



Study of Battery Technology: Advancements in Electric Vehicles

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Abstract: *For the purpose of this research article, the developments in battery technology that have occurred within the electric vehicle (EV) sector are investigated. Electric cars have begun to emerge as a potentially viable alternative for environmentally responsible transportation in light of the increased focus placed on lowering emissions of greenhouse gases and mitigating the effects of climate change. The development of batteries that are both efficient and high-performance, and that are able to provide sufficient power, range, and longevity, is essential to the success of electric cars. This article is a detailed summary of the breakthroughs in battery technology that have been made in electric cars. It discusses the historical context, the current situation, recent developments, and future trends. The many forms of battery technology, such as lithium-ion batteries, solid-state batteries, and lithium-sulfur batteries, are investigated in great length, along with the advantages, disadvantages, and applications that are associated with each of these distinct types of batteries.*

Key words: Battery, Technology, Advancements, Electric, Vehicles etc.

Introduction

The necessity of lowering emissions of greenhouse gases and fighting climate change is driving a huge transition in the transport industry, which is now in the process of having this transformation. In this environment, electric vehicles (EVs) have emerged as a significant answer for sustainable transportation, and they are becoming increasingly popular. One of the most important factors that will determine the success of electric cars is the development of battery technology. Battery technology is the primary factor that will determine the performance, range, and cost of these vehicles. As the demand for electric vehicles (EVs) continues to increase, which is being driven by environmental concerns, legislative incentives, and technical breakthroughs, there is an urgent need for continuous innovation and improvement in battery technology in order to satisfy the ever-changing requirements of the market.





Historical Background

The history of battery technology in electric vehicles (EVs) is distinguished by a journey that spans centuries and is characterised by invention, setbacks, and revival. This journey has brought about advancements in the field. At the beginning of the nineteenth century, inventors and scientists started conducting experiments with electric motors and batteries, which laid the foundation for the development of electric propulsion. During the 1830s, Scottish inventor Robert Anderson developed one of the early electric cars. This vehicle was powered by primary cells that did not have the ability to be recharged. The subsequent decades saw the emergence of specialised uses for electric cars in urban environments due to the fact that they operate in a quiet manner and do not produce any emissions. The widespread acceptance of gasoline-powered cars, on the other hand, dwarfed the adoption of electric vehicles by the early 20th century. This was driven by developments in internal combustion engines as well as the availability of inexpensive fuel. Electric cars continued to be used in specialised areas, such as golf carts and industrial applications, despite the fact that their overall volume decreased. Concerns about air pollution, energy security, and climate change were the driving forces for the resurgence of electric cars, which did not occur until the latter half of the 20th century. As a result of advancements in battery technology, notably in lithium-ion batteries, there was a resurgence of interest in electric propulsion, which ultimately led to the debut of contemporary electric cars in the 1990s and early 2000s. Electric vehicles, which are driven by superior battery technology, are becoming increasingly common in today's society. These vehicles provide consumers with an ecologically friendly alternative to conventional gasoline-fueled automobiles. It is a monument to human creativity and the never-ending search for cleaner and more environmentally friendly transportation options that the historical trajectory of battery technology in electric cars serves as a historical trajectory.

Types of Battery Technologies:

For the purpose of storing and delivering energy for propulsion, electric vehicles (EVs) take advantage of a variety of battery technologies. Every variety of battery possesses a unique collection of qualities, benefits, and drawbacks that are unique to itself. When it comes to electric cars, the following are some of the most frequent types of battery technology that are utilised:





1. Lithium-ion Batteries (Li-ion):

- Because of its high energy density, relatively low self-discharge rate, and extended cycle life, lithium-ion batteries are the most common type of battery used in electric cars. This is because of the combination of these three characteristics.
- During the process of charging and discharging, they make use of lithium ions as charge carriers, which move between the positive (cathode) and negative (anode) electrodes.
- Since lithium-ion batteries are both lightweight and small, they are an excellent choice for use in automotive applications, which are characterised by the importance of space and weight concerns.

