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Optimization of Production of Li-Ion Batteries based on Quality and Time

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Abstract:- The objective of this research is to automatically design to produce Li- ion battery packs and optimize in terms of quality of battery pack, also in terms time. Since energy shortage is rising across the world, every firm wants to improve their facilities of energy sources in the field of renewable and electric vehicles.

So, Li-ion batteries come out as a revolutionary resource of energy with great advantages and reliability. In this modern world almost, every electronic device either micro or macro level comes out with this eco- friendly technology exclusively laptops, smart phones, power banks as well as in EVs, etc. Li-ion batteries have improved performance including cycle ability, charging rate, stability, safety, and improved specific energy and volumetric energy density.

The main aim is to optimize the Li- ion batteries for the future with basic concepts and studies for various constraints regarding the abovetechnology.

Abbreviations:

EVs	Electric Vehicles
Ah	Ampere-hour
Wh	Watt-hour
BMS	Battery Management System
Si	Silicon
Sn	Tin

I. INTRODUCTION

Li-ion batteries are the most futuristic, ultra-modern rechargeable batteries focusing on some previous decades due to their comparably high energy and power density, better volumetric and gravimetric densities and truncated maintenance.

In the context of delivering the required power and energy output asper the demand of various applications, it is obligatory to assemble many Li-ion cells in different configurations either parallel or in series to make up a single module. Hundreds of individual modules make a complete Li-ion battery pack either in series or in a parallel configuration.

In India, lithium cells are imported from foreign countries such as Japan, Singapore, Korea, Malaysia, Taiwan, the USA, and China. The Maximum import of lithium cells is from China along with Korea, Taiwan, Japan, and the USA respectively. All these lithium cells are finally assembled in India with various configurations as per the voltage and capacity (Ah). Li-ion batteries are more flexible in terms of design so they can form into a large variety of shapes and sizes in which they can easily fit into the accessible space. The Li-ion consists of a cathode made of a MO2 either in a laminated structure such as lithium cobalt oxide, or a tunneled structure, such as lithium manganese oxide. The anode is made of graphite carbon. Additionally, Li-ion batteries have exceptionally good properties like low self-discharging rate, long cycle life, and wide operating temperature range however these batteries are also more expensive than other batteries type and require a critical power management system (commonly known as BMS) to preventdegradation due to fluctuated use.

To overshoot all these issues Li-ion batteries costs should be minimized by increasing the production capacity and optimizing the methodology to build the battery packs, their management system,and enhance their capacities.

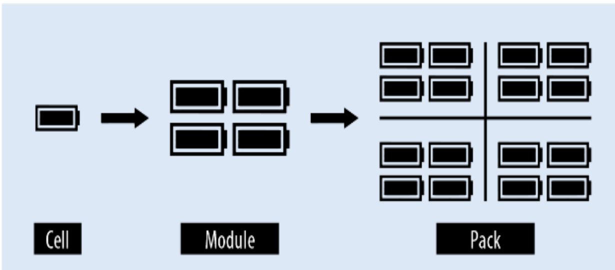

Fig. 1

II. BASICS OF LI-ION BATTERY PACK

These batteries are build by connecting the lithium cells in parallel, in series or in combined configuration. The parallel configuration is used to increase current whereas the series configuration is used to increase the voltage in the battery packs. Multiple cells can be arranged into a module. Multiple module can be integrated into a battery pack. For example, the 60V and 30Ah battery pack contains 95 cells.

Basically a Li-ion cell consist of a cathode (+ve electrode) and an anode (-ve electrode), which are connected by an electrolyte containing lithium ions. Both electrodes are isolated by a separator, typically a thin polymer micro porous membrane which allows to exchange of lithium ions but not electrons between them.

The performance of these batteries can be estimated by various parameters viz, specific energy, volumetric energy, specific capacity, cyclabilty, safety, abuse tolerance and the charging/ discharging rate. Specific energy measured in

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terms of Wh/kg and it is defined as the amount of energy that can be stored or released per unit mass of battery.

