ENGINEERING CHALLENGES IN EV SAFETY

REPORT

TEAM

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Contents

1.Fire involving EV vehicles worldwide

Electric Vehicles	India	China	UK	USA
2 Wheelers	28			
3 Wheelers	21			
4 Wheelers		86	81	152
Buses	1	5	1	

Table 1.1

- Statistics on EV fire incidents received from Norwegian Insurance companies.(Table 1.2)

Insurance Company	Total No. of vehicle Fire incidents	No. of EV fire incidents(percentage of total)
A(2006-2016)	567	27(4.8%)
B(2014-2016)	499	13(2.4%)
C(2016)	386	9(2.3%)

2.Region-wise break up on fires in India

Table 2.1

Electric Vehicles	North Zone	South Zone	East Zone	West Zone
Ola Electric				1
Pure EV		3		
Jitendra EV				20
Okinawa Autotech		3		
Boom Motor		1		
Multiple e rikshaw manufacturers	21			

3.Market leaders in battery management system (bms)

1. **Lithium balance:-**It is a leading manufacture of battery management system.[A] It manufactures four types of battery management system.

	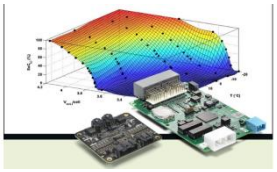	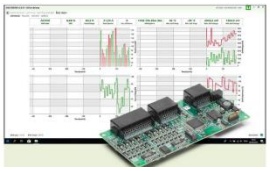	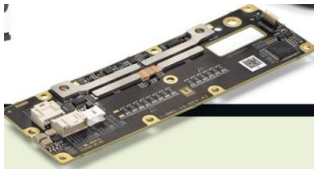
s-bms	**n-bms**	**c-bms**	**i-bms**
Distributed system.	Distributed system.	Integrated system	Integrated system.
8 voltage channels per slave.	12 voltage channels per slave.	Up to 24 voltage channels.	Up to 15 voltage channels.
256 cells in series.	384 cells in series.	Not required in integrated system.	Not required in integrated systems.
2 temperature channels per slave.	4/12 temperature channels per slave.	6 temperature channels.	6 temperature channels.
12-1000v	12-1000v	12-100v	17-60v
1 can channel	2 can channel	1 can channel	Parallel pack and hot swap functionality.
Pro configuration software.	Creator configuration software.	Creator configuration software.	On-board pre charge circuit,shunt,battery disconnect and power supply.

Table 3.1

2. **Analog devices inc[B]**:-The wireless battery management system (wBMS) developed by ANI and pioneered by general motors. A conventional BMSuseswires which increase development effort, manufacturing cost, and weight, while also reducing mechanical reliability and usable space. Also,wired packs must be assembled and the connections terminated manually. This is a costly and hazardous process. The advantage provided by the Analog Devices modular and scalable wBMS system platform is that an OEM can fully automate battery pack assembly. After the elimination of the wiring harness, the only connections a battery module requires are the power terminals, which can readily be made by robots in an automated process. By eliminating manual labor, OEMs also eliminate the safety risks to assembly line workers.

3. **Bmspowersafe[C]**:- BMS PowerSafe has developed a unique Hot Swap parallelization technology in its BMS (Battery Management System).

- The Hot Swap technology allows to connect battery modules during their operation. First advantage: there is **no interruption of the system**, and no discontinuity during power supply.
- The BMS does **not need an additional ECU or electronic module** to act as a master BMS. This represents a significant financial saving in the system, less space, less wiring, therefore less potential technical or service problems in the product.
- With this built-in intelligence, each BMS is potentially a master or a slave, and **this is defined automatically**.

4. **Texas instruments[D]**:-Texas instruments(ti) has developed it's own wireless bms certified by TUVSUD RAIL GmbH.

Other market leaders also manufacture their own bms solution however their technology is same as lithium balance bms.

4.CHARGING STATION SUPPLIERS:-

Chargepoint(USA,Europe)[E]

CP Home -This is a small home charger that won an Edison Award for new product innovation and human-centered design. It is available in 16A and 32A versions.

CT4000 Family - The CT4000 is intended for property owners, businesses and municipalities providing charging stations for their employees, customers, residents and fleets. It was the first to support power sharing along multiple ports.

CP4000 Family - Three phase Mennekes charging for Europe, up to 22 kW. Can share a single three phase 63A circuit or use two separate 32A circuits.

CPE 100 and CPE 200 - ChargePoint Express DC fast chargers offer fast charging for most DC-capable electric vehicles. With an embedded AC-to-DC converter, they directly charge the vehicle battery and can charge some EVs in less than 30 minutes. Express stations are particularly suitable for short dwell time parking, freeway corridor locations and quick turnaround fleet charging. Express 100 is 24 kW, Express 200 is 50 kW, and Express 250 is 62.5 kW.

