International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 05 | May 2022 www.irjet.net p-ISSN: 2395-0072

Design of Durable Battery for Electric Vehicles with Hybrid Battery Thermal Management System (HBTMS)

Rakesh Kumar Shah[1], Habib Dhuniya[2], Pankaj Yadav[3], Prabin Mahato[4]

[1]*Final year Aeronautical Engineering Student, Excel Engineering College*
[2-4]*Final year Mechanical Engineering Student, Excel Engineering College*

Excel Engineering College, Tamil Nadu, India

Abstract - *Battery durability and Battery Thermal Management System (BTMS) are ever-present challenges within the Electric Vehicle engineering industry. Although, the electric vehicle fueled by lithium-ion battery has become a hotspot in the international electric vehicle market yet it has been working in research and development of the heat dissipation scheme of the battery so that it can solve the problem of large amount of heat generation when they are used, resulting in an increase in the temperature of the battery that not only hampers the performance of the battery, but also the durability of the battery and the safety of the battery. This paper presents two substantial lithium-ion battery problems (i.e. battery durability and battery thermal management system) along with the alternative solutions (i.e. powering the electric vehicles through either Solid State Batteries (SSB) or Nano-wire batteries). Thus, this paper also explored two novel solutions for increasing the battery lifespan and heat dissipation to attenuate the effects of temperature and excessive heat generation, during the over-usage of battery. Despite of being faced by some challenges while carrying out the research and validating with model, the study concluded that the battery life was highly increased and temperature management was also solved to a huge extent.*

Key Words: **Battery durability, Battery thermal management system, Nano wire batteries, heat dissipation, Solid state batteries etc.**

1. INTRODUCTION

Due to the increasing interest and attraction of people towards sustainable and zero emission energy system, many vehicle manufacturers are carrying out research in battery, its compositions, working principle, heat dissipation phenomenon and effects of temperature on battery's performance and lifespan. Electric vehicles, which are fueled by lithium-ion battery presently not only are the means of road transport but also are playing a significant role for motivating and encouraging public towards green and zero emission energy system which is the indeed demand of present scenario. Due to the increasing demand of lithium-ion battery in various applications in almost all the electronic equipment used today, they either need to be designed in manner such that all the parameters can meet and satisfy today demands or to be replaced with some other alternative source that can perform better than it and provide sustainable durability. Therefore, after a lot of research and in-depth study and analysis comes an idea of incorporating either solid state batteries or nano wire batteries that can not only provide a better performance than existing lithium-ion batteries but also ensures the whole temperature of the battery in the ideal temperature range, by conforming the temperature difference between each battery monomer is within the acceptable range or not.

2. Literature Survey

Several research and analysis have been carried out by researchers and manufacturers regarding electric vehicle battery and a lots of research papers have also been published over the decades. Considering them as references, we also studied and carried out a little but deep research regarding the batteries used in EVs from the early day to present day. Actually, it is very difficult to pinpoint the invention of the electric vehicle to a single innovator or nation. Rather it was a series of breakthroughs starting from the battery to electric motors -in nearly 18th century that led to the first practical electric vehicle on the ground to be tested and operated. The first battery used in electric vehicle in ancient era was lead acid battery but due to its lots of disappointing disadvantages such as heavy and bulky size but with limited cycle life, limited useable capacity, huge charging time, frequent and periodic maintenance requirement. This is the main reason that led researchers and manufacturers to carry out further investigation, research, experiments and come up with an idea to solve this problem. And finally, after a lot of researches and performance analysis the researchers came up with an idea of powering the electric vehicle through lithium-ion battery instead of lead acid batteries. And this breakthrough of fueling the vehicle by lithium-ion battery impeccably transformed the faith of electric vehicle. Although it is being used till today's date also but there are some aspects of it which needs to be given much more importance while manufacturing it due its few issues such as thermal management system and its durability.

The below given chart defines the future global electric car sales in 2030 by considering two potential scenarios: 23 million units in the New Policies Scenario and 43 million units in the EV30@30 Scenario.

