordinate force, amperage or unnecessary speed increase, and that implies that it ought to be difficult to actuate the regulator when the gas pedal is squeezed. For electric vehicles having presence of a device is required (switch) if there should be an occurrence of crises. The regulator's operation must be unaffected by external or internal electromagnetic interference. Assistant power supplies are utilized for lighting, wipers of the windscreen and other comparative weights. It is controlled by the drive battery through the DC/DC converter despite the fact that with most vehicles there is assistant battery. No matter what the power supply crafted by extra purchasers (particularly lights) should be guaranteed in all circumstances. As far as regenerative slowing down there ought to be some security references. Regenerative slowing down just works through a transmission shaft and working at exceptionally low velocities or at a halt. Now and again the degree of deceleration is restricted and is not adequate for quick slowing down. The impact of recovery slowing down can be diminished when the battery is completely energized. For these reasons essential erosion slowing mechanism ought to have the option to stop the vehicle for any reason.

VII. BATTERY AGEING

Seyed Mohammad Rezvanizaniani et al. (2014) identified that the characteristics of the electrolyte, anode, and cathode, as well as the layout of the battery's component parts, alter irreversibly during maturation processes. The battery maturing interaction can be divided into two classes: those that involve slow debasement over time that can be monitored, and those that have no discernible mode or symptom until a significant problem or rapid changes in battery performance occur. Dendrite formation in lithium-particle batteries serves as one example of this. When a battery ages, minute lithium particles form a fiber structure called dendrite on the carbon anodes of the battery, which can result in a battery fire. When that happens, short circuits may also occur, which results in horrifying battery failure and unanticipated temperature increases. Such sudden shifts can be viewed as a serious threat to the batteries' health. However, the focus of this study will be on consistent execution failure in batteries.

VIII. DEGRADATION FACTOR

Seyed Mohammad Rezvanizaniani et al. (2014) also identified that how the battery works decides its exhibition and corruption instruments. Wenzl et al. has distributed a definite conversation and investigation concerning how the working environment's pressure factors can affect battery life and degradation. Stress factors are defined as quantifiable components or altered scalar factors that are obtained from a time series of battery operating variables such as voltage, current, temperature, as well as SOC (State of Charge). Recently, several experts have made an effort to define battery corruption variables, specifically to assess the effect that these aspects have on battery remaining useful life (RUL), as well as how they can increase battery displaying. The following are the most important corruption aspects in the application of cars, taking into account this space:

-Temperature of the climate
-Disclosing the current rate
-Time intervals between full charge cycles;
-Profundity of Release (DoD);
-Charging Rate (rapid charging);

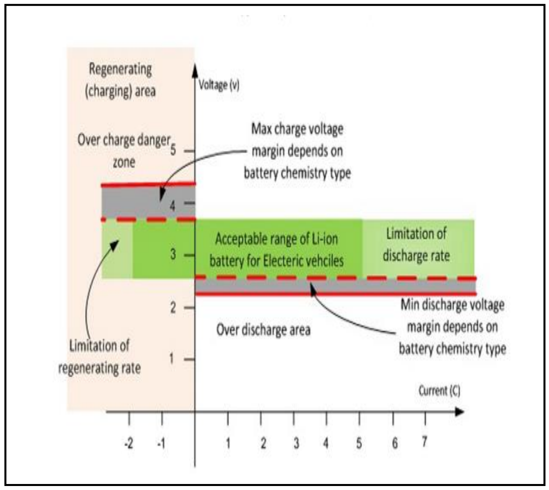

Fig. 1 Li-ion battery discharge and charge rate stress factors

The Li-particle battery's most well-known current and voltage range is depicted in Figure 1. The y hub displays the voltage (v), while the x hub discusses the current in relation to the battery's theoretical limit (C-rate). Certain current values represent the release cycle, whereas negative current characteristics are comparable to charging or recovering cycles. If the battery voltage exceeds the maximum characterized charging voltage, cheating will occur; if it falls below the characterized cut-off release voltage, over releasing will occur. As a result, there are two fundamental boundaries (black zones), which vary depending on the type of Li-particle battery (for example, the maximum voltage for $LiCoO2$ is 4.35 v, and the maximum voltage for $LiFePO4$ is 3.7 v). Batteries were designed to operate within a certain range; thus, any overcharging or discharging might hasten battery deterioration and shorten its lifespan. However, the rate of battery degradation in the appropriate range is not constant and depends on the rate of charge or release (stress factors). Normally, the release rate is very dynamic and straightforwardly relies upon the working condition. The, as a matter of fact, release rate relies upon the incline of the course, the heaviness of the vehicle, and the speed and speed increase of the vehicle. Generally speaking, EV planners set an edge to restrict the most extreme release current rate. The rate of charge is fairly stable throughout the charging system. A greater charging rate can charge the battery more quickly, but it can also result in a shorter battery life. Therefore, designers try to strike a balance between the charging rate and potential effects on battery life; this adjustment process affects the rate of charge available in charging stations (such level 1 and level 2). This rate is constrained during the charging process by the battery management system (BMS). Additionally, the battery charging process is quite sensitive to environmental temperature. The ideal range of temperature for charging lithium-ion batteries is depicted in Figure 2. In Ref., the authors demonstrate how anode film formation can be used to examine how ambient temperature affects battery cycle life.

