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Fast-charging of battery electric vehicles: protocol and cell design

Battery-based electric vehicles (EVs) are rapidly penetrating the market thanks to recent technological advances in Li-ion batteries. Still there are challenges in widespread adoption of EVs including the range anxiety. Ironically, the main factor causing the "range" anxiety is not the driving range of EVs; recent EVs have driving ranges over 600 km on a single charge, longer than those of internal combustion engine vehicles (ICVs). Rather it is the charging time that makes EV drivers concerned about trip distance; state-of-the-art EVs take more than 20 min to charge 75% of their battery capacities and even far longer to charge 100%, while ICVs take less than 2 min to fully refuel their tanks.

In this talk, I will present two of my recent studies to reduce the charging time of EVs. The first study introduces a new type of charging protocol, named constant-risk protocol, which maximizes the charging current while keeping risk variables (e.g., anode overpotential, and maximum temperature) under their predefined limits selected to manage the risk of degradation. Using the constant-risk protocol, 80%-charging of a typical NMC/Graphite cell can be achieved within 10 min when charged at a moderate risk level. We also demonstrate the constant-risk protocol shifts down the cost curve of fast-charging cells, enabling affordable fast-charging.

In the second study, we present battery cells of a new form factor (i.e., exterior shape). While battery cells are being larger and larger in size to increase energy density, large cylindrical cells (e.g., 4680 of Tesla) have limited fast-charging capabilities due to their long heat transfer length. Tubular form factor adds a coaxial cooling channel to the central pole region of cylindrical cells, whose volume were unutilized before, and enhance heat dissipation capabilities. 46mm-diameter tubular cells can be charged as fast as 6.5C (9 min-equivalent charging rate) keeping the internal temperature below 40°C, which is faster than 4.5C of conventional 4680 cylindrical cells.