Specific energy (Wh/kg) is the product of specific capacity (Ah/kg) and operating battery voltage (V). Specific capacity is the amount of charge that can be reversibly stored per unit mass of the battery. Cyclabilty is measure the reversibility of the lithium ion interexchange process in the terms of number of charge an discharge cycles before the battery losses its energy. The safety requirement is roughly high for these batteries.Battery Management System (BMS) are basically implemented in the battery packs to prevent any possible heating issues. The BMS are able to detect any battery cell failure inside a battery pack and also isolate that particular battery cell from the arrangement. The rate of charge or discharge measures how far the battery can be fully discharged and charged. The measures of these charging and discharging is denoted by C-rate. At 1C the battery is fully discharged evolving its maximum capacity in the time of one hour.

In actual practice, to measure specific capacity of Li-ion battery cell, the cathode and anode materialsare not only taken into the consideration but also some others important components are taken into account to measure specific capacity of these battery cells such as binders, separators, conductive enhancers, current collectors, electrolyte, case, tabs, as well as the BMS. Therefore, the actual energy density is always less than the theoretical estimated battery values.

III. DIFFERENT SHAPES OF THE LI-ION CELLS

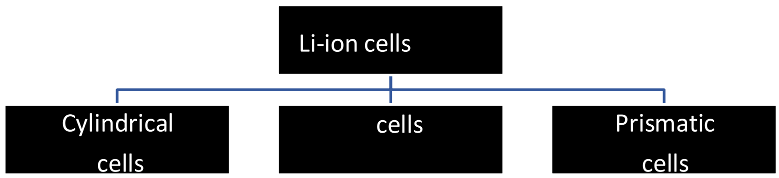

Fig.2

- **Cylindrical:-** These cells are used for high specific energy density good mechanical stability. This cylindrical shape offers good safety and agood cycle life at a low cost but it has lower packaging density.
- **Pouch:-** These cells are light in weight and cost effective but exposure to high temperature and humidity can shorten its life.
- **Prismatic:-** these cells areconfined in aluminium or steel packaging for good stability. It is space effective as compared to cylindrical cells but they are very costly to manufacture.

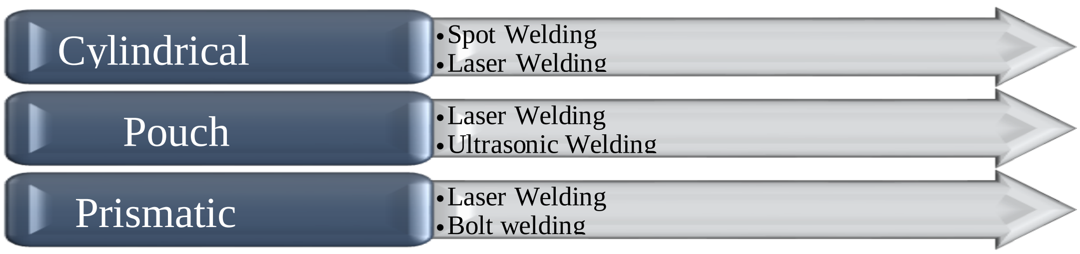

Fig. 3

IV. NOMENCLATURE OF LI-IONCELL/ BATTERY

The Li-ion batteries will beSpecified as:

N1 X1 X2 X3 N2 /N3/N4-N5

where,

N1 denotes number of cellconnected in series.

N5 denotes number of cellsconnected in parallel.

(The both above numbers are used only when the number is greater than 1 and only applied to batteries).

X1 denotes the basis of –veelectrode phase, where "I" for Li-ionand "L" for Li-metal or alloy.

X2 denotes the basis of +ve electrode phase, where "M", "N", "C", "T" or "V" for manganese, nickel, cobalt, titanium and vanadium respectively.

X3 denotes the shape of the cell, where "R" used for cylindrical cell and "P" for prismatic cell.

N2 denotes the maximum diameter or maximum thickness in mm (for cylindrical cells we use maximum diameter and for prismatic cells we use maximum

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thickness).

N3 denotes the maximum width in mm (only for prismatic cells).

N4 denotes the maximum overall height in mm.

