Increasing The Life Cycle of Lithium-Ion Battery

[1] Purushottam Kumar, [2] Ramkesh Meena and [3] Jaspreet Hira
[1] M-Tech. (EE)Student ,[2] Electrical Head (H.O.D),[3] Associate Professor and Dean,Raffles University, Neemrana

Abstract - Electric mobility has proven to be essential for the carbon neutrality of the transport sector. However, several studies have demonstrated the environmental costs linked to the supply of rechargeable batteries, which should not be overlooked. The supply of some elements has raised concerns, either because they are associated with environmental and social risks, or because they are considered critical raw materials due to their concentrated geographical supply the lifetime of lithium-ion batteries decreases economic costs and environmental burdens in achieving sustainable development. Cycle life tests are conducted on 18650-type commercial batteries, exhibiting nonlinear and inconsistent degradation. The accelerated fade dispersion is proposed to be triggered by the evolution of an additional potential of the anode during cycling as measured vs. Li+/Li. A method to prolong the battery cycle lifetime is proposed, in which the lower cutoff voltage is raised to 3 V when the battery reaches a capacity degradation threshold. The results demonstrate a 38.1% increase in throughput at 70% of their beginning of life capacity. The method is applied to two other types of lithium-ion batteries. A cycle lifetime extension of 16.7% and 33.7% is achieved at 70% of their capacity, respectively. The proposed method enables lithium-ion batteries to provision time, cost savings, and environmental relief while facilitating suitable second-use applications. Now the lithium-ion batteries are widely used in electric vehicles (EV). The cycle life is among the most important characteristics of the power battery in EV battery.

Keywords: - Lithium-ion batteries, Battery models, Lithium plating, Inhomogeneity, Fast charging, State of charger estimation, Anode or Cathode, Distribution of electrolyte, etc.

I. INTRODUCTION

Lithium-ion batteries are unquestionably one of the most promising energy storage components used in electrically operated devices due to their power and energy capabilities, and batteries with long lifetimes are crucial in reducing the negative environmental impact. Batteries have become essential for the reduction of carbon emissions in the transport sector, being the key technology in electric vehicles (EVs). They are considered a critical technology for achieving the goals defined in the EuropeanGreen Deal, which aims at a 55% reduction of greenhouse gases (GHG) emissions withinthe European Union by 2030 compared to 1990 levels, as well as ensuring that Europe becomes the first climate-neutral continent by 2050. An important parameter of LIBs for EVs is the battery capacity, but also the charge and discharge speed play a key role.
Battery manufacturers have invested in the development of fast-charging battery materials to address the demand for this technology. The LTO-based batteries have shown satisfactory results in this respect, being a successful technology in the fast-charging battery market, and this anode is often combined with an NMC cathode in the battery cell Although LTO batteries have been reported to have a low energy density, their positive aspects, such as safety, extended lifetime, fast charging and slow discharge have enabled their use in the automotive sector, even for large vehicles such as buses.
LTO has been reported to be safer than graphite, which is nowadays the most widely used anode material, even though it does not have fast-charging properties.

II. MATERIAL AND METHODS

To perform a fair comparison of ECA-302 and LTO, a similar LIB cell design was assumed for both materials, both cells corresponding to the LIB cells prototype validated in a Battery Design Model, described in detail in of the supplementary information (SI). Except for the anode active material, all the other cell components were similar, including the cathode, which was an NMC cathode with high nickel content as illustrated in. Since the anode active materials were different in composition, the anode slurry
recipe and the thickness of the anode coating were fixed for the two cells, so that an equivalent cell design was achieved to make a comparison as equivalent as possible between the different chemistry systems. In this way, only the thickness and mass loading of the cathode is varied within a fixed volume of cell, to match the changing capacity

of the anode coating. The objective of this study is to perform a comparativeLCA study of two LIB cells composed of two different anode active materials: an emerging Nb-based active material formulation ECA-302 and its well-known alternative, LTO, which is widely used in LIBs. This assessment includes the elaboration of a life cycle inventory describing the production of the LTO and ECA-302 anode active materials the quantification of the environmental impacts and their comparison for ECA-302 and LTO at the production and energy delivery simulation tests, considering the global warming potential, ozone depletion, ozone formation, acidification and the use of fossil resources impact categories the identification of the environmental hotspots along the cradle-to- gate stages of the anode active materials.