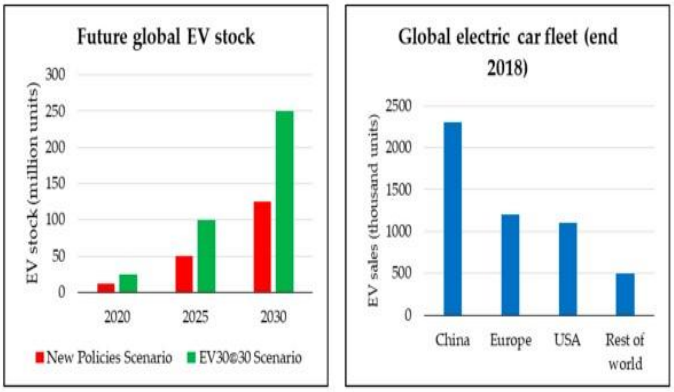

Fig 1. Global EV stock in 2020–2030 period and global EV sales in 2018.

2.1 Working Principle of Lithium-ion battery

As we all know that a typical battery normally compromises of two electrodes i.e., cathode and anode where cathode forms the positive terminal and anode forms the negative terminal of the battery. Here, in case of lithium-ion battery lithium compound is used as cathode whereas the graphite is core element for anode. Whenever the battery is plugged in with an electric supply, the lithium ions tend to move from the positive electrode i.e., cathode to the negative electrode i.e., anode. Thus, this phenomenon is known as charging the battery. Similarly, during discharging of the battery, the movement of lithium ions gets exactly reversed i.e., from anode to cathode thus the electrical energy gets transferred to the attached load. Due to the movement of lithium ions back and forth between the two electrodes of the battery, thus the working principle of lithium-ion battery is also termed as "Rocking Chair" principle.

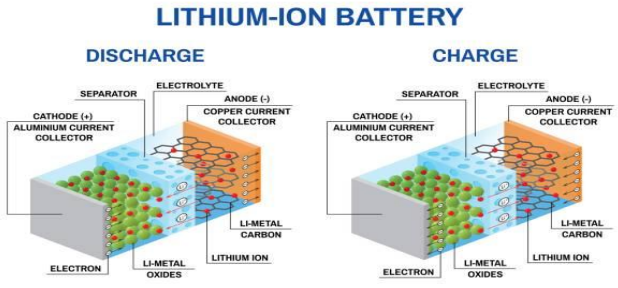

Fig 2. Working principle of lithium-ion battery.

3. Problem Definition

The future is here after the introduction of electric vehicles in commercial market since it has solved the most significant problem of environmental pollution through its zero-emission technology. One of the main challenges that is associated with buying and owning an electric vehicle is its range anxiety, the other problem being temperature management of the battery during its functioning. Although the sales of electric vehicles have been increasing significantly, but they are found to be used for intra-city travelling only. In order to increase the utilization limits and allow people to travel across city limits, the long-haul travel issue along with temperature management system needs to be addressed. Even with the current challenges, electric vehicles show huge potential to reduce our carbon footprints and provide a cost-effective mode of transportation. And therefore, the only way to contribute towards this growth process is to buy an electric vehicle.

4. Research objectives

- ✓ To provide an alternative battery system to avoid range and temperature management issues.
- ✓ By using electric energy as source of fuel, that emits zero-emission, it also caters to the eco- friendly and sustainable environment.
- ✓ To achieve enhanced battery performance and controllable temperature management system.
- ✓ To keep the future environments free of carbon footprints and environmental pollution.

5. Design Philosophy

Through the in-depth study, research and analysis, we came to know that an alternative solution must be brought instead of lithium-ion battery in electric vehicles in order to satisfy the vehicle owners with its range, charging speed and temperature management system. For this, we decided to propose a solid -state battery, the reason is that lithium -ion battery contains a liquid electrolyte while a solid -state battery contains a solid one as its name suggest itself. This is the reason that allows solid state batteries to be lighter, have more energy density, increased travel range along with fast charging capability. Not only this but according to the researcher's statistics, it has been found that solid state battery can reach an 80 % charge within 15 minutes and can still maintain 90% of its capacity after 5000 cycles whereas in case of lithium-ion battery it starts degrading and losing power capacity only after 1000 cycles.

Along with the introduction of solid-state battery, here we introduce a noble idea of improving the battery technology by introducing a noble metal. Here the noble metal is gold that can be used in the form of nano wires and called gold nano wires since the nano wires are even smaller than the tip of hair, it helps to achieve large surface area by bundling them together so that they can offer higher storage capacity. It is even claimed that gold nano wires show no corrosion in a test of over 2,00,000 cycles which makes it the best choice against the lithium-ion battery that starts swelling only after 6000-7000 cycles.