V. ASSEMBLING PROCESS OF LI-ION BATTERY PACK

- **Cell Sorting –** It is the process of identification and grouping the cell with similar characteristics, features and parameters so that they have similar output during operation cycles. It is the most important and critical step to ensure the safety of the battery pack. The common sorting method is VCI (voltage, capacity and AC internal impedance). The capacity and voltage are measured with charge- discharge & the AC internal impedance is measured at a constant frequency of 1 kHz with low AC current. The cells with shape operating parameters are good together in a battery pack so that stability and consistency of the whole battery pack is assured duringits life.
- **Pasting of Insulating paper on the +ve pole -** After the cell sorting process is completed, an insulating sticker is pasted on the +ve poles of Li-ion cells to avoid the short circuit during the welding process.
- **Inserting the cells into the cell holders –** These cells are arranged in the cell holder, such a way to get desirable output capacity and voltage along with pre-described casing shape. Nickel strips are placed into the cell holders to weld the cells together.
- **Welding of Cells –** After the cell are placed into the cell holders the welding is to be done to fix the cells. Welding of multiple cells gives a higher capacity battery.

  There are various methods for welding the different types of Li-ion cells:- Spot Welding is the most common technique used in India for stacking Li-ion cells.
- **Connecting BMS –** Battery management system is connected to the battery pack, so that it can be operated into desirable range. TheBMS helps to achieve the longer lifeof the battery.
- **Pasting FRP Paper –** Firstly the FRP (fibre reinforced plastic) sheet is cut into the shape of battery pack, Then these sheets are pasted on the battery pack to prevent the chance ofshort circuit issue.
- **Battery Pack Testing –** A completed battery pack is finally tested to evaluate the charge and discharge voltage, charge and discharge current, and total internal resistance.

For battery life estimation, aseparate battery aging test is conducted in which a battery pack is charged and discharged in multiple cycle, then its capacity is recorded at each charge and discharge to detect the battery charge protection and discharge protection.

VI. CHALLENGES IN LI-ION BATTERIES

Li-ion batteries have been, commercialised for about for past two decades. These batteries have been frequently used in mobile electronic devices, including laptop, PC and cell phones, also starting to play vital role in electric vehicles. This technology is considered relatively mature based on the current battery chemistry. The stepping up demand for energy storage required much more improvements in the present Li-ion batteries and the development of Hi- Tech Li-ion batteries particularly in various fields:

- **Cost of Li-ion Batteries –** The cost of Li-ion batteries are quite highbecause of their anode and cathode materials. As anode are basically made up of Si materials, there preparation of nano-materials on large scale is very high. The summation of cost of BMS, casing isalso responsible for the enhancementof cost of Li-ion batteries.
- **Issue in Energy Density-** Due to low specific capacities and low operating cell voltages there are ahuge number of anode particles that could increase the specific capacities but due to issue of poor cycle performance of simple Si or simple Sn based anodes, it is because of pulverization process.
- **Safety issue in Li-ion Batteries-** The safety concern is the mostchallenging part that needs to be properly highlighted. The recent news on explosion of Li-ion batteries, involving Ola motor bike in India, Tesla model S car, Realme Smart phones batteries, highlights the importance of battery safety.

  This is because of improper management of battery system which results in heating of battery packs.

VII. OPTIMIZATION ON LI-IONBATTERIES

Since the current scenario is focussed on liquid electrolyte based Li-ion batteries, but they have significant issues i.e. low energy density by size ratio, safety concern, carbon footprint during extraction of anode and cathode materials and their high cost. Therefore there is need to shift towards solid state Li- ion batteries.

In Li-ion batteries, metallic lithium forms dendrites in liquid battery system which affects the cycle life and safety of the battery. On replacing the highly reactive electrolyte with a solid state electrolyte which is much more safer and mechanically more rigid and tougher increases the battery's energy density with high safety. Solid state Li-ion battery comprises solid metal electrodes and solid electrolyte which avoid leakage and corrosion problem in electrodes, which reduces the risk of catching fire and lowers the cost of design because it eliminates the need of safety features.

Solid state Li batteries are expected to overcome the concern of energy density presently being experience in current Li-ion batteries. Finding the right separator material that allows the Li-ions to flow between anode and cathode while also blocking dendrites isquite harder.

To minimise the cost of Li-ion batteries, increasing electrode thickness to reduce the balance of cell cost. This solution raises unitcell energy density while simultaneously reducing the battery pack cost. Electrode processing is also a main element of this strategy, and it can be implemented on the front end of a longer term. Electrodeprocessing cost and energy consumption is connected to solvent type, dispersion solid including, drying temperature, air flow rate etc. Electrode thickness affects on the cost related to the amount of separators and inactive current collector.

