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Media outlet: Engineering Online

Date of publication: June 24, 2024

How is “Cell-to-Pack” Revolutionizing EV Battery Pack Designs?

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The electric vehicle (EV) sector is evolving, with manufacturers continuously innovating battery designs to bolster energy density for extended range, optimize space, and reduce battery cost — which accounts for about **30% of total vehicle costs**. This article reviews the current trends and challenges in EV battery design, focusing on the transition from modular to cell-to-pack (CTP) arrangements, a significant development that deserves attention.

Original equipment manufacturers (OEMs) are exhibiting no clear preference for cell-to-pack or cell-to-chassis designs.

- **Cell-to-pack (CTP)** designs integrate battery cells directly into the battery pack, eliminating intermediate modules to enhance energy density and simplify manufacturing.
- **Cell-to-chassis (CTC)** designs incorporate the battery cells directly into the vehicle’s chassis, optimizing space, reducing weight, and improving structural integrity.

Some OMEs prefer the traditional modular setup housing 16 or 32 modules per pack, while others choose CTP designs to reduce the module count. However, select Chinese OEMs are consistently selecting CTP designs, marking a departure from convention. But why is that?

Comparing modular and CTP designs underscores a significant increase in current density with CTP configurations, a decisive factor in boosting overall EV performance and range. Among the prevalent battery cell formats — prismatic, pouch, and cylindrical — prismatic cells are favored in China but lag behind pouch cells in current density.

This discrepancy is leading many Chinese OEMs to CTP designs, enabling them to eliminate the modular side walls, increasing energy density, and dropping considerable weight — a win-win situation.

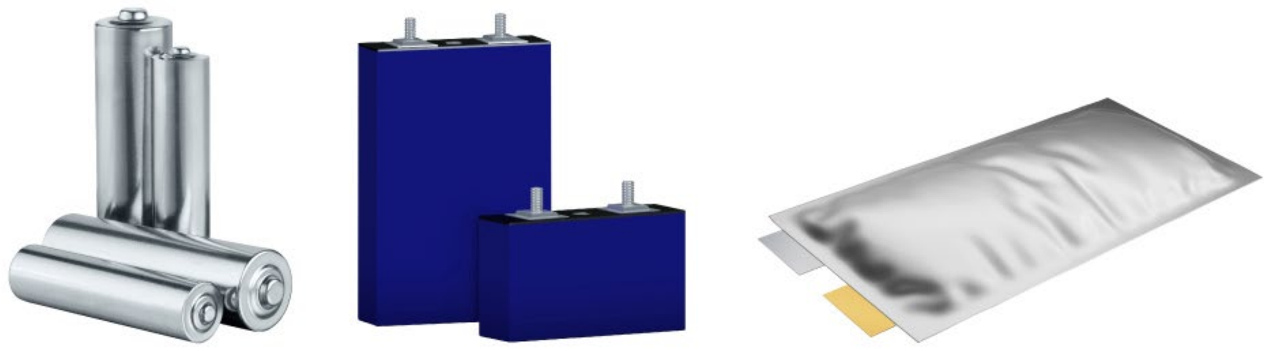

Figure 1. The common cell types for EV batteries: cylindrical, prismatic, and pouch.

Despite the merits of CTP, pouch-based designs have yet to emerge, mainly because of the practical challenges in welding multiple pouches together. Nevertheless, pouch designs are evolving, with larger, elongated variants surfacing. In cylindrical formats, inherent dead space between the cells in CTP setups can be removed using hexagon-shaped cells instead.

In addition to conventional prismatic cells, leading e-mobility interconnect solutions providers are working with automakers and EV battery manufacturers on other prismatic cell formats. The latest prismatic blade cells are one of the latest CTP concepts. The blade batteries are as long as the width of a battery pack, running up to 2.5m in length. The design provides enhanced safety, durability, performance, and greater battery space.

Innovations in cell connecting systems

Elongating a cell connecting system (CCS) to accommodate the new 2.5m blade cells poses intricate precision and tolerance challenges. The advanced stamping capabilities use a unique cell-connection system that facilitates placement on the prismatic blade cells while ensuring accuracy and complication-free welding.

Ideally, a clip-on design that eliminates welding will be developed soon, which aligns with the anticipated transition to wireless battery management systems (BMS). By equipping each cell with a wireless chip, OEMs can access detailed charging data for predictive maintenance. Unlike current welded battery connections, which necessitate destructive processes for cell replacement, clip-on interconnects offer single-cell serviceability. They enable OEMs to replace individual cells, substantially cutting costs from up to $20K for a pack to only $200 for a single cell replacement.

Instead of the chemically etched copper traces on the FPC, which takes a lot of energy to extract the copper from the chemicals, the die-cutting process allows instant recycling of the copper waste.

Figure 2. Advanced stamping capabilities and flexible die-cut circuits are supporting new CTP and CTC battery setups.

Combining stamping capabilities with FDC design supports new CTP and CTC setups for OEMs transitioning from modular approaches. While FDC entails certain design restrictions, opting for four elongated FDCs over four flexible printed circuits (FPCs) could yield a 25% cost benefit.

Transitioning to CTC designs

Cell-to-chassis (CTC) epitomizes the evolution beyond CTP, wherein the chassis safeguards battery cells for safety. However, fortifying chassis structures to avert cell rupture or combustion during vehicle impacts poses challenges. Material choice is critical for OEMs considering CTC adoption. Transitioning from aluminum cans to stainless steel enhances structural integrity but also means increased costs and weight.