2. Solid-State Batteries:

- Solid-state batteries are the next step forward in battery technology. They have the potential to offer a number of benefits that are not available with ordinary lithium-ion batteries. These benefits include a better energy density, improved safety, and quicker charging rates.
- Solid-state batteries use solid electrolytes, which are less likely to leak and thermal runaway than liquid electrolytes, which are used in typical Li-ion batteries. Solid electrolytes are also more resistant to thermal runaway.
- Because they solve significant constraints of present battery technology, such as energy density and safety issues, solid-state batteries have the potential to revolutionise the electric car industry. This is because they have the ability to overcome these shortcomings.

3. Lithium-Sulfur Batteries:

- Batteries that include lithium sulphur are a possible alternative to lithium-ion batteries because they provide better theoretical energy densities and cheaper material prices than lithium-ion batteries.
- As the cathode material, they make use of sulphur, which is not only plentiful but also extremely affordable and lightweight.
- As a result of their ability to pack more energy into a smaller and lighter container, lithium-sulfur batteries have the potential to dramatically extend the driving range of electric vehicles from their current state.

4. Nickel-Metal Hydride Batteries (NiMH):

- Because of its stability, safety, and relatively low cost, nickel-metal hydride batteries were frequently employed in the early generations of hybrid electric vehicles (HEVs) as well as in certain electric cars.





- Nickel-metal hydride (NiMH) batteries are well-known for their durability and their ability to withstand high temperatures, despite the fact that their energy density is lower than that of lithium-ion batteries.
- Nickel-metal hydride (NiMH) batteries are being gradually phased out in favour of lithium-ion batteries due to the fact that NiMH batteries have a lower energy density and weigh more.

5. Sodium-Ion Batteries:

- Instead of using lithium ions to store energy, sodium-ion batteries are a relatively new type of battery technology that is currently in the process of being developed.
- Because sodium is more readily available and less expensive than lithium, sodium-ion batteries have the potential to be more cost-effective and ecologically sustainable than lithium-ion batteries.
- In spite of the fact that sodium-ion batteries are still in the preliminary phases of research, there is reason to be optimistic about their potential uses in solar energy storage and electric cars.

Current State of Battery Technology

The present status of battery technology in electric vehicles (EVs) reflects a dynamic environment that is characterised by fast breakthroughs, continuous research, and efforts to commercialise the technology. Lithium-ion batteries continue to be the most widely used technology in the electric vehicle market because of its high energy density, extended cycle life, and relatively cheap total cost. Battery chemistry, electrode materials, and manufacturing methods have all undergone continuous advances, which have resulted in higher energy densities and reduced prices. These advancements have made it possible for electric vehicles to reach larger driving ranges and enhanced performance. The design and engineering of batteries are being driven forward by efforts to improve their capabilities for rapid charging as well as their safety specifications. Research into new technologies such as lithium-sulfur batteries and solid-state batteries has potential for further enhancing battery performance and solving critical difficulties such as cost and environmental sustainability. In addition, research into these technologies holds promise for tackling key challenges. As the number of people using electric cars (EVs) continues to increase and the need for environmentally friendly transportation continues to expand on a worldwide scale, investments in battery technology are increasing. This is pushing additional advancement and innovation in the search for energy storage solutions that are more efficient, economical, and sustainable for electric vehicles.





Environmental and Social Implications of Battery Technology in Electric Vehicles:

It is important to note that the widespread adoption of electric vehicles (EVs) that are powered by sophisticated battery technology has substantial ramifications for both the environment and society. When compared to cars powered by internal combustion engines, electric vehicles (EVs) have the potential to cut emissions of greenhouse gases and air pollution; however, the environmental and social implications of EVs extend beyond the tailpipes of the vehicles themselves. Here are some important things to keep in mind:

1. Reduction of Greenhouse Gas Emissions:

- When electric vehicles are fueled by energy generated from renewable sources such as solar, wind, and hydroelectric power, none of the emissions that are produced by the tailpipe are produced.
- Electric cars (EVs) help to the mitigation of climate change and the reduction of the environmental imprint of the transportation sector by substituting electric vehicles that are fueled by fossil fuels.

