About DEP: Detroit Engineered Products (DEP), is an engineering services, product development, software development, consulting, and talent acquisition company. Since its inception in 1998 in Troy, USA, DEP is now a global company with footprints in Europe, China, Korea, Japan, and India. DEP uses the accelerated and transformed product development process, accomplished by utilizing our proprietary platform, DEP MeshWorks, which rapidly reduces the development time of products for all segments. The MeshWorks platform delivers tool sets that accelerate virtual validation activities associated with powertrain development across all stages for both conventional and electric powertrains.

Smarter solutions. Realized.

Battery Solutions: DEP's battery design solutions are founded on a comprehensive approach that encompasses various aspects of battery design and simulation. This involves creating system models to predict the battery's performance and efficiency, understanding battery chemistry and its thermal and structural behavior, optimizing design parameters, conducting reverse engineering of existing systems, and validating the results through testing. These processes play a vital role in developing safe, efficient, and reliable battery solutions for diverse applications. Additionally, battery testing validation is conducted through our partnerships with testing allies. As a result, we offer a one-stop shop for battery solutions to EV companies.

BATTERY SOLUTIONS: PATHWAY TO GREEN MOBILITY

DEP's Core Competencies:

System Level Modelling

Cell level and Module Level Analysis

- Newman Electrochemistry
- Equivalent Circuit Modelling
- Lithium Plating
- Cell Charging and Discharging
- Cell Over Discharging
- Cell Crush
- Cell Ageing
- Cell Thermal Analysis

Battery Pack Analysis

- Bus bar- Heat Generation
- Thermal Runaway-Damaged Cell
- Battery Pack Aging analysis
- Battery Pack Thermal analysis
- Battery Pack Structural Analysis
- Parametric Optimization
- Reverse Engineering
- Testing and Certification Support
- Advanced method development

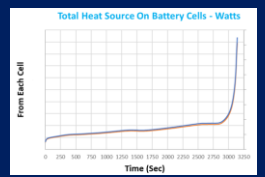
Typical Analysis Processes

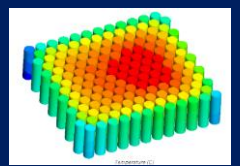
Pack-level

Thermal runaway :
Thermal runaway is triggered in one cell in a battery pack (using 3 times higher voltage input) and thermal analysis is performed over the entire battery pack to understand the series of cell failures caused by one damaged cell.

Outputs :

- Battery pack temperatures
- Battery cell-level temperatures
- Series of cell failure study
- Heat loss through battery





Software and Tools

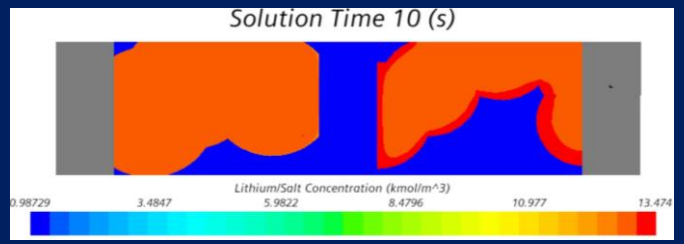
- Model Libraries - Vehicle system and sub-system models, Fuel Cell stack model, sensor and actuator models, battery models
- Custom Tools - Customized software for specific purposes

Cell level

Electrochemistry:
Electrochemistry simulation at the cell level involves modeling of the Solid-Electrolyte Interface (SEI) and simulating the behavior of an electrochemical cell, such as a battery or fuel cell, to understand its electrochemical stability, performance deterioration, cell safety and life-span. This type of simulation is crucial in the design, optimization, and safety assessment of electrochemical devices.

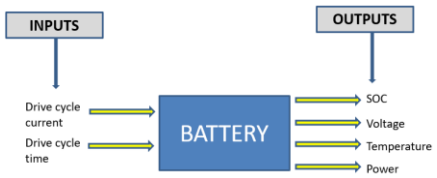
Outputs:

- Electrolyte concentration
- Electric current density distribution
- Concentration near SEI



System Level Modelling

System modeling involves the comprehensive representation of an entire vehicle, encompassing its motor, battery, vehicle characteristics , and control systems. System-level modeling analyzes the vehicle application and drive cycle, enabling the simulation of the motor's required electrical power as a function of its variable mechanical load. It also predicts battery performance under diverse conditions, such as temperature variations, load profiles, and charging/discharging rates.