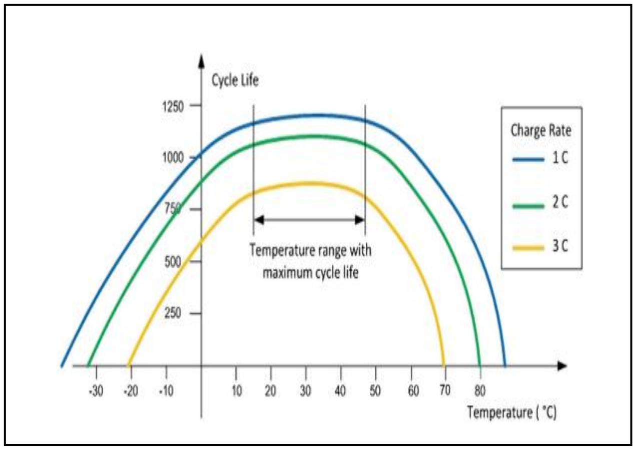

Fig. 2 Temperature and charging rate affect lithium-ion battery life.

Low temperature decreases battery duration because of a subsequent expansion in internal opposition, in any case, in higher temperatures, not in the least does the existence of battery decline, yet in addition the gamble of horrendous disappointment is more prominent, which is a basic wellbeing issue. For instance, two LiFePO4 cells were studied by Dubarry et al. at 25 and 60 degrees Celsius. The experiment demonstrates that LiFePO4 resistance for the battery at 60° C is significantly higher than that for a battery tested at 25° C.

IX. MONITORING BATTERY HEALTH DIFFICULTIES

Yinjiao Xing et al. (2011) presented that since the complex electrochemical cycles in batteries are difficult to see by any immediate estimation, the majority of battery observational methods rely on identifying the primary factors that become apparent during activity and providing accurate and realistic information about the internal battery compound responses. These observed factors may routinely include information calculated at the cell or bundle level that is potentially related to battery problems. Some studies lay out prognostic forecasts based on factors that are continuously obtained or calculated from a designated exploratory cycle in which the battery is exposed to a defined testing procedure under controlled conditions. These parameters include battery temperature (Tb), ambient temperature (Ta), internal battery resistance (R), voltage (V), current (I), and activity time (t). This method can help prevent noise in the information that is gathered as well as estimation susceptibility due to startling battery conduct that cannot be calculated during complete charge and release schedules. This method can provide a much more accurate and useful assessment of the battery's health. The main drawback of this approach is that internet access is not possible during normal battery operation. The most effective and simple method for determining battery conduct in the majority of real-world applications depends on monitoring battery voltage, current, temperature, and occasionally pressure. A portion of these factors can be estimated during battery activity without interference of the principal usefulness of the gadget; this is alluded to as online estimation. These web-based estimations actually experience the ill effects of sign commotion, unsettling influences and low quality, which can be a consequence of corrupted sensors from brutal workplaces. In this way, the prognostic exertion of assessing the battery wellbeing from on the web observing can prompt off base outcomes. Another problem with this strategy is that it depends on the accuracy and precision of the sensors being used, which might affect the outcomes of any observation or forecast. For instance, if a voltage sensor's accuracy is just 0.1 V, it won't be able to detect changes inside of 0.01 V, which will affect how the impedance is calculated. Additionally, depending on how long the battery will last, it might be necessary for the battery pack to respond to a blackout within a few seconds or milliseconds to prevent the loss of crucial data. In these cases, information obtaining frameworks ought to have the option to record crude information at a high recurrence. Generally little mistakes will collect over the long run, adversely affecting the precision of results particularly in deciding the condition of charge.

X. BATTERY HEALTH MONITORING

Yinjiao Xing et al. (2011) also presented that specific personal conduct requirements will typically be present in the rudimentary information available from a battery and should be highlighted. Many components from the incomplete information can be eliminated. Not all highlights will be debasement-related highlights, which are explicit components in the raw data that vary depending on the thickness of the battery's inner compound component. The most useful details should focus on observable battery performance trends and be related to the real causes of degradation in light of electrochemical reactions within the battery. The engineering, load profile, and control are categorically susceptible to their life and the associated components of disappointment.

