Training Course on Thermal Management in EV Battery Systems

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

This specialized training course provides an in-depth understanding of Thermal Management in EV Battery Systems, equipping participants with the critical knowledge and practical skills required to design, analyze, and optimize thermal solutions for high-performance electric vehicle battery packs. Training Course on Thermal Management in EV Battery Systems delves into the fundamental principles of heat generation, heat transfer (conduction, convection, radiation), and various cooling strategies including air cooling, liquid cooling (direct and indirect), and refrigerant-based cooling systems. Attendees will gain expert-level understanding of how effective thermal management directly impacts battery lifespan, performance (power and energy output), fast charging capability, and crucial safety parameters (thermal runaway prevention). This course is essential for battery engineers, automotive thermal engineers, and EV powertrain developers aiming to push the boundaries of battery technology and ensure robust, reliable, and safe electric vehicle operation.

The program emphasizes practical implementation and addresses trending topics in the evolving electromobility sector, such as advanced thermal modeling and simulation (CFD), multi-physics co-simulation, integrated thermal management systems for the entire vehicle, second-life battery thermal considerations, and the application of AI/ML for predictive thermal control and diagnostics. Participants will explore the intricate trade-offs between thermal performance, system complexity, cost, and packaging constraints. By the end of this course, attendees will possess the expertise to architect, analyze, and optimize sophisticated thermal management solutions for EV battery systems, enabling extended battery life, enhanced vehicle range and power, stringent safety compliance, and accelerated development cycles. This training is indispensable for professionals driving innovation and performance in the electric vehicle and energy storage industries.

Programme Curriculum

Training Course on Thermal Management in EV Battery Systems

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Course duration

10 Days

Course Objectives

1. Understand the sources and mechanisms of heat generation within EV battery cells and packs.
2. Apply fundamental heat transfer principles (conduction, convection, radiation) to battery systems.
3. Analyze and design various air cooling strategies for EV battery packs.
4. Implement and optimize liquid cooling systems (direct and indirect) for superior thermal performance.
5. Comprehend the principles of refrigerant-based (active) cooling and heating for battery temperature control.
6. Develop thermal models of battery cells, modules, and packs using analytical and numerical methods.
7. Utilize Computational Fluid Dynamics (CFD) tools for detailed thermal analysis and optimization.
8. Design for thermal runaway propagation prevention and mitigation within battery packs.
9. Evaluate the impact of temperature on battery performance, degradation, and safety.
10. Integrate Battery Thermal Management Systems (BTMS) with the overall vehicle thermal architecture.
11. Explore advanced thermal materials and phase-change materials (PCMs) for battery cooling.
12. Apply AI/ML techniques for predictive thermal management and diagnostics.
13. Understand manufacturing and assembly considerations for BTMS components.

Organizational Benefits

1. Extended lifespan and improved performance of EV battery packs, reducing replacement costs.
2. Enhanced safety of electric vehicles by effectively preventing thermal runaway.
3. Faster and more efficient battery fast charging capabilities, improving user experience.
4. Optimized vehicle range and power delivery across diverse operating conditions.
5. Reduced warranty claims related to battery degradation and thermal issues.
6. Accelerated R&D cycles for new battery pack designs and thermal solutions.
7. Competitive advantage in the rapidly evolving EV market through superior battery performance.
8. Compliance with stringent safety and performance standards for EV batteries.
9. Development of in-house expertise in a critical EV system engineering domain.
10. Contribution to sustainability goals by maximizing battery utility and lifespan.

Target Participants

- Battery Engineers
- Automotive Thermal Engineers
- EV Powertrain System Designers
- Mechanical Engineers working on EV components
- Electrical Engineers involved in Battery Pack Design
- Researchers and Developers in Battery Technology
- Product Development Teams in the EV Industry

Course Outline

Module 1: Introduction to EV Battery Systems and Thermal Challenges

- **EV Battery Chemistries:** Li-ion characteristics and thermal sensitivity (NMC, LFP, NCA).
- **Heat Generation Sources:** Ohmic losses, entropy changes, side reactions.
- **Impact of Temperature:** Performance (power, energy), degradation, safety (thermal runaway).
- **Operating Temperature Window:** Optimal range for different battery types.
- **Case Study:** Analyzing the typical temperature profile of an EV battery during fast charging and discharge cycles.

Module 2: Fundamentals of Heat Transfer for Batteries

- **Conduction Heat Transfer:** Mechanisms, thermal conductivity of battery materials, contact resistance.
- **Convection Heat Transfer:** Forced vs. Natural convection, fluid properties (air, liquid coolants).
- **Radiation Heat Transfer:** Emissivity, view factors.
- **Thermal Resistance Network Modeling:** Simplified thermal models of cells and modules.
- **Case Study:** Calculating the heat conduction through different layers of a prismatic battery cell.

Module 3: Air Cooling Systems for Battery Packs

- **Air Cooling Principles:** Direct and indirect air cooling layouts.
- **Design Considerations:** Airflow paths, pressure drop, fan selection.
- **Advantages:** Simplicity, low cost.
- **Limitations:** Lower cooling capacity, temperature non-uniformity.
- **Case Study:** Designing an air cooling system for a small EV battery pack, optimizing fan placement and airflow distribution.