2. Resource Extraction and Supply Chain Impacts:

- The creation of lithium-ion batteries needs considerable quantities of raw materials, such as lithium, cobalt, nickel, and rare earth elements. This has led to concerns over the depletion of resources and the destruction of the environment that are linked with mining activities.
- In order to reduce the negative effects that the extraction of raw materials has on the environment and society, it is vital to ensure that responsible sourcing methods are followed and to promote mining techniques that are ethical.

3. Battery Recycling and End-of-Life Management:

- For the purpose of reducing pollution to the environment and maximising resource recovery, it is essential to recycle and dispose of electric vehicle batteries in an appropriate manner.
- In order to effectively handle the increasing quantity of batteries that have reached the end of their useful lives, it will be necessary to develop recycling techniques that are efficient and to construct infrastructure for the collecting, recycling, and reuse of batteries.

4. Energy Transition and Grid Integration:

- There are both possibilities and obstacles for the incorporation of renewable energy sources into the electric grid that are presented by the growing use of electric vehicles.





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- Managed charging and vehicle-to-grid (V2G) technologies have the potential to improve grid stability, optimise energy consumption, and reduce peak demand; but, in order to achieve these goals, careful planning and investment in grid infrastructure are required.

5. Social Equity and Access to Transportation:

- Increasing the use of electric cars has the potential to enhance access to transportation that is both clean and inexpensive for underprivileged groups. This would reduce the reliance on petrol and diesel-powered vehicles, which have a disproportionately negative impact on low-income and minority populations.
- However, in order to guarantee that electric vehicles, charging infrastructure, and the benefits associated with them are accessible to all, it is necessary to solve obstacles like as the initial expenses, the availability of charging infrastructure, and the availability of dependable energy.

6. Job Creation and Economic Opportunities:

- Manufacturing, research and development, and infrastructure deployment are some of the industries that will benefit from the shift to electric mobility since it will generate potential for job creation and economic growth prospects.
- Maximising the economic benefits of the transition to electric cars may be accomplished through the bolstering of worker training programmes and the provision of incentives for the local manufacture of electric vehicle components.

7. Public Health Benefits:

Electric vehicles (EVs) contribute to the improvement of public health outcomes and the reduction of healthcare expenses connected with respiratory and cardiovascular illnesses. This is accomplished through the reduction of air pollution and emissions of dangerous pollutants such as nitrogen oxides (NO_x) and emissions of particulate matter (PM).

8. Technological Innovation and Collaboration:

- Synergies are fostered between automotive manufacturers, battery suppliers, research institutions, and government agencies as a result of the development of new battery technology for electric vehicles (EVs), which fosters innovation and collaboration across industries.





- The acceleration of progress towards transport solutions that are more environmentally friendly and socially responsible may be facilitated by providing support for research and development efforts and encouraging collaboration amongst various stakeholders.

Conclusion

When it comes to tackling the critical environmental, social, and economic concerns that are involved with transportation, the improvement of battery technology in electric vehicles (EVs) has a great deal of promise. In light of the fact that the world is working towards a future that is less carbon-intensive and more environmentally friendly, electric vehicles that are powered by cutting-edge battery technology are becoming growing important. In this research study, the present status of battery technology in electric vehicles (EVs) has been investigated, with a focus on the most significant breakthroughs, obstacles, and consequences for society and the environment. The landscape of battery technology is continuously expanding, driven by ongoing research, innovation, and investment. This is the case for all types of batteries, including lithium-ion batteries, solid-state batteries, and lithium-sulfur batteries are examples of new technologies. Because to these breakthroughs, electric vehicles (EVs) have become more practical, economical, and accessible to consumers all over the world. These advancements have led to increases in energy density, range, affordability, and safety. Furthermore, the environmental benefits of electric vehicles, which include decreases in emissions of greenhouse gases and air pollution, are helping to efforts to battle climate change and enhance public health.

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