XI. DANGEROUS AFTER EFFECTS OF RAW MATERIALS

Tobias Elwert et al. (2016) proposed that due to their financial importance and supply risk, all parts utilized in HEV comprise components that the European Commission currently classifies as basic crude materials (Figure 3). These mostly include cobalt (in NiMH and LIB batteries), light REEs (in NdFeB magnets and NiMH batteries), dysprosium of the heavy REEs (in NdFeB magnets), gallium, antimony, and palladium of the platinum group metals, which are or may be used in (future) power hardware. Furthermore, Elsner et al. have recently expressed growing concerns about the future tin availability. According to the EU criticality analysis, tin is close to being basic. The cobalt market is typically small (112,000 t in 2014) and is characterized by rapid annual growth rates. In 2014, the Republic of the Congo under majority rule was where half of the mines were first developed. The other half is distributed fairly evenly among more than ten other countries. Despite the fact that cobalt deficiency is not typical in the coming years, cobalt is nevertheless seen as essential due to the political instability of the primary producer.

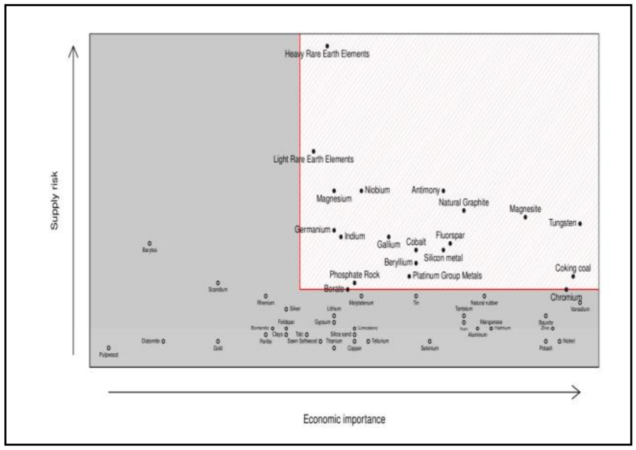

Fig. 3 The important raw materials are highlighted in the red shaded (upper right) criticality zone of the graph as a result of the 2013 EU criticality assessment.

In 2012, battery synthetic compounds accounted for 38% of the cobalt production. The current characteristics of layered oxides make it difficult to replace cobalt completely in the cathode materials of LIBs. Even though REEs are fairly common components that can be found in many different retailers throughout the world, China has almost achieved a monopoly for REEs thanks to a state-run unpolished components strategy. This agreement has increased costs and supply risks for REEs outside of China. Due to the (re)opening of mines outside of China that mostly contain light REEs, there is currently a small facilitation of the market for light REEs. China continues to have complete control over the large REE market. REEs are of low importance in relation to (H)EVs as REE demand for NiMH batteries is waning and alternatives exist for REE-containing coordinated engines. However, the widespread adoption of electromobility will result in areas of strength for an interest in neodymium and dysprosium on the off chance that simultaneous engines will be the defining innovation in future (H)EVs. For the most part, it can be said that the impact of force hardware for (H)EVs on the need for electronic metals is minimal. Buchert et al. only predicted a possibly major impact on the general desire for gallium. Supply gambles benefit fundamentally from strong supply convergences due to palladium and antimony. 74% of the 190-t extricated palladium and 78% of the 160,000-t antimony were mined in Russia and South Africa, respectively, in 2014. 52% of the 296,000 t of tin produced annually in 2014 were used in bindings. Elsner et al. predict a gap between market interest from 2018 onwards due to a typical decline in Peruvian and Indonesian tin productions that is mostly brought on by the exhaustion of some stores. This deficit is probably not going to be compensated by new mining ventures in the short to medium term. Lithium needs to be carefully examined even if it is currently not regarded as essential by the EU criticality assessment and most tests because there is no practical substitute for lithium used in batteries. Moreover, the realized stores are moved in couple of nations.

