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Design and Development of an Intelligent Li-Ion Battery

Narayan Sagar[1], Pratap Navle[2], Krunal Kawthalkar[3], Chitanya Bhise[4], Atharv Kadam[5], Prof. Nilesh Alone[5]
Students, Department of Mechanical Engineering[1,2,3,4]
Guide, Department of Mechanical Engineering[5]
JSPM'S Jayawantrao Sawant College of Engineering, Pune, India Guide

Abstract: *In this contemporary mobile society, Li-ion batteries, which are only utilized in mobile phones and laptop computers, are the driving force behind the digital electronic revolution. Commercial Li-ion battery success in the 1990s was a consequence of extensive study and the contributions of many outstanding scientists and engineers, not an instant breakthrough. The performance of Li-ion batteries has since seen tremendous improvement as a result of extensive work. Intensified research is needed to create next-generation Li-ion batteries with dramatically better performances, including improved specific energy and volumetric energy density, cyclability, charging rate, stability, and safety, in order to meet the rising demand for energy storage, particularly from the increasingly popular electric vehicles.There are still notable challenges in the development of next-generation Li-ion batteries. New battery concepts have to be further developed to go beyond Li-ion batteries in the future. In this tutorial review, the focus is to introduce the basic concepts, highlight the recent progress, and discuss the challenges regarding Li-ion batteries. Brief discussion on popularly studied "beyond Li-ion" batteries is also provided.*

Keywords: Blockchain, Voting System, Biometric Authentication, Security

I. INTRODUCTION

Li-ion batteries, as one of the most advanced rechargeable batteries, are attracting much attention in the past few decades. They are currently the dominant mobile power sources for portable electronic devices, exclusively used in cell phones and laptop computers [1]. Li-ion batteries are considered the powerhouse for the personal digital electronic revolution starting from about two decades ago, roughly at the same time when Li-ion batteries were commercialized. As one may has already noticed from his/ her daily life, the increasing functionality of mobile electronics always demand for better Li-ion batteries. For example, to charge the cell phone with increasing functionalities less frequently as the current phone will improve quality of one's life.

Another important expanding market for Li-ion batteries is electric and hybrid vehicles, which require next-generation Li-ion batteries with not only high power, high capacity, high charging rate, long life, but also dramatically improved safety performance and low cost. In the USA, Obama administration has set a very ambitious goal to have one million plug-in hybrid vehicles on the road by 2015.

There are similar plans around the word in promotion of electric and hybrid vehicles as well. The Foreign Policy magazine even published an article entitled "The great battery race" to highlight the worldwide interest in Li-ion batteries

II. LITERATURE SURVEY

It would be interesting to briefly review the history on the development of Li-ion batteries. The first rechargeable Li-ion batteries with cathode of layered TiS2 and anode of metallic Li was reported by

Whittingham while work- ing at Exxon in 1976 [7]. Exxon subsequently tried to commercialize the Li-ion batteries, but was not successful due to the problems of Li dendrite formation and short circuit upon extensive cycling and safety concern [2].

Also in 1976, Besenhard proposed to reversibly intercalate Li+ ions into graphite and oxides as anodes and cathodes, respectively [8, 9].

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In 1981, Goodenough first proposed to use layered LiCoO2 as high energy and high voltage cathode materials. Interestingly, layered LiCoO2 did not attract much attention initially [10].

In 1983, Goodenough also identified manganese spinel as a low-cost cathode materials [11]. However, the lack of safe anode materials limited the application of layered oxide cathode of LiMO2 (M = Ni, Co) in Li-ion batteries.

It was discovered by Besenhard [8], Yazami [12], and Basu [13] that graphite, also with layered structure, could be a good candidate to reversibly store Li by intercalation/deintercalation in late 1970s and early 1980s. In 1987, Yohsino et al. [14]. filed a patent and built a prototype cell using carbona- ceous anode and discharged LiCoO2 as cathode (Fig. 3). Both carbon anode and LiCoO2 cathode are stable in air which is highly beneficial from the engineering and manufacturing perspectives.

This battery design enabled the large-scale manufacturing of Li-ion batteries in the early 1990s.