From a production standpoint, CTP designs facilitate offline pack production, whereas CTC mandates chassis completion before cell integration. Individually placing thousands of cells into a chassis poses production efficiency hurdles, particularly for OEMs aiming for rapid EV rollouts. Due to these inherent pros and cons, a gradual transition from CTP to CTC is anticipated, necessitating meticulous cost assessments, strength evaluations, and range implications.

Coexisting designs

While transitioning from modules to CTP may seem straightforward, owing to substantial weight reductions, complexities exist. OEMs entrenched in smaller module production lines might encounter challenges when transitioning to 2m-long modules, requiring additional production equipment investments.

The coexistence of module, CTP, and CTC designs appears probable. New EV entrants are favoring CTP or CTC for production efficiency, leveraging flexibility absent in pre-existing production setups.

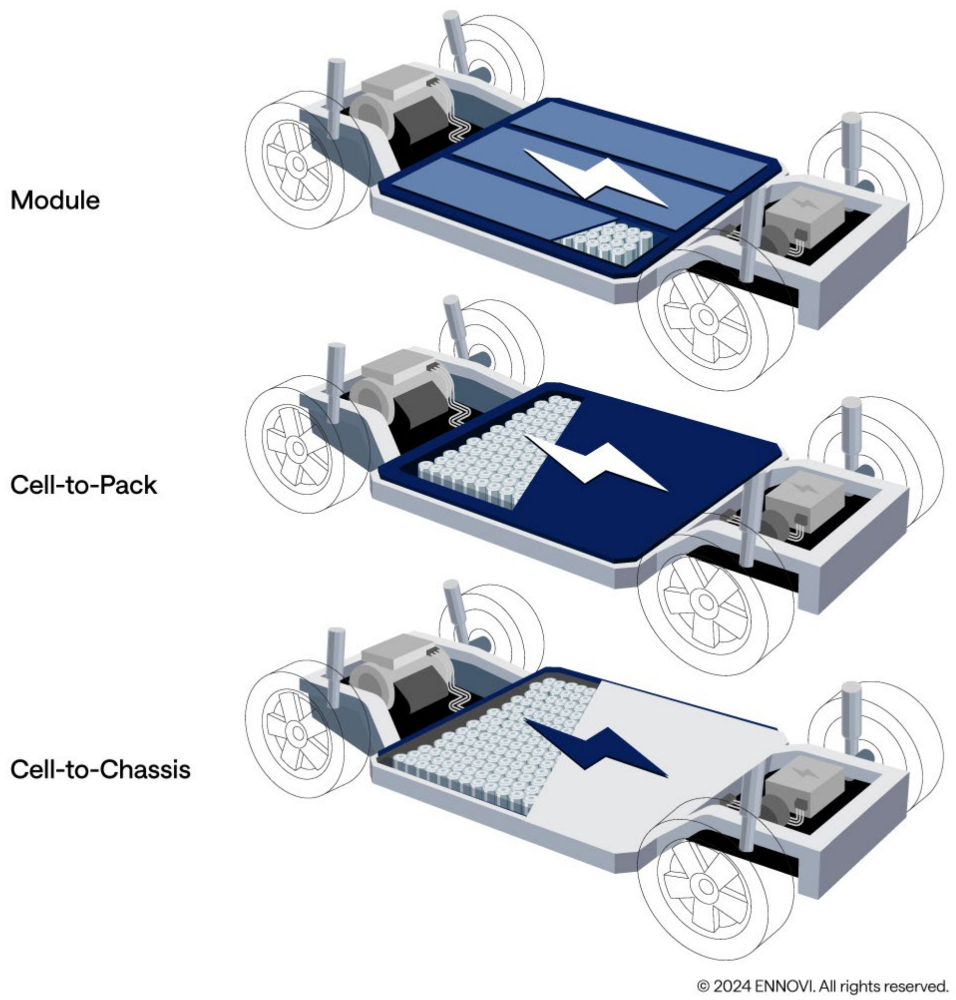

Figure 3. Larger cell groupings demand larger, more reliable CCSs with increased functionality.

With fewer components in EVs compared to conventional internal combustion engine (ICE) vehicles, the barrier to entry has lowered. Essentially comprising a chassis, battery, and four electric motors, EVs eliminate the need for a gearbox, simplifying manufacturing. As a result, any entity with the required funding and design capabilities can venture into producing affordable EVs with respectable ranges.

Autonomous driving

OEMs considering fully autonomous vehicles seem inclined to integrate self-driving tech into commercial vehicles, such as trucks and robotaxis. Battery manufacturers are now introducing skateboard platforms pre-equipped for self-driving capabilities, enabling newcomers to focus on aesthetics and streamlining EV production, aligning with approaches in the ICE era.

Divergent strategies emerge among incumbent OEMs, with the focus shifting to battery tech, current density, and consumer-centric aspects — like charging time and range. While some explore battery swapping for rapid charging, others transition to 800-V battery packs for faster charging. However, achieving the elusive 10-minute charging benchmark remains a challenge.

Navigating the future

The shift from modular to CTP and CTC reflects the EV industry's pursuit of enhanced performance, energy density, and use of efficient space. The coexistence of module, CTP, and CTC designs offers OEMs flexibility, with newcomers favoring CTP or CTC for production efficiency.

Safety considerations, production efficiency, and material choices will shape the future of EV battery designs. As the industry focuses on affordable EVs with impressive ranges, shorter charging times, and advanced features, OEM decisions will chart the course of sustainable transportation.

About the Author

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