XII. POWER ELECTRONICS

Tobias Elwert et al. (2016) also said through his framework that currently, only one research project in which the founders are active oversees the recycling of power devices from (H)EVs. The project is sponsored by the German Government Service for the Climate, Nature Preservation, Building and Atomic Wellbeing and is categorized as "Reusing of electric vehicles 2020 — Key part power hardware". The project's initial findings show that continuous power devices can be used in the same way as other types of electronics. That means that after comminution to separate the individual elements, there will be grouping and arrangement to produce attractive metal concentrates for further metallurgical handling. In any event, this doesn't actually mean that there isn't a need for study because there will likely be a lot of changes in the next years. For instance, the electric engine's probable combo of force hardware would necessitate brand-new destructing concepts. The use of GaN semiconductors rather than SiC- or Si-based semiconductors could lead to the development of another test. Due to the relatively small size of the gallium market, observable effects can be expected in the event of a strong market debut. First studies on the recycling of gallium nitride-containing semiconductors reveal that due to the low gallium sum per unit and complex assemblies, a profitable gallium extraction will be challenging to complete. Furthermore, it should be noted that many other electronic metals, such as antimony and tantalum, are inaccessible to the current electronic piece recycling techniques, which focus mostly on copper and precious metals.

XIII. TYPICAL FIRE ACCIDENTS ASSOCIATED WITH HEV'S

Peiyi Sun et al. (2020) gathered information and their paperwork says that risk assessments for electric and hybrid vehicles may take into account the known causes of harm seen in the scant occurrences of adverse events and accidents connected with them up to this point. Models of electric vehicles that caught fire during an accident or in carports where they were stored have been identified. This occasionally happened as the car's batteries were being charged. The vulnerability associated with a battery that supported mechanical damage is the most worrying issue, regardless of how such vehicles are used. Sometimes the connectors may be damaged, and some or all of the battery sections may lose their mechanical or electrical correspondence. Simultaneously, an obscure measure of charge might stay in the battery cell framework. For this situation, taking care of and eliminating a harmed battery turns out to be undeniably challenging. Because the carbon compounds in a damaged battery may be flammable, problems with the battery's breakdown may manifest as an electrolyte spill or even as the battery's ignition. Similar risks could be posed by dangerous particles and high temperatures. The observed temperature values due to a failing battery are more than 1200° C. In order to do this, tests are being developed that imitate various ecological, mechanical, and electrical contexts in which the batteries would operate. According to reports, the most severe fire incident occurred in 2011 when a Chevrolet Volt passed an accident test at the MGA research center. As a side consequence during a segment of the NCAP test at 30 km/h, the batteries caught fire three weeks later. Adjacent automobiles were instantly damaged by the fire. It was discovered that a small amount of coolant that accidentally entered the high voltage battery packaging during the impact caused a short out, which in turn caused an uncontrollable increase in temperature. After Sandy Storm made landfall at the port of New Jersey in 2012, the flood engulfed and destroyed sixteen Fisker Karma electric cars. One vehicle's battery experienced a short, which led to an uncontrollable rise in temperature. Then the fire spread, causing the cremation of fifteen other nearby vehicles. In addition, it was stated that two Tesla model S automobiles caught fire in 2013 while being driven in the USA (Figure 4).

Fig. 4 Tesla S vehicle on fire as a result of battery penetration and a short circuit.

Depending on the type of disaster (e.g., fire, collision, floods), emergency responders must adhere to specific criteria for handling several types of typical battery systems, including lead acid, nickel-metal hybrid, and lithium-ion. Although the manufacturer's literature provides instructions on how to handle these batteries, they are not always consistent or easy for emergency personnel to access. The risks encountered by first responders and towing services in incidents involving electric vehicles have been highlighted by the Society of Automotive Engineers (SAE), including the possibility of electric shock from damaged systems. SAE advises electric vehicle makers to include switches that, in the event of an accident, turn off the battery, with defined switch locations for security. Operators of towing services should also undergo thorough training on how to handle hybrid and electric automobiles. Safety can be further improved by providing emergency responders with simple access to battery information and standardizing the placement of battery deactivation in all electric and hybrid cars. It's also crucial to remember that at low speeds, the noise produced by electric and hybrid vehicles is very low. For visually handicapped pedestrians who depend on traffic sounds for orientation, this absence of noise presents a problem. To solve this problem, hybrid and electric cars should have a warning system that alerts pedestrians to their existence and motion. Due to their tiny size and potential for urban mobility, the use of small light electric vehicles (SEVs) is expected to grow significantly over the next 20 years, thus it's important to take into account their particular safety requirements. Short front and rear overhangs are one of the distinctive features of SEVs, which are intended for less than five passengers. Collisions between SEVs, at-risk road users, and larger vehicles will be different from collisions with conventional vehicles. To ensure the safety of SEVs, future legislation must place a high priority on protecting vulnerable road users, being compatible with heavier vehicles, and incorporating innovative active safety systems.