III. HOW TO IMPROVE LIFE CYCLE

1. Water-based LIB pack configuration for a mid-size EV: -

A mid-size EV, i.e. Nissan Leaf, is taken as the baseline EV in this study (Blackley, 2021). The water-based NMC battery pack is configured to provide energy for the mid-size EV to drive up to 240 km, which is the same as the Nissan Leaf's EPA driving range (US Department of Energy, 2021). The parameters of the 2021 Nissan Leaf S are shown in Table S1 (Supporting Information). For the EV battery system configuration, the electric vehicle supply equipment (EVSE) transfers electric energy.

2. Life cycle inventory of the water-based LIB pack: -

Both material and inventory data are compiled in the life cycle inventory analysis results for the configured water-based LIB pack. The material inventory in Table 1 provides the masses of all materials required to produce the water-based LIB pack throughout its entire life cycle. As evaluated, 559.27 kg of material inputs is needed in total along the life cycle of the 292.27 kg water-based LIB pack. From the inventory analysis, the most material-consuming component is the NMC-based positive.

IV. CONCLUSION

Climate change: **-** This study focused on a comparative environmental performance assessment of two long-life and fast-charging anode technologies for LIBs, namely lithium titanate (LTO) and an innovative niobium-based active material (ECA-302), with the assessment based on primary industrial data. Besides the comparative life cycle assessment (LCA) including five impact categories, a comparison between the global warming potential of these materials with a lower lifetime and non-fast charging technology, graphite, was also performed. Overall, ECA302 demonstrated outstanding results compared to LTO in all categories evaluated, not only regarding lower detrimental environmental impacts at the manufacturing stage, but also at the energy delivery simulation tests. The results for global warming potential for the ECA302 were 2.1 times lower than the LTO considering the material production, and this difference increased to 2.6 when the energy delivery was considered. Even better results were obtained for photochemical ozone formation, for which the ECA-302 had up to 3.5 times lower impacts than the LTO at the material level, and up to 4.4 times lower for the energy delivery tests. The improved performance of ECA-302 at the energy delivery over a cycle life indicates that this material is more efficient in terms of resource use to store and deliver renewable electricity in relation to the LTO, with a mass requirement 20% lower to deliver 1 kWh. Compared to graphite, ECA-302 showed a global warming potential about 2 times lower at the anode material manufacturing stage, and potentially significantly lower when the battery lifetime is considered.

This study builds on our previous cradle-to-gate LCA modeling work and aims to develop an in-depth cradle-to-grave LCA model for water-based lithium-ion battery (LIB) manufacturing, facilitating optimization and further development of the manufacturing processes by identifying environmental hotspots.

The highlights of this study are as follows:
(a) The developed cradle-to-grave LCA model was applied to a mid-size EV.
(b) The functional unit was set as per kilometer driven in a mid-size EV.

REFERENCES

1. https://www.org.com/science/article/pii/S2212827116313397
2. https://doi.org/10.1016/0167-2738(83)90268-0.
3. https://doi.org/10.1016/0378-7753(89)80152-1
4. https://doi.org/10.1016/j.jpcs.2007.10.134
5. https://doi.org/10.1016/j.jpowsour.2010.09.060
6. https://doi.org/10.1016/0022-4596(84)90141-5.
7. https://doi.org/10.1016/j.jpowsour.2012.01.090
8. https://doi.org/10.1016/j.electacta.2005.05.053.
9. https://doi.org/10.1016/j.jpowsour.2005.03.065.
10. https://doi.org/10.1016/j.elecom.2008.02.026
11. https://doi.org/10.1016/0022-4596(84)90228-7
12. https://doi.org/10.1016/j.ssi.2011.08.002
13. https://doi.org/10.1016/S0167-2738(99)00095-8.
14. https://doi.org/10.1016/j.ssi.2010.05.026.
15. https://doi.org/10.1016/S0924-0136(01)00797-X.