How do different SOC segments impact kinetic parametrization?

Designing and manufacturing a battery testing setup and investigating the impact of different SOC segments on kinetic parametrization.

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Abstract

The aim of the project was to ascertain the difference between larger and smaller State Of Charge (SOC) segments in the parameters produced using kinetic parametrization.

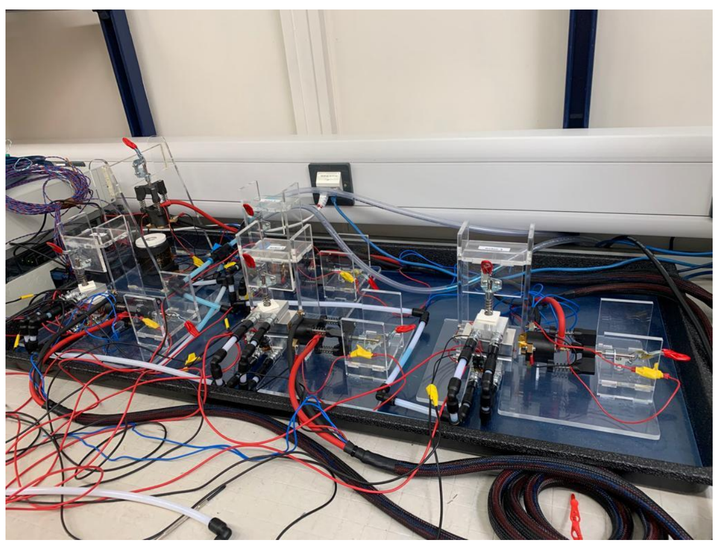
- A battery testing rig was designed and manufactured to conduct a Galvanostatic Intermittent Titration Technique (GITT) test to gather data.
- Kinetic parametrization was conducted in SOC segments of 4%, 10%, and 20% at various SOCs.
- The difference between larger and smaller SOC segments was found to be relevant for the τ_1 and τ_2 parameters of the 2RC Electrical Circuit Model (ECM) while the other parameters were not majorly impacted by the SOC segments used.

Motivation

- The SOC segments used during kinetic parametrization are a key aspect in ensuring the accuracy of the ECMs for a battery.
- Therefore, improving the understanding of how SOC segments influence the accuracy of ECM parameters would aid in improving parametrization techniques and their resulting ECMs.

Analytical Method

- A battery testing setup with a battery cycler was used to perform a GITT test on a battery. The data generated was then inputted into a bespoke kinetic parametrization code which produced the ECM parameters. The 10% and 20% SOC segment data was then interpolated to provide a better comparison with the 4% data points.



- The testing rigs had water-cooling block and Peltier elements attached to the battery setup maintain each battery at specified temperature set by the control system

Figure 1: Battery testing rigs in operation.

Battery Testing Setup - Design and Manufacturing

- The design of the battery testing setup had a four main design priorities: safety, ease of use, a compact size, and high maintainability. The setup was manufactured using 3D printing, laser cutting, and milling with multiple design iterations to converge onto a setup which met all the design priorities.
- Electrical components were insulated and separated from the water-cooling pipes which meant that the setup was safe to use with minimal risk for a short-circuit occurring. The setup was compact such that multiple rigs could be placed side by side without issues.
- In addition, the setup was simple to use with only two clamps to operate during testing. The testing setup could be taken apart quickly and easily for inspections which allowed for maintenance to be performed easily.
- The battery testing setup was then finalised with four test rigs produced with four more rigs planned to be built in the near future to increase the number of batteries that can be tested at one time. This would help provide a larger sample size for any battery tests undertaken.