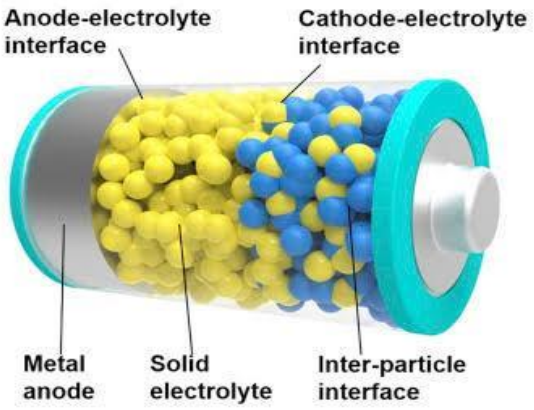

Fig 3. Solid state battery

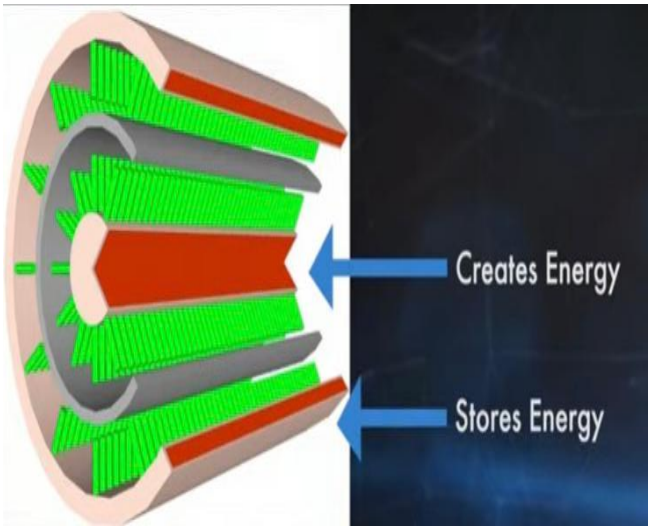

Fig 4. Gold nano wire battery

Many reseachers and battery manufacturing companies are working in the idea of replacing gold and introducing Silicon,Germanium etc so as to improve its perfomance along with cost reduction.

5.1 Battery Thermal Management System

The Battery Thermal Management System is a system which is designed to manage and dissipate heat produced during the electrochemical processes occurring in cells, allowing the battery to function safely and efficiently.The four significant functions that must be equipped in a battery thermal management system are heating,cooling, insulation and ventilation in order to ensure proper functioning of a battery.There are already a lots of cooling and thermal management system in the present electric vehicle industry .Some of them are shown in the chart below:

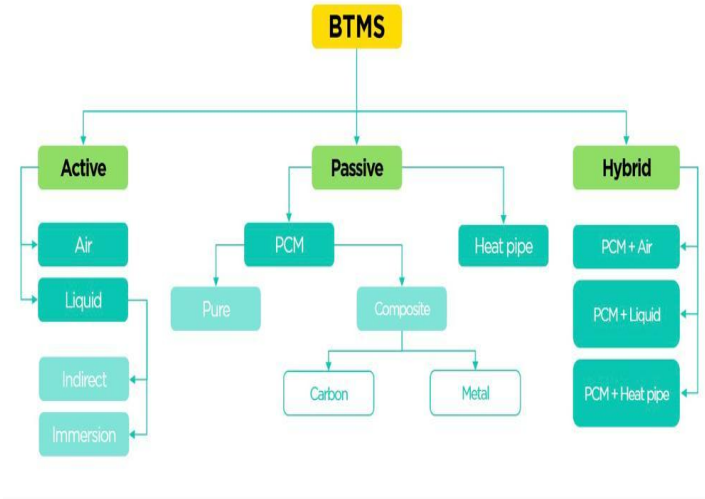

Fig 5. Types of Battery Thermal Management System (BTMS)

But here ,we proposed to use Hybrid BTMS in order to achieve the advantages of both active and passive systems. The first one is PCM with forced air ,it can be adopted in order to acquire good temperature distribution in the battery pack .The second one i.e.PCM with liquid cooling can be used so as to evacuate the heat generated to the outside .Similarly the last one is PCM with heat pipes , which is designed with the aim to improve the heat transfer from the PCM to the outside of the cells,so that the cells can be cooled through natural convection. Although the above discusses BTMS are highly effective than pure passive and active systems in managing the temperature of the battery pack but due its complex design and cost it has been a limiting factor for implementing in electric vehicles.

