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Investigation of Immersion Cooling in Battery Packs with PIV and Simultaneous Heat Flux Measurement in an Optical Oil Flow Channel

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Extended Abstract

We combine flow investigations with particle image velocimetry (PIV) and simultaneous heat flux measurement across the surface of real battery modules using the atomic layer thermopile (ALTP) technique in a new optical oil flow channel. It represents the dimensions of a realistic immersion cooled battery pack. The objective is to compare the cooling performance of different oils, where some received viscoelastic properties through additives. In previous studies, we performed characterization that is more fundamental in benchmark geometries [1].

The channel cross section is of rectangular shape with a height of 100 mm and width of 47.5 mm. Along the main flow direction, there are four battery cells of 147 mm length lined up with a spacing of 27.5 mm. They cover the height of the channel. On both sides, a gap of 10.4 mm remains. The channel walls are made from acrylic glass, allowing for optical access. We perform time-resolved two-dimensional two-component PIV with a high-speed camera. We vary the flow conditions in terms of Reynolds numbers.

Through a closed flow loop, we secure and survey the upstream temperature of the oil. We charge and discharge the batteries at different rates to reproduce realistic thermal loads. An electric load monitors the output voltage and current. Additionally, we position ALTP sensors on the side faces of the cell, where the heat transfer to the oil takes place. The sensors facilitate direct measurement of the heat flux, obviating the necessity to calculate it from temperatures and to base this calculation on assumptions. In a recent study, we demonstrate the experimental principle in a benchmark case [2]. Each sensor is of rectangular shape with an active area of 100 mm x 8 mm. Additionally we employ dummy cells, which we can heat in a controlled and reproducible manner. There the heating rates can significantly exceed the rates that results from charging and discharging the real cells. We compare our experimental results to computational fluid dynamics (CFD). Karathanassis et al. recently reported preliminary results from related simulations [3].

The new flow channel allows us to conclude the preparative, fundamental work we did on heat transfer in viscoelastic oils. By including and discharging the batteries, we take a big step closer to the real-world application.

References

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