It should be highlighted that Yohsion also carried out first safety test on Li-ion batteries to demonstrate their enhanced safety features without ignition by dropping iron lump on the battery cells, in contrast to that of metallic lithium batteries which caused fire [3].

Yohsino's success is widely considered the beginning of modern commercial Li-ion batteries. Eventually Sony, dominant maker of per- sonal electronic devices such as Walkman at that time, commercialized Li-ion batteries in 1991. It was a tremen- dous success and supported the revolution of personal mobile electronics. To acknowledge their pioneering con- tribution to the development of Li-ion battery, Goodenough, Yazami, and Yoshino were awarded the 2012 IEEE Medal for Environmental and Safety Technologies

2.1 Objective

- To Start your car, motorcycle, bus or truck.
- To Carry around portable devices such as cell phones, laptops, GPS, power tools and watches.
- To Store energy from renewables – both on and off-grid -such as solar or wind and use it at a later stage when no renewable energy sources are available.

2.2 Working Principle

Li-ion batteries are highly advanced as compared to other commercial rechargeable batteries, in terms of gravi- metric and volumetric energy. Figure 2 compares the energy densities of different commercial rechargeable bat- teries, which clearly shows the superiority of the Li-ion batteries as compared to other batteries. Although lithium metal batteries have even higher theoretical energy densities than that of Li-ion batteries, their poor recharge- ability and susceptibility to misuses leading to fire even explosion are known disadvantages.

I anticipate that lithium metal batteries based on solid-state electrolytes with enhanced safety will be commercialized in the next decade. Recently, lithium-air and lithium-sulfur batteries regain wide interest, although the concepts have been proposed for a while.

Promising progress has been achieved regard- ing Li-air and Li-sulfur batteries, but it may take another two decades to fully develop those technologies to achieve reliable performances that will be comparable to Li-ion batteries.

It is expected that Li-ion batteries will still be dominant in rechargeable battery market, at least for the next decade, for advantages they offer.

Li-ion batteries are design flexible. They can be formed into a wide variety of shapes and sizes, so as to efficiently fit the available space in the devices they power. Li-ion batteries do not suffer from the problem of memory effect, in contrast to Ni-Cd batteries. Li-ion batteries have voltages nearly three times the values of typical Ni-based batteries.

The high single-cell voltage would reduce the number of cells required in a battery module or pack with a set output voltage and reduce the need for associated hardware, which can enhance reliability and weight savings of the battery module or pack due to parts reduction.

The self-discharge rate is very low in Li-ion batteries – a typical figure is $<5\%$ per month which compares very favorably to 20–30% of Ni-based batteries

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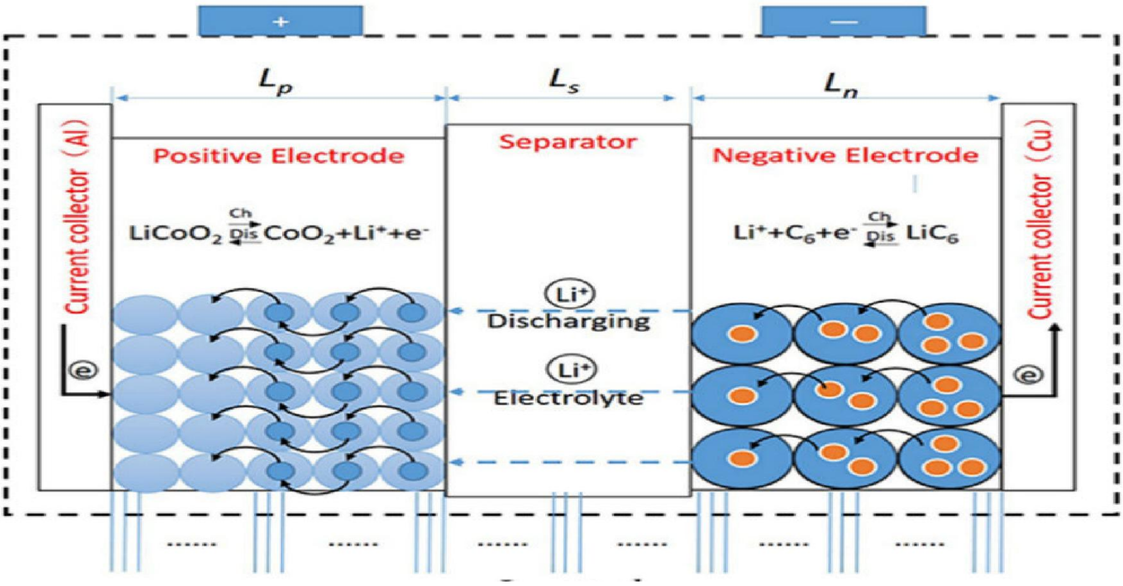
III. DESIGN