6.Conclusion and Recommendations

Through this paper we have discussed the importance of battery range and battery thermal management systems for electric vehicles and its industrial and commercial demands in upcoming future. Thus,Electric vehicles are the future of road transportation with the increasing dangers of climate change, global warming and environmental pollution.Electric vehicles are no more a surreal dream, but a reality,since we have already seen a lots of development and progress in the electric vehicle industry. Although a lots of modifications and improvements have been done and are still on-going in battery sector , it is recommended that still huge advancements can be achieved by improving the design of elctrode used in it by reconsidering the design ,shape ,size and type of materials utilized for battery manufacturing. It can be claimed that the cell capacity and durability can be increased by reducing the internal resistance of the electrodes in order to decrease the heat generated when the chemical reactions takes place at electrodes.Thus this paper

gives a proper review of lithium -ion battery along with its alternative option i.e solid state battery and nano wire battery with advanced battery thermal management system to cope of with present travel range and thermal management system issues.

REFERENCES

[1] Rao and S.Wang, A review of power battery thermal energy management, Renewable & Sustainable Energy Reviews 15 4554-4571

[2] Z Wan, J D Eng, B Li, Y Xu, X Wang and Y Tang, 2015 thermal performance of a miniature loop heat pipe using water-copper nanofluid Applied Thermal Engineering 78 712-719

[3] https://www.jdpower.com/cars/shopping-guides/what-is-a-solid-state-battery-for-an-electric-car

[4] T M Bandhauer, S Garimella and T F Fuller 2011 A Critical review of thermal issues in lithium-ion batteries, J.Electrochem. Soc., 158 R1-R25

[5] Valeo 2010 Battery Thermal Management for HEV & EV – Technology overview.

[6] Kai Chen, Zeyu Li and Shuangfeng Wang 2017 Design of Parallel Air-Cooled Battery Thermal Management System through Numerical Study Energies 10 1677

[7] https://electronics.howstuffworks.com/everyday-tech/lithium-ion-battery.htm

[8] Zhao, R Zhang, S Liu and Gu J 2015 A review of thermal performance improving methods of lithium- ion battery electrode modification and TMS Journal of Power Sources 299 557-577

[9]https://www.allaboutcircuits.com/news/nanowire-batteries-the-next-step-in-battery-evolution/

AUTHOR'S PROFILE

1)Mr. Rakesh Kumar Shah, currently pursuing Final year of Aeronautical Engineering at Excel Engineering College, Tamil Nadu, India. Has presented papers at many National level symposium and seminars, also published 4 research papers on Wing morphing, water scooping mechanism for Fire- fighting Aircraft, Noise attenuation technology in Turbojets. Research interest includes Aerodynamics, Propulsion, Aircraft Model designing, Electric Vehicle, Robotics etc.
Contact: rakeshkumarshah70@gmail.com

2)Mr. Habib Dhuniya, currently pursuing Final year of Mechanical Engineering at Excel Engineering College, Tamil Nadu, India. Has presented papers at many national level symposium and seminars and published papers on Water scooping mechanism for Aircraft, Design of trash removal using oil skimmers. Research interest includes Pumps and Turbines, Electric vehicles designing, Automation and AI.

Contact: habibdhuniya@gmail.com

3. Mr. Pankaj Yadav, currently pursuing Final year of Mechanical Engineering at Excel Engineering College, Tamil Nadu, India. Has presented papers at many national level symposium and seminars and published papers on Design of trash removal using oil skimmers. Research interest includes Pumps and Turbines, Electric vehicles designing, Automation etc.

Contact: pankazyadav10@gmail.com

4)Mr. Prabin Mahato, currently pursuing Final year of Mechanical Engineering at Excel Engineering College, Tamil Nadu, India. Has presented papers at many national level symposium and seminars. Research interest includes Electric vehicles designing, Designing Software (SolidWorks, Catia)

Contact: prabinmahato778@gmail.com