Now in the modern scenario, we can add up the battery pack with latest technology in which we areable to monitor the real time current,voltage, charging and discharging time on the LED screen panel, also can be connected with IOT based application software which gives thereal time data on your PC's , laptopsand also in smart-phone.

VIII. CONCLUSION

In present Li-ion batteries, having so much of drawbacks i.e. heating problem, dendrites formationbetween anode and cathode via separator, low energy density ratio, improper flow of output, cost of manufacturing etc.

In order to overcome with these issues we came across to the result that separator between cathode and anode must be of more useful to stopdendrites formation which increase safety, stability, cycle life, heating issues also lowers the corrosivity rate in electrodes. By replacing current lithium ion batteries to solid state lithium batteries improve the mechanical rigidity, energy density to weight ratio and also prevents the chances of short circuiting.

By increasing the thickness of electrode, it results into reduction in cost of the battery. Proper designing of battery packs along with suitable connection (parallel, series, combined) helps to reduce the sizeof battery and its weight at givenoutput conditions.

REFERENCES

[1.] Pritwani, K., Sustainability of Business in the Context of Environmental Management, TERI, New Delhi, India 2016, pn. 136.
[2.] Deshpande, A., Electric mobility India perspective, Vector IndiaConference, Pune, India 2017.
[3.] NITI Aayog and Rocky Mountain Institute, India leaps ahead:transformative mobility solutions, 2017
[4.] Thackeray, M. M., W. I. F. David,
[5.] P. G. Bruce, and J. B. Goodenough. 1983. Lithium insertion into manganese spinals. 18:461–472.
[6.] Yazami, R., and P. Touzain. 1983. A reversible graphite-lithium
[7.] -ve electrode for electrochemicalgenerators. J. Power Sources 9:365– 371.
[8.] Basu, S., C. Zeller, P. J. Flanders,
[9.] C. D. Fuerst, W. D. Johnson, and J.
[10.] E. Fischer. 1979. Synthesis and properties of lithium-graphite intercalation compounds. Material Science Engineering. 38:275–283.
[11.] Yoshino, A., K. Sanechika, and T. Nakajima. 1987. USP4,668,595. 15. Chan, C. K., H. Peng, G. Liu, K. McIlwrath, X. F. Zhang, R. A. Huggins, et al. 2008. High- performance lithium battery anodes using silicon nano-wires. National Nanotechnology. 3:31–35.
[12.] N. J. Dudney, B. Neudecker, Bates, J. B., A. Ueda, and C. D. Evans. 2000. Thin-film lithium and lithium-ion batteries, Solid State Ionics. 135:33–45.
[13.] Li, H., X. J. Huang, L. Q. Chen,
[14.] Z. G. Wu, and Y. Liang. 1999. A high capacity Nano-Silicon composite anode material for lithium rechargeable batteries.
[15.] Electrochemical Solid State Lett.2:547–549.
[16.] J. R. Dahn, Xing, W. B. and A.
[17.] M. Wilson, G. Zank, and 1997. Pyrolysed pitch-polysilane blends for use as anode materials in Li-ion batteries. Solid State Ionics 93:239– 244.
[18.] Xing, W. B., A. M. Wilson, K. Eguchi, G. Zank, and J. R. Dahn. 1997. Pyrolyzed polysiloxanes for use as anode materials in lithium-ion batteries. J. ElectrochemicalScience. 144:2410–2416.
[19.] Wilson, A. M., G. Zank, K. Eguchi, W. Xing, and J. R. Dahn. 1997. Pyrolysed silicon-containing polymers as high capacity anodes for li-ion batteries. J. Power Sources 68:195–200.
[20.] Xue, J. S., K. Myrtle, and J. R. Dahn. 1995. An epoxy-silaneapproach to prepare anode materials for rechargeable lithium ion batteries. J. Electrochemical. Soc. 142:2927–2935.
[21.] Deng, D., and J. Y. Lee. 2010. Direct fabrication of double-rough chestnut-like multifunctional Sn @ C composites on copper foil: lotus effect and lithium ion storage properties. 20:8045–8049.
[22.] Deng, D., and J. Y. Lee. 2009. Reversible Storage of Li in a Rambutan-Like Sn-C Electrode. Angew. Chem. Int. Ed. 48:1660– 1663.