IV. PROBLEM STATEMENT

Engine overheating is a problem that many car owners have come across. This would result from various things such as low coolant level, clogged hoses, a burnt-out radiator, or a blown head gasket loss. Other causes of engine overheating are broken plugs or broken engine components

Compared with internal combustion engines cars with an electric battery have less tailpipe emission and are very quiet than internal combustion engines. Another advantage of electric battery over IC engines is that it has very few moving parts. There is no need of balancing when electric batteries are used.

Calculation:

Capacity (in Ampere-hours, Ah):

The capacity of a lithium-ion battery is typically specified in Ampere-hours (Ah), which represents the amount of charge the battery can deliver over a certain period of time. To calculate the capacity, multiply the discharge current (in Amperes, A) by the discharge time (in hours, h). Mathematically, it can be expressed as:

$$\text{Capacity (Ah)} = \text{Discharge Current (A)} \times \text{Discharge Time (h)}$$

For example, if you have a discharge current of 2A and a discharge time of 5 hours, the capacity would be:

$$\text{Capacity} = 2A \times 5h = 10\ Ah$$

Energy (in Watt-hours, Wh):

The energy of a lithium-ion battery represents the total amount of work it can perform and is measured in Watt-hours (Wh). To calculate the energy, multiply the nominal voltage (in Volts, V) by the capacity (in Ampere-hours, Ah). Mathematically, it can be expressed as:

$$\text{Energy (Wh)} = \text{Nominal Voltage (V)} \times \text{Capacity (Ah)}$$

For example, if the nominal voltage is 3.7V and the capacity is 10Ah, the energy would be:

Energy = 3.7V × 10Ah = 37 Wh

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V. FINAL MODEL OF THE PROJECT

VI. CONCLUSION

In conclusion, the project "Design & development of an intelligent Li-ion battery with an 8S3P combination" has successfully achieved its goals of creating an advanced and efficient lithium-ion battery.

The project focused on utilizing an 8S3P combination, which refers to a configuration of eight series-connected cells with three parallel sets of cells. This configuration offers several advantages, including increased voltage output, higher capacity, and improved power delivery.

The intelligent aspect of the battery design involves the implementation of advanced battery management systems (BMS) and intelligent control algorithms. These systems monitor the battery's performance, manage cell balancing, control charging and discharging processes, and provide protection against overvoltage, undervoltage, and overheating. The intelligent features ensure optimal performance, extend battery life, and enhance safety.

Throughout the design and development process, various factors were considered, such as cell selection, thermal management, mechanical design, and safety measures. Rigorous testing and validation were conducted to ensure the battery's reliability, efficiency, and adherence to industry standards.

The resulting Li-ion battery with an 8S3P combination offers numerous benefits. Its increased voltage output and capacity make it suitable for various applications, including electric vehicles, renewable energy storage systems, and portable electronics. The intelligent features provide efficient power management and enhance user safety.

VII. FUTURESCOPEOFTHEPROJECT

- Increased Flight Time: One of the main areas of development is focused on improving the energy density of lithium-ion batteries to extend drone flight times. Longer flight durations allow drones to cover more distance, perform complex tasks, and increase their overall efficiency.
- Fast Charging: Another area of focus is reducing the charging time for drone batteries. Faster charging enables more frequent flights and minimizes downtime. Advancements in battery technology, such as improved electrode materials and charging algorithms, aim to enhance the charging speed of lithium-ion batteries.

- Enhanced Safety: Safety is a critical aspect of drone operations. The future scope involves developing lithium-ion batteries with enhanced safety features to minimize the risk of thermal runaway, which can lead to fires or explosions. Researchers are exploring advanced battery management systems, better thermal management, and improved cell chemistries to enhance safety standards.

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