LionTelligence
Intelligent Battery Life Cycle Management

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Electrification of cars made the battery storage the central element of the drive-train. Due to their above average energy and power density, lithium ion batteries, LIBs, are considered as the best choice for electric car makers. However, engineers see themselves confronted with some mayor issues, concerning the LIB. The performance and the ageing of LIBs heavily depend on external ageing factors like temperature, discharge and charge current, average state of charge (SOC) or depth of discharge (DOD). Wrong treatment of the battery may lead to a thermal runaway ending in an exothermic reaction. In most cases, this results in a fire. Therefore it is important to monitor the battery during its entire life span. The combination of electrochemical battery models and deep battery knowledge with big data algorithms and intelligent cloud software empowers LionTelligence, the central cloud based platform of CTCs Lion Product family, to provide smart services and solutions for all entities along the battery life cycle. The main focus is to gain additional economical, ecological and technical value.

1 Context

CTC cartech company is a flexible developer and manufacturer of individualised electronics for the automotive industry, particularly in the fields of electro mobility and control system, measuring and testing technology. The focal points are electric drives as well as their supporting components such as loading systems, energy distributors, transducers, energy storage and wiring harnesses. Overall vehicle networking and topology are also one of the company's prime concerns. CTC participated in several research projects, resulting in the development of test stands and devices for the characterisation of LIBs. Data is the essential production factor for innovative product developments. The advancements in information technology enabled organisations to accumulate ever bigger amounts of this once scarce production factor. The efficient handling

of the resulting flood of data and the effective transformation of incoherent data into usable knowledge represents one of the key challenges of 21st century product development. Thus, CTC works on interconnected products, applications and services to foster the entire battery life cycle.

2 Motivation

LIBs are classified as a type of electrochemical energy storage. Due to low production cost, Pb-acid batteries are mainly used as 12V -batteries. The high number of charging cycles, low internal resistance, low self-discharge rate and high energy- and power density make LIBs the best choice for the traction battery of electric vehicles (EV) or plug in hybrid electric vehicles (PHEV). At the moment, the production process of LIBs isn't as well understood as that of Pb-acid batteries.This leads to higher production cost per kilowatt-hour (kWh). This issue will be solved within a few years. At that moment LIBs will also be used as 12V batteries. The operation as traction battery of an EV requires an trade-off between power- and energy density of the battery. Acceleration leads to high currents which demands for high power density but high capacity is needed to gain range of the vehicle. Due to it's design, LIBs can be used as power or energy cell. Nevertheless, there are still some issues to be solved concerning the performance of LIBs. They react very sensitive to wrong treatment. Especially the impact of high temperature, high charge- and discharge currents, high average SOC and DOD lead to accelerated electrochemical ageing processes inside the battery. Thus, the characterization and analysis of the battery performance is mandatory to gain knowledge about the dependence of electrochemical processes to the aforementioned external ageing factors. There is a need of devices and services to monitor and characterize the battery performance.

3 Battery Life Cycle Management

Since the renaissance of electro mobility[1], several entities need to work together to develop batteries that fulfil the requirements of electric vehicles. Besides developing 12V batteries, battery makers and car makers haven't had any mutual projects. Deep knowledge exists on both sides but engineers struggle for a common understanding. Additionally, the majority of battery makers are located in Asia while car makers are spread all over the world. The battery life cycle is subdivided into four parts: Cell development and production, Integration into application, Operation of the battery and the Second life and recycling sector.

3.1 LionTelligence

LionTelligence serves as the central, intelligent platforms which provides algorithms and battery models that calculate not only the state of health but also the residual lifetime and the state of value of the battery for different applications. Thus the economic benefit of the battery is optimised. By gathering data from all Lion-Products, the LionTelligence algorithms improve permanently and smarter services for every company can be provided. LionTelligence is able to generate requirements, calculate state of health and value, determine useful 2nd life applications and predict application specific residual life time. The modular structure of the platform allows for flexible and scalable networking of this different services. Thus user, battery and vehicle data is se-

[1] Note that the first battery was already developed by Volta in 1799 [Pan90]

mantically captured from all Lion devices and is used to improve battery models and to generate battery specific decisions and user instructions.

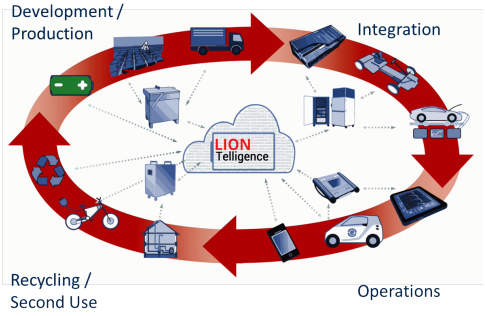

Figure 1: LionTelligence - Battery Life Cycle Management

3.2 LionTrace

LionTrace is a modular battery test stand for cell, modules or battery stacks. It cycles and characterises batteries by impedance spectroscopy in full automatic 24/7 mode. Thus it serves as ageing, cycling and characterisation tool for cell developers and car-manufacturers development engineers. Additionally it may also be used as End of Line or in line testing. LionTrace provides an interface looking similar to that of mobile phones. Complex test set-ups can easily be programmed by click and drop.

3.3 LionGuard

The compartment, which ensures safe transport and operation of lithium ion cells, modules and stacks is called LionGuard. A three level safety and hazard mitigation concept has been implemented. Highest level is given by the communication with the battery BMS. The thermal conditioning by Peltier elements is considered as the second level. The battery is encapsulated by an expanded glass granulate, which melts in case of thermal runaway and takes away the oxygen and the heat. After cooling down it can be removed with the battery inside.

3.4 LionAid

If the number of electric cars rises, there will also be a demand for small test devices, especially for workshops, which characterise the battery by using the data provided by the on-board diagnosis system or the battery management system. The workshop diagnosis tester LionAid provides complex test routines with easy "traffic lights" interfaces, to ensure ideal maintenance of the LIB.

3.5 LionHome

2^{nd} Life applications like energy storages for used automotive batteries will be a big market at the latest if the first automotive batteries have to be replaced. In order to support the 2nd use sector, we develop health observing modular energy storages which we call LionHome.

4 Further work

Both companies will intensify their cooperation to improve smart services like battery models and the calculations of application specific LIB-parameters like residual lifetime and State of Value.

References

[Pan90] G. Pancaldi. "Electricity and life. Volta's path to the battery". In: *Historical studies in the physical and biological sciences* 21.1 (1990), pp. 123–160 (cit. on p. 2).