CPF25 Family - The CPF25 is designed for select fleet and multi-family applications. For fleets, CPF25 stations are suited for depot charging. For multi-family communities, CPF25 stations are intended for personal charging in assigned parking spots. **CPF32** is a European Type 2 version (still limited to single phase 32A charging). The **CPF50** added 50A charging support.

Tesla(USA)[F]

Tesla supercharger:-A **Tesla Supercharger** is a 480-volt DC fast-charging for EV's. Supercharger stalls have a connector to supply electrical power at maximums of 72 kW, 150 kW or 250 kW. Tesla claims it takes only 15 minutes to reach 80% charge.

Tesla destination or Wall connector chargers-,which are located places that a driver may stop for reasons other than charging, such as hotels, restaurants, and shopping centers. These chargers are slower (typically 22 kW) than Superchargers, and are intended to charge cars over several hours while the driver conducts other business.

Exicom power solution(India)[G]

Quick charger:-Exicom's Quick Charger 6kW/9kW is an industrial grade DC charger and suitable for Li-ion battery based passenger cars, E-rickshaws, E-Autos for fast charging scenarios. Optional RFID and remote communication allow for authentication and connection to network for doing analytics, upgrades and dynamic pricing. Its high conversion efficiency of over 95% saves electricity usage and makes owning of battery powered vehicles cheaper when compared to traditional chargers.

Multi standard:-Exicom's Harmony multi standard fast DC charger is all in one electric vehicle charging solution and with 3 output connectors complying with CHAdeMO, CCS and Type 2 AC, it serves all types of vehicles and charging needs. Single design can provide flexibility to accommodate anywhere between 30kW-200kW. These chargers come with connected services to allow integration with payment platforms or smart electrical systems apart from housekeeping functions such as remote upgrades, diagnostics etc. These are ideal for highways, fleet operations, parking etc.

Gbt:- Exicom's Harmony GB/T fast DC charger has wide output voltage range of 200Vdc to 750Vdc allows to charge all types of vehicles from entry level passenger cars to heavy commercial vehicles. High efficiency modular power converter configuration allows easy field upgrades and maintenance.

Bharat ev:- Exicom's Harmony DC-001 EV charger is an ideal product for charging vehicles with battery voltage < 100V. The charger supports high current output of up to 200A for fast charging . Wide output voltage range allows these assets to be used for charging anything from a 2 wheeler to a passenger car while optional configuration of 1 or 2 guns provides the required flexibility. High efficiency modular power converter configuration allows easy field upgrades and maintenance.

5.**Risk concerns[H]**

"From supply chain networks to production processes to the product itself — the automotive industry will have to respond to many emerging risks to make e-mobility happen, including data quality, weather issues and cyber risks, to name just a few," says Daphne Ricken, Senior Underwriter Liability at AGCS

PIC1[I]

The fire scene of a Lifan 650 EV, where the fire started at the battery pack installed in the vehicle chassis, and EV was completed destroyed by fire without effective fire suppression [106]

FIRES

A number of fires involving EVs have attracted headlines in recent years, although there is no evidence to suggest that EVs pose a higher fire risk than conventional vehicles. However, there are aspects of the technology that present different, and as yet undetermined, risks.

As with conventional vehicles, defective electrical and short circuits can spark a fire, while lithium-ion batteries may combust when damaged, overcharged or when subjected to high temperatures. When they do burn, high voltage batteries can experience a chain reaction known as thermal runaway, where one cell ignites another, causing yet higher temperatures and further cells to combust. Improved battery control systems and cell technology, however, have made batteries safer and more resistant to thermal runaway, and battery management systems are designed to prevent overcharging

Once ignited, high voltage battery fires can be very intense and difficult to extinguish, and can also release high levels of toxic gases. Fires involving EVs are typically hotter, take longer to control and are prone to reigniting — an EV fire can take 24 hours9 or longer to control and be made safe enough to move the vehicle. Due to the relative rarity of EV fires, first response and rescue services have limited experience dealing with such incidents, and good data and information on dealing with an EV fire event is lacking.

DIFFERENT WEATHER CONDITIONS

In coldtemperatures, the battery's internal resistance increases. This resistance can promote the growth of metallic dendrites to take place within the battery, which increases the chance for a battery fire to be triggered.In high-temperature conditions, some unwanted chemical reactions can occur and result in overheated batteries. With a poor thermal dispassion ability, it is then possible to trigger a thermal runaway. Investigation showed that the EV had soaked in water for more than 2 h after a heavy rainstorm which caused water to leak into the battery pack. Afterward, when the owner drove the vehicle, this leakage may have caused short-circuit inside the battery pack and thus causing thermal runaway and fire.