- EV Battery sizing, optimization, thermal management and control strategies
- Estimating the battery's range, efficiency, and lifespan in real-world scenarios.
- Gain insights into battery performance, behavior, and interactions with motor and power electronics components in the system
- Significantly reduce the time and cost required for physical prototyping and testing
- Development of more reliable, efficient, and cost-effective electric vehicles

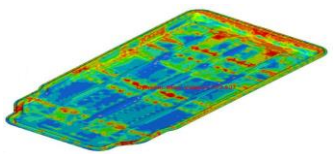
Battery structural analysis

Structural durability analysis of the battery pack assembly is conducted to ensure its structural integrity can withstand a wide range of loads, including road conditions, internal battery loads during thermal runaway, and mishandling during transportation or assembly processes. This approach aims to enhance safety for occupants and protect the internal battery modules.

Battery pack sealability ensure that it can withstand internal gas pressure due to operating and failure conditions

Outputs :

- Stresses and plastic strains all structural components
- Fatigue damage
- Air gap between cell module and structural components

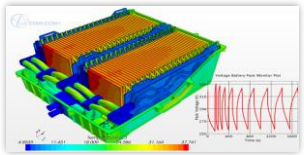


Battery Thermal analysis

Battery pack thermal analysis involves modeling and simulating the battery pack to perform conjugate heat transfer (CHT) analysis, considering the heat sources on the battery pack.

Outputs :

- Minimum and maximum temperatures in battery and its components
- Transient temperature distribution in battery components
- Heat dissipation and Heat balance
- Coolant temperature, velocity and pressure distribution

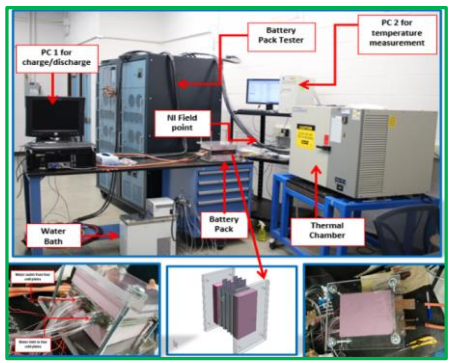


Pack level cooling analysis

Performance Testing

We collaborate with battery suppliers and battery testing partners to accelerate the battery testing process according to customer requirements. Our one-stop shop provides comprehensive battery solutions to EV companies.

- Cell, Module, and Pack level cycling
- Charge/Discharge cycle durability
- Drive cycle testing
- Pulse Power testing
- Shock and Vibration
- Thermal Cycling
- Altitude simulation
- Ingress Protection
- Controller Area Network, Communication, and Control.
- Free Fall testing
- Charge Retention/ Overcharge Testing

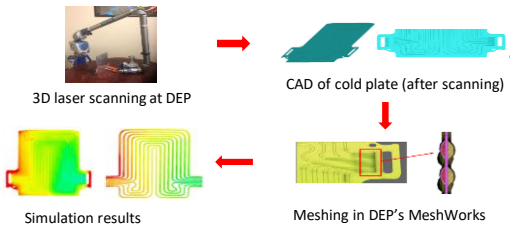


Reverse Engineering

Reverse engineering is a process of deconstructing an EV battery or any product, to understand its design, components, and operating principles.DEP is equipped with 3D laser scanning facility. Destructive testing (tear down),Non-destructive testing technique like 3D scanning followed by CAD creation and simulation, which can be applied to a battery.

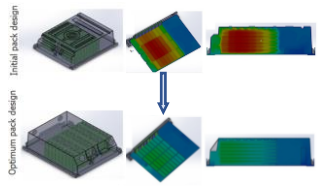
Typical parameters extracted from tear down and reverse engineering :

- Number of cells
- Number of anode & cathode and separator sheets
- Cold plate design
- Layer unit stack resistance
- Thermal conductivity of +ve and -ve electrode
- Material properties
- 3D scan of battery pack level thermal management system



Battery Parametric Optimization

The DEP Weight Optimization Approach aims to optimize the design of battery pack components by establishing shape, section, and gauge parameters, leveraging baseline simulation results. These parameters can be utilized and integrated with Design of Experiments (DOE) to achieve design and performance targets, reduce product weight, and lower manufacturing costs.



Advanced method development

With extensive experience in advanced battery method development, DEP encompasses a wide spectrum of research and engineering efforts. Our primary focus lies in enhancing battery technologies and gaining a deeper understanding of battery behavior. DEP offers comprehensive support for the advanced simulations for battery packs including, Cell swelling, Gasification Analysis, etc.

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