6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

TOWARDS A HYBRID TWIN PARADIGM FOR BATTERY MANAGEMENT SYSTEM

Abel Sancarlos[1], Kunal Jain[2] , Emmanuelle Abisset-Chavanne[1], David Gonzalez[3], Elias Cueto[3] and Francisco Chinesta[4]

[1] ESI Group Chair @ Centrale Nantes & ESI Group Chair, Nantes, France, abel_dev_xd@hotmail.com, Emmanuelle.Abisset-chavanne@ec-nantes.fr
[2] ESI GROUP, Paris, France, Kunal.Jain@esi-group.com
[3] University of Zaragoza, Zazagoza, Spain, gonzal@unizar.es, ecueto@unizar.es
[4] ESI Group Chair @ ENSAM ParisTech, Paris, France, Francisco.Chinesta@ensam.eu

Key Words: *Digital Twin, Hybrid Twin, Model Order Reduction, Batteries, Multiphysics Problems, Multiscale Problems.*

The performance of the Electric Vehicle (EV) is closely tied to the performance of the battery. Most EVs have an onboard battery management system (BMS) that maintains safe and consistent operation of the battery module. Furthermore, the BMS deploys strategies such as cell balancing to reduce degradation and optimize performance of the battery system. The BMS reads in voltage, current, temperature to estimate the State of Charge (SOC) and the State of Health (SOH). The SOC refers to the amount of remaining charge in the battery pack and the SOH refers to the amount of degradation that has occurred in a battery. Empirical models become inaccurate as the batteries degrade. Alternatively, there are physics-based models that are accurate but highly time-consuming to be of practical use in real-time applications. The challenge is therefore to develop BMS models that are both fast and accurate. We believe that the Hybrid Twin paradigm is the right approach to building the BMS models that are physics-based but use the sensor data to continually update the operating parameters.

New numerical technologies based on Model Order Reduction - MOR - techniques opened new possibilities for more efficient simulations. These new simulation techniques are the basis of the so-called digital twins that allowed assimilating data collected from sensors. However, when these techniques were integrated into data-driven applications systems, unexpected difficulties appeared immediately. For example, significant deviations between the predicted and observed responses were noticed. In order to address these deviations, one possibility lies in constructing “on-the-fly" a data-driven model able to fill the gap between prediction and measurement. Only when this gap disappears, system control can be efficiently attained. This is the rationale defining the concept of HYBRID TWINS.

In this work the hybrid twin paradigm will be applied to BMS. The battery continuum model consists of a system of non-linear tightly coupled multiscale parametric partial differential equations describing the reaction-diffusion-thermal transport. It is in this scenario that Hybrid Twin paradigm becomes an appealing route making use of the physical-based models, and whose parameters could be updated online from the collected and assimilated data such as local temperature. Next, the noticed deviations between model predictions and measurements will be corrected with a data-based model that is constructed using appropriate machine learning algorithms.