BATTERY ISSUES

Battery life and performance are a critical issue for EVs. High voltage battery cells have a limited lifespan, which today is around 7 to 9 years in service. However, battery life is dependent on a variable number of factors, such as how they are charged and discharged, operating temperature and cell chemistry. The regular use of rapid charging, for example, shortens the life of a battery. Given the high cost of replacement, the health of batteries is one of the most challenging issues for claims handling, especially in terms of residual value or warrantied characteristics. The concern for insurers, however, is a lack of data on the speed at which a battery's capacity declines. A failure to live up to performance guarantees will pose questions around liability for manufacturers and suppliers, as well as the cost of repair or replacement of battery units. If the defective part in the battery pack can be clearly identified, the liability then will fall back to the supplier or subsupplier of the defective part. However, if this cannot be proven, the issue of replacing and disposing of the battery pack would then stay with the car manufacturer.

Battery producers are under pressure to promise longer warranties but we know it will take time to develop and test the technology in field conditions. As we already see with our mobile phones, battery performance can vary greatly depending on how they are charged, usage and on updates. As yet, the best charging strategy for EVs has not been determined,says Ricken.

6.Correlation of technology with published literature

Fire prevention method for lithium ion batteries[J]

Cathode Materials

Cathode materials mainly include $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$, $LiFePO_4$ and so on.When the surface of cathode materialsis coated with oxides such as MgO, Al_2O_3, SiO_2, TiO_2, ZnO, SnO_2, ZrO_2, and other materials, the coatings prevent the direct contact with the electrolyte solution, suppress phase transition, improve the structural stability, and decrease the disorder of cations in crystal sites. As a result, side reactions and heat generation during charging are decreased.

Recently, a novel temperature-sensitive cathode material, $LiCoO_2$@P3DT was reported by Xia et al. This material has function of protect itself from thermal runaway at elevated temperature of 110 °C, which is good way to avoid the thermal runaway.

Anode Materials

The thermal decomposition of the SEI(Solid Electrolyte Interface) is the most easily triggered chemical reaction in lithium ion cells and plays a critical role in determining the battery safety. The SEI can be modified by mild oxidation, deposition of metals and metal oxides, coating with polymers and other kinds of carbons. Through these modifications, the surface structures of the graphitic carbon anodes are improved. As a result, the direct contact of graphite with the electrolyte solution is prevented, its surface reactivity with electrolytes, the decomposition of electrolytes, the co-intercalation of the solvated lithium ions and the charge-transfer resistance are decreased, and the movement of graphene sheets is inhibited.

Electrolyte Material

way to improve the stability of electrolyte is to change the compounds of solvent and lithium salt, which also should be guaranteed has good compatibility with the electrodes. Lithium bis(oxalate)borate (LiBOB)/γ-butyrolactone (GBL) based electrolyte was proposed recently. Ping et al. found that the 1 M LiBOB/GBL + dimethyl sulfite (DMS) (3:1 wt.) electrolyte mitigates the irreversible capacity and enhances the first coulomb efficiency and the capacity retention. The thermal stability of LiBOB/GBL series electrolytes are improved greatly than that of $LiPF_6$/EC + DEC electrolyte. These beneficial effects make LiBOB/GBL possibly to be a promising alternative electrolyte for lithium ion battery.

Safety devices

Thermal fuse permanently shut down the battery if it is exposed to excessive temperatures. Thermal fuses are employed as protection against thermal runaway and are usually set to open at 30–50 °C above the maximum operating temperature of the battery.

To provide safe operation and optimum performance, these large lithium ion battery packs must be supervised by an electronic BMS that monitors and services each of the individual cells. The

features of a BMS includes data acquisition, battery state determination, electrical management and thermal management, safety management. An advanced bms can increase the cooling rate and inform the user of thermal runaway to minimize casualties.

ALTERNATIVE OF BATTERIES[K]

A capabus in Kai Tak, Hong Kong

Using capacitors instead of batteries to store energy in form of electric fields. As of 2010, the best ultracapacitors can only store about 5% of the energy that lithium-ion rechargeable batteries can, limiting them to a couple of miles per charge. This makes them ineffective as a general energy storage medium for passenger vehicles. But ultracapacitors can charge much faster than batteries, so in vehicles such as buses that have to stop frequently at known points where charging facilities can be provided, energy storage based exclusively on ultracapacitors becomes viable.

Sinautec estimates that one of its buses has one-tenth the energy cost of a diesel bus and can achieve lifetime fuel savings of $200,000. The buses use 40% less electricity even when compared to an electric trolley bus, mainly because they are lighter. They do not catch fire as easily as lithium ion batteries and no problem of thermal runaway.The buses can also capture energy from braking.

Sinautec is in discussions with MIT's Schindall about developing ultracapacitors of higher energy density using vertically aligned carbon nanotube structures that give the devices more surface area for holding a charge. So far they are able to get twice the energy density of an existing ultracapacitor, but they are trying to get about five times. This would create an ultracapacitor with one-quarter of the energy density of a lithium-ion battery.

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