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Multiscale modelling strategies for predicting the mechanical response of Li-ion batteries in electric vehicles

Lecture of

Dr. David Carlstedt

Battery Structural and Thermal Simulations,
Volvo Car Corporation, Sweden

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Volvo Cars is taking a bold lead with electrification. By 2030 the goal is to only produce electric vehicles (EVs). To drive this lead, efficient design solutions for energy storage systems are being explored and designed. Moreover, novel evaluation tools are being developed to assure the safety and reliability of the systems during operation.

The dominating solution for energy storage in EVs is Lithium-ion (Li-ion) batteries. Two key aspects in the EV design are safety and durability. For example, in the case of a car crash, mechanical deformation of the battery cells can lead to electrical short circuits that may end up in potential safety issues. Moreover, batteries are known to swell during operation which, due to the partly constrained expansion of the cells, will generate mechanical loads on the surrounding structure. Hence, to accurately predict the severity of such events in the EV design, reliable computational models are needed which accurately predicts the mechanical response of the battery cells.

The mechanical response of Li-ion batteries is known to be highly affected by its geometric features, constituents, and the operating conditions. For example, the response is influenced by the geometric properties of the cell components (e.g., form factor and jelly roll stacking sequence) as well as the mechanical loading conditions (or speed of applied external mechanical load). To evaluate the mechanical response of Li-ion batteries in EVs, Finite Element (FE) based models are generally used. The precision of such models depends strongly on the utilized modelling strategy, and the quality of the geometric and material data.

In this presentation, the main focus is on state-of-the-art multiscale modelling strategies developed at Volvo Cars to predict the mechanical response of Li-ion batteries in EVs. For example, the complexity of the involved length and time scales will be elaborated in terms of mechanical loading scenarios relevant to EV design. Further, strategies to deal with the multiple length/time scales and geometric features are reviewed in lights of EV application. Finally, an overview of some of the latest structural battery simulations at Volvo Cars, supporting the company to become a leading electric car original equipment manufacturer (OEM), are showcased.