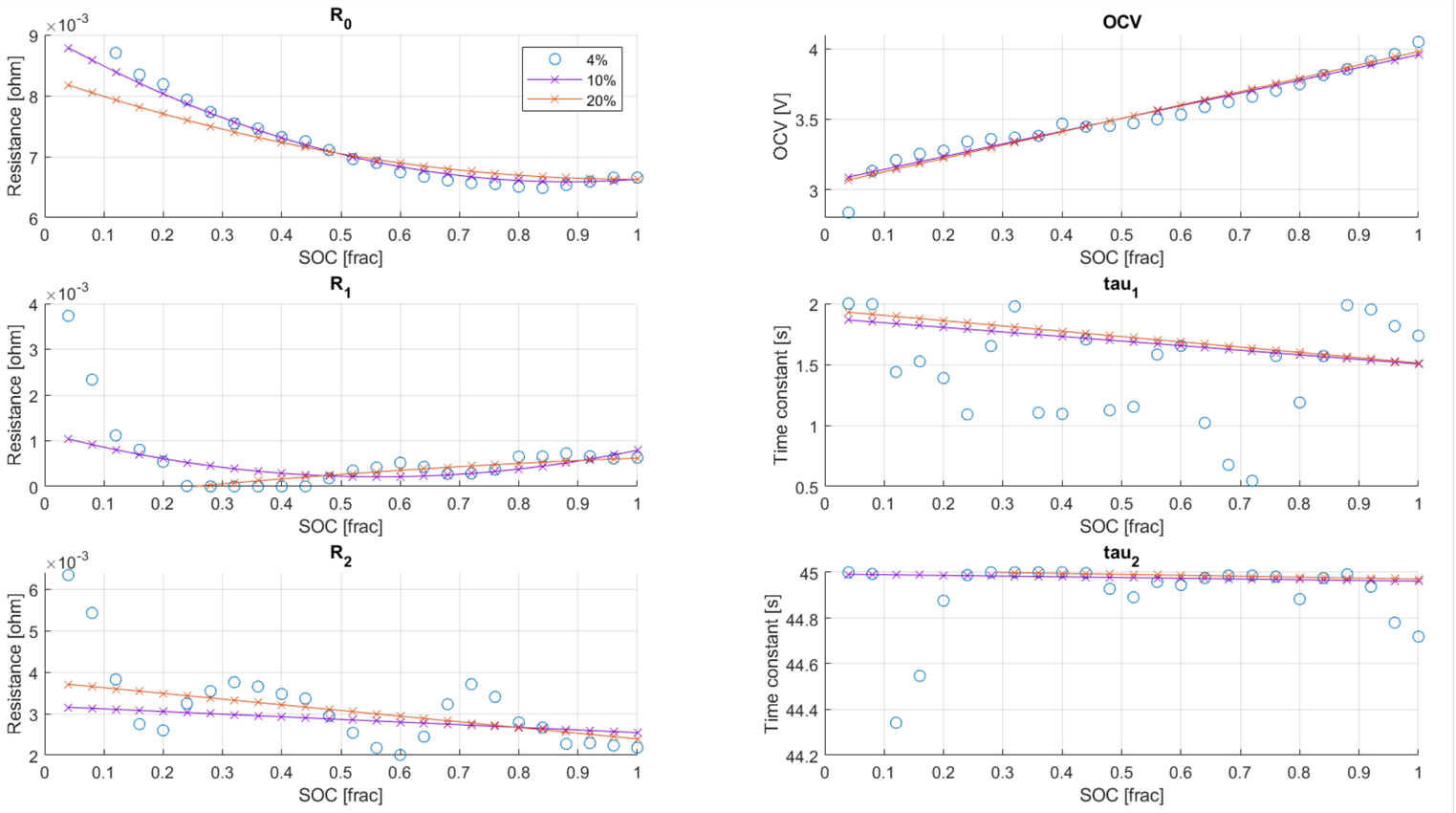


Figure 2: Comparison of the 4%, 10%, and 20% SOC segments for the various parameters

Results & Conclusions

- The Root Mean Square Error (RMSE) for τ_1 and τ_2 when comparing the use of 10% and 4% SOC segments were 0.470 and 0.172 respectively as well as 0.491 and 0.179 when comparing 20% and 4%. The RMSE for R_0, R_1, R_2 and OCV was a maximum of 0.067.
- The main conclusion is that a smaller SOC window has a negligible impact on the parametrisation of R_0, R_1, R_2 and OCV while having a significant impact on τ_1 and τ_2 .
- For future parametrizations, the use of large SOC segments can potentially help reduce the computational time required to perform kinetic parametrization for GITT data.

Impact / Next steps

- The research contributes to better thermal management in batteries through aiding in the development of higher accuracy ECMs.
- An increased understanding of SOC segments on the various parameters for kinetic parametrization will support the creation of more efficient parametrisation algorithms.
- Further exploration of the impact of SOC segments can be carried out by analysing different sets of test data created by drive cycles, noisy load , and other test scenarios.
- Using larger data sets would aid in better interpolation of larger SOC segments for future comparisons of different SOC segments.

References

- Jackey, Robyn. "Battery Model Parameter Estimation Using A Layered Technique: An Example Using A Lithium Iron Phosphate Cell". *Mathworks*, 2022
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Intern bio

Ishan is in his final year of his MEng Mechanical Engineering degree at the University of Bristol. He has an interest in working on sustainable technologies in the energy and automotive sectors. His focus is on exploring avenues for delivering solutions to improve processes, systems and workflows to promote sustainability.

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