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Reverse Supply Chain Analysis of Lithium-Ion Batteries Considering Economic and Environmental Aspects

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Abstract : There is a strong emphasis on shifting to electric vehicles (EVs) throughout the globe for reducing the impact on global warming following the Paris climate accord. Lithium-ion batteries (LIBs) are predominantly used in EVs, and these can be a significant threat to the environment if not disposed of safely. Lithium is also a valuable resource not widely available. There are several research groups working on developing an efficient recycling process for LIBs. Two routes - pyrometallurgical and hydrometallurgical processes have been proposed for recycling LIBs. In this paper, we focus on life cycle assessment (LCA) as a tool to quantify the environmental impact of these recycling processes. We have defined the boundary of the LCA to include only the recycling phase of the end-of-life (EoL) of the battery life cycle. The analysis is done assuming ideal conditions for the hydrometallurgical and a combined hydrometallurgical and pyrometallurgical process in the inventory analysis. CML-IA method is used for quantifying the impact assessment across eleven indicators. Our results show that cathode, anode, and foil contribute significantly to the impact. The environmental impacts of both hydrometallurgical and combined recycling processes are similar across all the indicators. Further, the results of LCA are used in developing a multi-objective optimization model for the design of lithium-ion battery recycling network. Greenhouse gas emissions and cost are the two parameters minimized for the optimization study.

Keywords : life cycle assessment, lithium-ion battery recycling, multi-objective optimization, network design, reverse supply chain

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