Electric Bike (e-bike) Li-ion Battery Design Evaluation to Optimize Performance and Safety with AutoLion-1D™

Introduction

While electric bicycles (e-bicycles) are still a nascent market in North America, they have been embraced in many Asia Pacific countries as well as some countries in Europe. As the use of bicycles, scooters, and other forms of two-wheeled transport as commuting vehicles rises in large cities around the world, e-bicycles are expected to expand their reach steadily. Li-ion batteries for e-bikes or e-scooters are promising for their higher energy density and life compared to lead-acid batteries but cost is the key challenge. To keep the cost low, Li-ion cell manufacturers for e-bikes are considering thicker (>100µm) ceramic type separators that are substantially cheaper than thin (~20 µm) separators (e.g. Celgard®).

Challenge

Although cheaper, viability of ceramic-based thick separators for commercial e-bikes is not well proven. Detailed investigation of the temperature-dependent performance and safety of batteries that employ ceramic-type thick separators used in e-bike applications is needed.

Technology Used

AutoLion-1D™ to simulate e-bike Li-ion batteries with thick ceramic separators

Setup

- 2.2 Ah 18650 cells with NMC cathode and graphite anode are set up using AutoLion-1D™ in-built material database
- Four 18650 cells (all with 2.2 Ah capacity) with four different separator thicknesses are built in AutoLion-1D™: 20 (baseline), 50, 100 & 150 µm
- The 100 and 150 µm separators represent very thick ceramic-type separators that are employed due to very low-cost, and are currently used in batteries for e-bikes

Results

- Simulations are performed in AutoLion-1D™ to investigate the low (-20°C) and moderate (25°C) temperature performance of the e-bike batteries
- Simulations of external short circuit (ESC) are performed at ambient room temperature(25°C) by simply selecting constant resistance load profile in AutoLion-1D™

Figure 1: Simulated discharge curves and temperature rise for all four cells at 25°C at 1C.

Figure 2: Simulated discharge curves and temperature rise for all four cells at -20°C at 1C.
Figure 3: Current and temperature vs. time for all four cells undergoing ESC at 25°C (ambient).

**Benefits**

- The user-friendly interface of AutoLion-1D™ with in-built database for electrode materials accelerates setting up battery designs in the simulation environment.
- AutoLion-1D™ has shown that thick separators do not impact performance under normal operation but strongly influence battery performance under extremely low temperatures and safety.
- Simulations concludes that Li-ion cells using low-cost ceramic-type separators (i.e. 100-150 µm) for electric bikes perform well at room temperature and are extremely safe under external short.
- Li-ion cells using low-cost ceramic-type separators for electric bikes will fail at subfreezing conditions unless further optimized by using AutoLion-1D™.
- Evaluation of other cell chemistries and or other cell formats such as prismatic or pouch cells can be quickly done with AutoLion-1D™.
- In contrast, experiment-only approach to examine performance and safety of such batteries is not very time and cost effective given the large lead time in separator optimization and cell fabrication with ceramic separators.