Module 4: Liquid Cooling Systems (Indirect)

- **Liquid Coolant Properties:** Specific heat, density, thermal conductivity (glycol-water, dielectric fluids).
- **Cold Plate/Cooling Plate Design:** Internal channels, flow distribution, material selection.
- **Cooling Loop Components:** Pumps, heat exchangers, reservoirs.
- **Heat Transfer Enhancement:** Fins, turbulators.
- **Case Study:** Designing a serpentine cold plate for a battery module to achieve uniform temperature distribution.

Module 5: Liquid Cooling Systems (Direct)

- **Dielectric Fluids:** Properties and advantages (non-conductive, high boiling point).
- **Immersion Cooling:** Submerging cells directly in dielectric fluid.
- **Flow Rate and Pressure Drop:** Optimization for effective cooling.
- **Filtration and Maintenance:** Keeping fluid clean and healthy.
- **Case Study:** Comparing the thermal performance of an indirect liquid cooling system versus a direct immersion cooling system for a high-power battery pack.

Module 6: Refrigerant-Based Cooling and Heating (Active Systems)

- **Vapor Compression Refrigeration Cycle (VCRC):** Components (compressor, condenser, expansion valve, evaporator).
- **Refrigerant Types:** Environmentally friendly refrigerants (R134a, R1234yf).
- **Integrated HVAC Systems:** Utilizing vehicle's existing AC system.
- **Heat Pump Functionality:** Both cooling and heating capabilities.
- **Case Study:** Designing a battery thermal management system that leverages the vehicle's cabin HVAC system for both cooling and heating.

Module 7: Battery Thermal Modeling and Simulation

- **Equivalent Circuit Models (ECM) with Thermal Coupling:** Representing electrical and thermal behavior.
- **Lumped Parameter Thermal Models:** Simplified system-level analysis.
- **Finite Element Method (FEM) for Thermal Analysis:** Detailed cell/module temperature distribution.
- **Computational Fluid Dynamics (CFD) Simulation:** Analyzing fluid flow and heat transfer within the pack.
- **Case Study:** Creating a 3D CFD model of a battery module to predict temperature gradients under high discharge rates.

Module 8: Thermal Runaway and Safety

- **Thermal Runaway Mechanism:** Onset, propagation, triggers.
- **Propagation Prevention:** Cell-to-cell isolation, thermal barriers.
- **Ventilation and Exhaust Systems:** Managing off-gases and pressure build-up.
- **Early Warning Systems:** BMS integration for thermal runaway detection.

- **Case Study:** Designing thermal barriers and venting paths within a battery pack to limit thermal runaway propagation.

Module 9: Impact of Temperature on Battery Performance and Degradation

- **Cycle Life vs. Temperature:** Accelerated degradation at high/low temperatures.
- **Calendar Life vs. Temperature:** Storage effects.
- **Internal Resistance vs. Temperature:** Power capability.
- **Capacity Fade Mechanisms:** SEI growth, lithium plating.
- **Case Study:** Quantifying the expected lifespan reduction of a battery pack if continuously operated above its optimal temperature range.

Module 10: Integrated Vehicle Thermal Management Systems (IVTMS)

- **Coupling BTMS with Vehicle HVAC and Powertrain Cooling:** Holistic approach.
- **Waste Heat Recovery:** Utilizing heat from motor/inverter for battery heating.
- **Thermal Control Unit (TCU):** Centralized thermal management control.
- **Energy Efficiency of IVTMS:** Minimizing parasitic losses.
- **Case Study:** Developing an integrated thermal management strategy that shares cooling resources between the battery, motor, and cabin.

Module 11: Advanced Thermal Materials and PCMs

- **Phase Change Materials (PCMs):** Latent heat absorption, temperature buffering.
- **Graphite Foams and Composites:** Enhanced thermal conductivity.
- **Aerogels and Insulators:** For thermal runaway containment.
- **Advanced Adhesives and Gap Fillers:** Improving thermal contact.
- **Case Study:** Evaluating the effectiveness of a PCM layer in a battery module for reducing peak temperatures during aggressive driving.

Module 12: Control Strategies for Battery Thermal Management

- **PID Control for Temperature Regulation:** Simple feedback loops.
- **Model Predictive Control (MPC):** Anticipating thermal needs based on driving patterns.
- **Adaptive Control:** Adjusting to varying ambient conditions and battery state.
- **AI/ML for Predictive Thermal Management:** Learning optimal cooling/heating strategies.
- **Case Study:** Designing an MPC algorithm to pre-condition the battery temperature before a fast charging event.

Module 13: Manufacturing and Assembly Considerations

- **Module and Pack Assembly Challenges:** Ensuring good thermal contact.
- **Manufacturing Tolerances:** Impact on thermal performance.
- **Quality Control and Testing:** Thermal performance validation.
- **Repairability and Serviceability:** Designing for ease of maintenance.
- **Case Study:** Identifying critical manufacturing steps that could impact the thermal performance of a liquid-cooled battery pack.

Module 14: Second-Life Batteries and Thermal Management

- **Applications for Second-Life Batteries:** Stationary energy storage.
- **Thermal Considerations for Degraded Batteries:** Different thermal profiles, reduced efficiency.
- **BMS Adaptation for Second Life:** Thermal monitoring and control.
- **Safety Implications of Re-purposing:**Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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