XIV. PROTECTION AGAINST DIRECT CONTACT

Fabio Freschi et al. (2017) paper proposed that Effective insulation of live electric vehicle (EV) components, such as insulated wiring and enclosures, ensures the protection against direct contact. This insulation must be appropriate for the operating voltage of the system and should only be destroyable. Electric vehicles function as electrical systems with their source separated from the ground when they are not connected to the power source (i.e., when they are not charging). As a result, coming into contact with a live component won't cause dangerous currents to pass through a person. However, people may be at danger for electric shock if the insulation of live components deteriorates and they are concurrently accessible and attached to opposite terminals of the battery. This is due to the possibility that the operating voltages of the EV may exceed the safe voltage limit that has been traditionally defined; in general, voltages that exceed 30 volts of alternating current (AC) and 60 volts of direct current (d.c.) are hazardous and categorized as high voltages.

According to the reference given, it is possible to check for any loss of isolation by keeping an eye on the degree of insulation between the high-voltage source(s) and the conductive structure of the EV chassis. When the EV is not moving (for example, when the key is removed and the EV is in park mode), the source(s) from the power train or the rest of the power train can be automatically disconnected using this monitoring.

When the negative terminal of the battery is connected to the vehicle's chassis, which serves as the EV's conductive structure and is not powered during normal vehicle operation, the risk of electric shock increases. A person who is already in contact with a part that is at positive terminal potential is more likely to come into contact with the chassis in this case because of the vast conductive surface of the EV. The likelihood of the chassis briefly and inadvertently grounding rises with the connection between the battery's negative terminal and the chassis in place, as a result of contact with a car jack during a tire change or a person reaching underneath the hood for repairs, for example. Under these conditions, the source is no longer isolated from the ground, rendering a single-terminal contact just as perilous as a two-terminal contact.

XV. CONCLUSIONS

All in all, this review paper has dove into the basic topic of electrical part security inside electric and half and half vehicles. The fast development of car innovation has introduced another period of supportability and effectiveness, yet it has additionally highlighted the foremost significance of guaranteeing the security of these advancements. The investigation has featured the diverse idea of security concerns, going from battery the board frameworks to wiring respectability and electromagnetic impedance relief. By basically looking at existing exploration, guidelines, and administrative measures, this audit highlights the steps made in upgrading the security of electrical parts in electric and mixture vehicles. In any case, it is obvious that as these advances keep on progressing, continuous exploration and coordinated effort between makers, controllers, and scientists stay critical to address arising security challenges successfully. At last, protecting the prosperity of the two tenants and the climate requires a thorough methodology that coordinates mechanical development, thorough testing, and persistent cautiousness.

Conflicts of Interest: "The authors declare that they have no conflicts of interest to report regarding the present study."

REFERENCES

[1]. Fabio Freschi, Riccardo Tommasini and Massimo Mitolo, "Electrical Safety of Electric Vehicles.", IEEE, 2017 -PSEC-0063.

[2]. FREDRIK WALDERYD, "Hazard identification and safety goals on power electronics in hybrid vehicles", Chalmers University, SE-412 96 Göteborg, 2010.

[3]. Peiyi Sun, Xinyan Huang, Roeland Bisschop and Huichang Niu, "A Review of Battery Fires in Electric Vehicles", Fire Technology, 2020-Springer.

[4]. Seyed Mohammad Rezvanizaniani, Zongchang Liu, Yan Chen and Jay Lee, "Review and recent advances in battery health monitoring and prognostics technologies for electric vehicle (EV) safety and mobility", Journal of Power Sources 256 (2014) 110e124.

[5]. T A Stevan Kjosevski MSc, Ass. Prof. Aleksandar Kostikj PhD, Prof. Atanas Kochov PhD, Ss. Cyril and Methodius University in Skopje,"RISKS AND SAFETY ISSUES RELATED TO USE OF ELECTRIC AND HYBRID VEHICLES", stumejournals, YEAR II, ISSUE 1, P.P. 37-40 (2017).

[6]. Tobias Elwert , Daniel Goldmann, Felix Römer , Matthias Buchert, Cornelia Merz, Doris Schueler and Juergen Sutter, "Current Developments and Challenges in the Recycling of Key Components of (Hybrid) Electric Vehicles", mdpi, ISSN 2313-4321, Recycling 2016.

[7]. Wojciech Zakrzewicz, Ewa Sys, Adam Mrowicki, Krzysztof Siczek and Przemyslaw Kubiak, "Safety issues for electric and hybrid vehicles", IEEE, 2020, European Union.

[8]. Yinjiao Xing 1, Eden W. M. Ma, Kwok L. Tsui and Michael Pecht, "Battery Management Systems in Electric and Hybrid Vehicles", mdpi, ISSN 1996-1073, Energies 2011.